Hazardous Materials Safety Through Research: The South African Experience

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ABSTRACT

The Department of Transport of South Africa funded a 3-year research project, performed by the National Institute for Transport and Road Research, to examine the current safeguards in the road transportation of hazardous materials, identify any problem areas or potential hazards, and recommend the action that should be taken by both the public and private sectors in order to reduce the likelihood of a major disaster. An initial investigation soon highlighted the lack of legislation in South Africa controlling transportation activities for most of the classes of hazardous materials. The legislation that did exist, such as municipal flammable liquids bylaws, was far from comprehensive and extraordinarily nonuniform in such critical areas as the definitions of flammability classes and the maximum permitted carrying capacities of road tankers. The priority task was to identify those factors that could be rendered less critical by the short-term introduction of relatively simple legislative controls. The lack of formalized driver selection and training procedures and the haphazard placarding of road tankers were selected as the ones that most closely fitted these requirements. An ad hoc committee was convened to discuss the most suitable solutions from which proposed regulations were eventually drafted for inclusion under an existing statute--the Hazardous Substances Act. An incident-reporting requirement was included with the proposed regulations to enable the authorities eventually to assess the true extent of the problem and identify any common causes. The research approach to the problem is described and also how the recommendations based on the findings are gradually being put into practice through either legislation or voluntary operating procedures that have been formulated as a cooperative effort between the authorities, the industry, and various research and safety organizations. Current research topics such as routing and information systems are discussed, as are future plans for examining tanker construction and associated safety fittings. Because South Africa still lags far behind much of the Western world with regard to the control of hazardous materials transportation, many of the measures taken are adaptations of overseas practice, but some, together with the problems that they are intended to solve, although very much peculiar to this country, could well find application elsewhere.

The growth and increasing sophistication of South African industry have resulted in a continuously rising demand for complex chemicals and petroleum products for use as feedstocks and processing agents. Chemicals that were unheard of outside of a laboratory 20 years ago are now being used in considerable quantities by the pharmaceutical, plastics, paint, and mining industries. Many of these substances are hazardous to man or his environment and are transported by road because of the convenience of door-to-door delivery and the absence of certain controls applied by the other modes of transport. South Africa's unenviable road accident record, coupled with the increasing capacities of road tankers carrying such hazardous materials, has exposed this country to the very real threat of a major hazardous materials disaster.

A spate of international hazardous materials disasters in 1978, including the Spanish liquid propane gas tanker explosion that claimed 200 lives coupled with a spectacular fire in Durban caused by the rollover of a tanker carrying cyclohexane, prompted the South African authorities to review critically their involvement in the provision of adequate safeguards for this type of transportation.

The Department of Transport subsequently funded an initial 3-year project that was to investigate this situation, highlight any inadequacies, and recommend what action should be taken in order to make this activity as safe as humanly possible. The project was given to the Safety Branch of the National Institute for Transport and Road Research (NITRR), one of the larger members of South Africa's Council for Scientific and Industrial Research, where, because it was believed that road tanker design and maintenance was probably a major issue, the task was assigned to the Vehicle Safety Group.

The aim of this paper is to describe the research

approach used for the project, examine the six issues selected as being critical, and indicate what progress has been made in dealing with them.

PRELIMINARY INVESTIGATION

Before a research plan could be formulated it was first necessary to have a clear understanding of what the project was trying to achieve, what the current situation was, and why existing controls were unsatisfactory. In effect this required the definition of a hazardous materials incident, that is, that which needed to be prevented; an assessment of the current rate of occurrence of such incidents, that is, the magnitude of the problem; and a review of current legislation to ascertain the potential for improvement.

Definition

It soon became apparent that evaluating safety in road transportation of hazardous materials involved more than examining the on-road aspects of such cargos. Faulty loading procedures, for instance, could subsequently lead to an incident on the road and therefore had to be considered part of the transportation chain. For this and other reasons it was decided to include all activities involving a hazardous cargo from initial vehicle loading to final discharge. A hazardous materials incident was deemed to mean any situation that either resulted from the unintentional release of a product or substantially increased the likelihood of such an event. A road accident involving a vehicle carrying hazardous materials would invariably be classed as an incident under this definition, whereas the obverse would not be true.

Occurrence

Assessing the rate at which hazardous materials incidents had occurred in previous years proved extremely difficult. Newspaper files contained details of only those incidents that involved loss of life or extensive property damage, and fire department records listed only those that had required some form of emergency service. In both cases it was apparent that few such incidents had been reported and those that had usually involved a road tanker carrying petrol or some other flammable liquid. These incidents were usually deemed noteworthy not because of any ensuing conflagration but because the local fire brigades covered the tankers with foam as a precautionary measure, the result of which was certainly an unusual sight for passing motorists.

Limited access to company loss-prevention records told a much different story. By definition those companies that maintained such records had a responsible attitude toward incident prevention and yet they had experienced some alarming occurrences, cases such as the disappearance of 25 000 L of concentrated sulfuric acid en route between Johannesburg and Kimberley and the total loss of 30 000 L of spent cyanide solution because of a tanker rollover. Such incidents had never become known to the authorities or the media because no one had been killed or injured and the companies concerned had been able to clear up the mess where required. The situation with companies that would not allow access to their records or did not maintain such statistics might not have been any worse, but it was most unlikely that it was any better.

Legislation

A literature review of all relevant legislation soon revealed that there was little or no control over a majority of the classes of hazardous materials conveyed by road. Indeed, as one advisor pointed out, there were volumes of regulations covering the transportation of milk but not a page on the carriage of cyanide solution.

At the time only two classes of hazardous substances were controlled by South African law--explosives and radioactive materials--both of which were strictly controlled and the laws actively enforced. Nevertheless, accidents had occurred and the legislation was continuously reviewed and amended in efforts to prevent further occurrences.

Flammable liquids, usually taken to mean petroleum products, were subject to municipal bylaws, but not all municipalities had such laws and there was a wide variation among those that did in relation to tanker capacities and the definition of flammability. The oil companies whose vehicles could travel through several such municipalities on one trip were more than anxious to see the situation standardized.

The Road Transportation Act had deregulated some aspects of transportation by allowing public and private haulers to operate without permits within up to 40 and 80 km of their respective bases. For greater distances a permit was required from the Transportation Boards, who were required to satisfy themselves that any motor vehicle referred to in the permit was suitable for the class of road transportation for which it was to be used. Although this requirement appeared to be an effective means of restricting hazardous materials transportation to the properly equipped haulers, it was rarely, if ever, applied.

Finally there was the Department of Health's Hazardous Substances Act, which, although primarily aimed at controlling consumer goods, empowered the Minister to make regulations "authorizing, regulating, controlling, instructing or prohibiting the transportation of any grouped hazardous substances." This aspect made the act the most suitable medium for the introduction of any new regulations, and contact with the department was immediately established to further this very matter.

DETAILED RESEARCH

In the best traditions of research, the next step was to ask the people who knew, or at least should have known, what the problems were and what their possible solutions were. The responses received to this approach were as many and as varied as the interests questioned.

- Central government suspected that there might be a problem but had no facts and figures to support this supposition, besides which insufficient staff and facilities were available to draft and police any new controls.
- The fire services complained of dealing with unidentified loads and numerous spillages resulting from inadequate containers and associated valving. They also believed that vehicles carrying dangerous loads should be banned from town centers and other damage-sensitive areas.
- The haulers blamed fly-by-night operations because of their poorly maintained vehicles and inadequately trained drivers.
- Transport inspectors were of the opinion that overloading of vehicles, particularly tankers, was possibly the most likely cause of a major accident.

• South African Railways staff cited inappropriate packaging as the most likely cause of a major accident and listed several instances in which cargoes that they had rejected on these very grounds had been willingly but surreptitiously transported by private contractors who most likely had little knowledge of the dangers of such operations and even less concern.

• Road safety organizations believed that the lack of driver training and the widespread use of forged licenses were the most critical factors in road accident causation and that this applied to an even greater degree to drivers of vehicles carrying dangerous cargoes.

• The labor organizations blamed the employers for exacerbating the potential for accidents through requiring an excessive number of driving hours and failing to provide sufficient training for drivers, who had also to carry out loading and discharging operations.

• Motoring organizations identified driver fatigue and night blindness as the most likely causes of heavy goods vehicle accidents on the major truck routes and blamed part of this on the road authorities for failing to provide suitable service and rest areas.

As is the case in many other information-gathering circumstances, there is often a fairly wide discrepancy between what one is told and what one actually witnesses occurring. In most cases this is not because of any deliberate distortion or lack of veracity on behalf of the interviewee but is rather because of a distortion of what was intended or, conversely, a general exaggeration or distortion of an operational error as its report passes upward through the hierarchy.

The author was fortunately made aware of this at the early stages of his investigation when he chanced to ask the operations room staff of a large chemical plant for an extra copy of their tanker accident telephone report form, one of which he had recently received from the plant's loss-prevention manager. Not one member of staff had ever heard of such a form, let alone knew where to get one.

In view of this rather unsettling experience, it was decided to reassess each of the areas previously identified from the viewpoint of the lowest echelons in the problem chain, in particular, drivers and firemen.

In order to gain an insight into the difficulties that the average truck driver has to contend with on long-haul trips, one must actually experience some trips as a passenger in the cab. The requests made to haulage companies for such passages were viewed with the greatest suspicion, and where such a trip was authorized the company invariably dictated which vehicle was to be used and when the trip would be made. Not surprisingly, the drivers involved then turned out to be the company's best and their vehicle-hauling and driving techniques were of the highest order.

In spite of this, such trips proved to be highly educational in other ways. Fatigue was particularly noticeable after only 6 hr on the road, even when the driver had kept religiously to the company's requirement of a 10-min stop every 2 hr. Roadside facilities on these long hauls were almost nonexistent and parking for heavy trucks was rarely provided, let alone secure areas to prevent tampering and theft.

On one occasion a tanker was overloaded, partly because the product was of a higher specific gravity than those usually carried but mainly because the tank barrel was filled to the top, not leaving the slightest amount of ullage to allow for product expansion. The driver had no conception of the potential dangers of this situation and paid scant regard to the weighbridge certificate clearly indicating that four of his rig's five axles were some 20 percent overloaded. It further transpired that all he knew about the product he carried (toluol) was that is smelled funny. This later failing was, and no doubt still is, very common. When the effect of this was added to the almost equally common one of the listing by consignors of products to be carried in the vaguest of terms--thinners, cleaning agent, etching solution, and so on--it is no wonder that product identification was so difficult to achieve.

Problems of a different nature were experienced by firemen. Most chief fire officers are quick to point out that a fireman's job is to fight fires. All other activities that he is called upon to do are secondary to this and thus enjoy a lower priority in training and equipment provision. Fortunately not all fire chiefs rigidly apply this view in practice but some undoubtedly assign hazardous materials preparedness to a level equivalent to freeing people from stuck elevators. A major effort by the National Fire Protection Association in 1978 to promote hazardous materials preparedness resulted in the running of additional courses because of such a high demand. It was apparent, though, from talking to the average fireman that little, if any, of the information received by the senior personnel who attended these courses was ever disseminated to those who would ultimately have to use it. This situation was particularly acute in the smaller municipalities that relied on a volunteer force and a one-man fire-traffic-ambulance chief.

OVERSEAS EXPERIENCE

The development of international trade and communications has virtually ensured that few problems in transportation or related matters are unique to any one country. A literature survey of international research, publications, and symposia produced a surprising number of references covering every conceivable aspect of hazardous materials transportation, from risk assessment to product training and routing requirements to bursting-disc design. A number of periodicals [Hazardous Cargo Bulletin (Intapress Publishing Limited, London) and Hazardous Materials Intelligence Report (World Information Systems, Cambridge, Mass.] on the subject were subscribed to in order to keep up to date with developments in national and international legislation, new technologies, and details of major hazardous materials incidents.

Funds were provided in 1980 for the author to undertake a 3-week study tour to the United Kingdom, Holland, and the United States in order to discuss as many of these subjects as possible with those who had a first-hand knowledge of them. Twenty-one organizations were visited, including government departments, hazardous materials training centers, chemical associations, tanker manufacturers, fire services, response organizations, and enforcement agencies.

Apart from the basic information gained during these visits (1), it was apparent that Europe and the United States viewed the subject of hazardous materials safety far more seriously than South Africa did, and measures were in force there that South Africa had not even considered. The two most notable ones were some form of routing requirement to keep vehicles carrying hazardous materials out of tunnels and away from other damage-sensitive areas

and the provision of an all-hours phone-in information service for the identification of hazardous substances and their various properties. Most of these services were operated on a manual Cardex-type system but were gradually being replaced by computer data bases.

Other aspects that were noted were the status that the truck driving profession enjoys and the restrictive nature of much of the hazardous materials legislation. The former is something that does not apply in South Africa but would undoubtedly have had an impact on overall road safety if it did. The latter has led to friction between the industry and the authorities because of additional costs and administration, much of which has arisen from the less safety-critical aspects of the legislation. This friction was something that South Africa had to avoid if at all possible, an aim that called for maximum consultation during all stages of regulation formulation.

CRITICAL ISSUES

Once a mass of information on the various aspects of incident prevention had been obtained, the next step was to collate it under a limited number of prioritized headings. Titles for the headings were relatively easy to select from the subject matter discussed but placing them in order of priority required careful consideration. The position of an issue on such a list could vary considerably depending on the qualifying requirements--the potentially most critical, the actually most critical, the most easily remedied, or the most cost-effectively remedied, to cite but a few. After the matter had been discussed with interested parties, it was decided to opt for an order based on actual criticality tempered to a certain extent by the potential for remedy. The six issues identified are discussed in the following paragraphs.

Driver Selection and Training

The driver of a vehicle carrying hazardous cargo has potentially the greatest influence on the safety of its journey from collection to delivery. He is often intimately involved with the loading and securing of the cargo at the start of the journey and the unloading or discharge at the end. During the journey he alone is responsible for the safe handling and security of his cargo and, in the case of an emergency, he is often the only person available to initiate any immediate corrective action. In order for a driver to be in a position to accept these responsibilities realistically it is essential that he fully comprehend what is required of him and have the knowledge and ability to carry it out. This necessitates that he be properly selected and thoroughly trained and that his performance be regularly monitored.

The selection process should include license and health checks as well as psychological suitability, and the training must cover vehicle and product handling as well as accident procedures and the use of emergency equipment.

Placarding

One of the commonest causes of delays and inappropriate action in dealing with hazardous materials incidents was the inability to determine the product involved and its major hazard. A compulsory placarding system would solve this. Because of the international movement of bulk loads and International Organization for Standardization (ISO) containers, it is essential that any such placarding system be in line with international practice, which in effect means that it must utilize the international hazard pictogram and the United Nations product number.

The final cost of a hazardous materials incident in damage and lives is often directly dependent on what remedial action is taken during the first 20 to 30 min after an accident occurs. A placarding system that offers an immediate action guide, such as the U.K. HAZCHEM system, which displays an alphanumeric code indicating fire-fighting medium, protective clothing requirements, and dispersal guide, can be highly beneficial in this respect and its adoption was thus recommended.

Emergency Response and Information

Once an incident involving hazardous materials has occurred, its impact and consequential effects are largely in the hands of the emergency services who are called upon to deal with it. If the situation is handled in the correct way with speed and professionalism, the effects will be minimal. A haphazard approach and inappropriate treatment may well be worse than a do-nothing approach and, worse still, may actually add to the eventual cost in terms of both lives and property. It is therefore essential that emergency service personnel be suitably trained and properly equipped to deal with such incidents. This in turn necessitates a national standard for hazardous materials preparedness, including contingency planning, and a full-time information center in order to assist these personnel with product identification and hazard information. The standard should be produced by the services themselves but its use encouraged by cash grants from central government for those who implement it. The information center would be best developed by the chemical and oil industries, as is the practice overseas, but operated primarily for the benefit of the emergency services.

Reporting

A prerequisite for assessing the benefit from any new controlling measure, or indeed identifying the requirement for such a need in the first place, is to have access to sufficient incident data to enable comparisons to be made or problem areas to be identified. In South Africa, some data on hazardous materials incidents existed in the form of certain company records, which were not generally available for scrutiny by those outside the company. Most major companies maintain such records as a part of their loss-prevention schemes, but because they varied considerably in both content and detail, they were not suitable as a data source in their current form.

Some standardized form of incident reporting was therefore necessary if accurate evaluation was to be made of the current situation and the effectiveness of controlling measures was to be monitored.

Routing

It was apparent from overseas case studies that the potential for a major disaster resulting from a hazardous materials incident depended largely on the environment in which it occurred. Apart from the obvious assessment that urban areas are more susceptible to disasters than rural ones, there are many

other environmental factors that can affect the outcome of an incident. The proximity of a reservoir or watercourse to the site of a spillage can result in extensive pollution damage and require a full-scale cleanup operation. Dockyards, warehouses, and chemical plants are other areas where a relatively minor incident can develop into a major catastrophe. The time of day and traffic density can determine the number of people placed at risk and adversely affect the time taken for the emergency services to arrive on the scene. This is particularly so during urban rush hours when roads and sidewalks are filled to capacity. It was therefore considered that some form of routing requirement was needed to deny unnecessary access by vehicles carrying hazardous materials to damage-sensitive areas and to encourage the use of preselected routes that would be afforded maximum emergency cover. It was appreciated that such a scheme would require the full operation of the municipal authorities, who would have to consult fire and traffic departments, civil defense, ambulance services, municipal engineers, and local transporters in order to formulate an effective through-route system.

Hardware Specification

A vehicle carrying hazardous cargo should be inherently safe and maintained to the highest standards. This is only enforceable if such standards exist in the first place. Containers for hazardous substances must be able to contain them securely without loss during routine handling and distribution. Furthermore they should be sufficiently robust and protected to withstand moderate impacts and the effects of adverse weather without loss of or damage to contents.

In the case of a tanker or tank-trailer this requires that the vessel be protected against the effects of a rollover or side impact. This protection must extend to pipework and valves if the unit as a whole is to retain its integrity in an accident. Foot valves and shear sections to protect against pipework damage, sidewall cladding for rollover and impact protection, and valve chests and manhole guards to prevent these items from being torn off are but a few examples of what should be considered. Tank containers whose contents are under pressure or are subjected to pressure during loading or unloading are required to undergo periodic inspections. Atmospheric tanks used for hazardous materials are not liable to these inspections, which would appear to be a considerable oversight on the part of the authorities.

Casual observation indicated that a large percentage, if not the majority, of road-transported hazardous materials was carried in containers other than tanks. Drums holding 220 L, cylinders, sacks, and cartons were all being used for a variety of hazardous goods, but few were manufactured to any approved specification for the task they were expected to perform.

LEGISLATIVE PROGRESS

As a result of recommendations made by the NITRR (2), the Department of Health published proposed regulations under its Hazardous Substances Act that would require operators of road tankers transporting certain listed substances to select and train their drivers, placard their vehicles, provide product information, and report any hazardous materials incidents. The proposals were extensively commented on by all sectors involved, but virtually nothing had been changed when the final version was published in January 1985 (3) with an effective date of July 1985. The industry has major problems in complying with the regulations, and the NITRR is currently engaged in formulating guidelines on how the requirements should be met. This involves everything from producing a standard format for product information sheets based on the European TREMCARDS to assisting the Road Transport Industry's Training Board in formulating guidelines and curricula for suitable driver training.

Forged and stolen licenses will soon be a thing of the past because motorists will shortly be required to carry a separate personalized driving license whenever they drive a vehicle. The license system has also been amended to include a separate class for articulated vehicles, and testing centers will be required in future to test applicants in accordance with the standard driving test developed by the NITRR.

OTHER DEVELOPMENTS

The lack of a central emergency information source was rectified early in 1985 by the formation of the Chemical Emergency Information Centre (CHEMIC), which utilizes the British CHEMDATA database and is operated by the Johannesburg City Fire Department. Although CHEMIC is now operational, considerable effort still needs to be expended on training the system operators and modifying the software to include local South African information.

The situation with regard to the transportation of flammable liquids, by far the most commonly carried hazardous material, markedly improved with the introduction by the South African Bureau of Standards (SABS) of a specification for flammable liquid road tankers (4) and a code of practice for their operation and maintenance. Although the specification allows for a compartment capacity of 6500 L and a total tank load up to permissible axle loading--in practice a capacity of 36 000 L--not all municipalities have accepted these values yet and the United Municipal Executive has been asked to rectify this.

Other recent SABS publications that are potentially beneficial in hazardous materials transportation, particularly in drum traffic, are a code of practice for cargo securement (5) and specifications for tight and loose head drums. It is hoped that traffic officers and transport inspectors will utilize the securement code during roadside inspections.

THE FUTURE

Research involvement will have to continue if current measures are to be amended to be made more effective in the light of experience and new controls are to be introduced where the need is identified. The reporting required under the new regulations and the inquiry log from CHEMIC will be valuable tools in this monitoring process and this information must be fully utilized. The practicalities of introducing a routing requirement for hazardous materials cargos will have to be investigated and active support sought for its introduction. The protection of South Africa's water resources and the increase in urban terrorism should give this task a much higher priority than it has been given to date.

The need for equipment standards is well recognized, but because the publication of a number of SABS standards has already covered some issues, it is accepted that this process will continue. With permanent NITRR representation on such future SABS technical committees, there exists a direct link be-

tween research recommendations and the subsequent commercial standards, which is beneficial to all. Such standards or codes of practice can then be referred to as requirements by other regulations or permit conditions as being the industry standards.

Whether such steps will prevent South Africa from experiencing a major hazardous materials disaster only time will tell. In the meantime the situation must not be allowed to become static and the industry must be encouraged to review its own procedures and propose changes or improvements to existing controls.

CONCLUSIONS

It is highly unlikely that recent developments in improving the safety of the road transportation of hazardous materials would have occurred without the research effort of the NITRR, both pure and applied. That there is still far to go is quite apparent, but that is more a result of bureaucratic lethargy than any shortfall in knowledge or capability. Undoubtedly the greatest achievement of the project has been to increase the awareness of all those with a potential involvement in minimizing hazardous materials incidents of what the problems are and what current solutions are available. Provided this awareness continues to grow, the inevitable feedback of ideas and criticisms will, if acted upon, continue to improve the safety of what has now become a relatively safe operation.

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