Inquiry into a Pollution Incident Involving Toluene Diisocyanate

Report and Recommendations
of the
Environmental Protection Authority

Environmental Protection Authority
Perth, Western Australia
Bulletin 401 August 1989

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SUMMARY

On 11 May 1989, a derailment on the east-west railway line on the Nullabor Plain led to the leakage of almost eight tonnes of a dangerous good, toluene diisocyanate. The Minster for Environment commissioned the Environmental Protection Authority to establish an inquiry into the incident, and the response to the incident, to determine the extent of the resultant pollution, and to determine what lessons could be learnt, to ensure better management of toluene diisocyanate and better response in the future.

Isocyanates are not "cyanides", but their chemical and physical properties demand that special precautions be taken in their transport storage and handling. The Authority was also aware that the type of container involved in the incident was the same as that used for transporting sodium cyanide solution in Western Australia. This matter was of particular concern to the Authority.

The inquiry established that the container itself was not damaged in the incident. A frame surrounding the tank took the brunt of the forces experienced. The damaged frame in turn damaged a piping arrangement fitted to the tank. The pipe sheared at the point of entry to the tank, allowing product to escape. It is likely that if the piping arrangement had not been fitted, no leakage of toluene diisocyanate would have occurred. The piping had been fitted to the tank after the tank had been certified safe by an independent agency, Bureau Veritas. A less independent certification system subsequently decided that the piping was safe. The Environmental Protection Authority has made recommendations for improvement of certification procedures.

The tank containers used for the transport of sodium cyanide solution in Western Australia do not have any protruding external fittings. It is therefore reasonable to assume that should a sodium cyanide container have been involved in a similar incident, no sodium cyanide would have spilt.

The Authority considers that the short term pollution resulting from this incident was very significant, and would have been very dangerous if it had occurred in a populated area. Given the stable nature of the breakdown products of toluene diisocyanate after decontamination, and the remote location, long term pollution is not likely to result.

There was a disregard for standard safety procedures in the handling of this dangerous material. The consignor and the loader failed to notify the truck driver in New South Wales that he carried dangerous goods. The prime contractor did not provide a shipping document. The transport subcontractor did not provide notification of the toluene diisocyanate to the railway system in New South Wales. The New South Wales State Rail Authority and Australian National Railways did not check wagon loads against consignment notes. The normal procedure of "carding" rail wagons was ignored.

The Authority found that emergency response times were much longer than they should have been. The causes of the delays included lack of information about dangerous goods on the train (the documentation requirements of the Australian Dangerous Goods Code were not met), lack of awareness of the Western Australian based emergency response scheme by Australian National Railways, communication difficulties brought about by the derailment itself (railway telephone lines were brought down), the "crash" of the Telecom computer in Perth on the day following the incident, and extremely poor radio communication reception in the area in which the incident occurred.

The nature of the health risk at the crash site was not realised until at least six hours after the derailment, and after many men had been exposed to chemical fumes. Decontamination procedures did not begin until one and a half days after the derailment.

The Authority has made a number of recommendations on the certification and marking of tank containers, and on emergency response requirements.

1. INTRODUCTION

On 11 May 1989 an Australian National Railways train derailed on the interstate rail system 48 kilometres west of Forrest. Forrest is a siding on the east-west rail line, approximately 85 kilometres west of the Western Australian - South Australian border. The derailment resulted in the spill of a hazardous material called toluene diisocyanate. Twenty seven men suffered short-term medical disorders due to exposure to the chemical, having been in close vicinity to the spill. These included Australian National Railways (Australian National) employees and Telecom employees. The Telecom employees were working on the installation of an optic fibre communications network near the derailment site, and at the request of Australian National, they came to the assistance of Australian National employees.

Following the incident, the Minister for Environment and Transport Mr R Pearce requested a report on the environmental effects of the incident from the Environmental Protection Authority. The Authority subsequently established an inquiry into the incident. Senior representatives of Westrail and the Mines Department were invited to assist in the inquiry because of their specific experience and expertise in the management of the transport of dangerous goods by rail and road respectively.

1.1 ENVIRONMENTAL PROTECTION ACT 1986

The inquiry has been instigated by the Environmental Protection Authority, in accordance with its functions, as detailed in Section 16 of the Environmental Protection Act 1986. These functions include:

"S16 (b) To consider and initiate means of protecting the environment and means of preventing, controlling and abating pollution.

16 (c) To encourage and carry out studies, investigations and research into the problems of environmental protection and the prevention, control and abatement of pollution.

16 (d) To obtain advice of persons having special knowledge, experience or responsibility in regard to environmental protection and the preventions, control and abatement of pollution.

16 (e) To advise the Minister on environmental matters generally and on any matter which he may refer to it for advice including the environmental protection aspects of any proposal, and on the evaluation of information relating thereto".

1.2 OBJECTIVES OF THE INQUIRY

The inquiry was established by the Authority to investigate the cause(s) of the incident, the effectiveness of the response(s) to the incident, and to make recommendations with a view to improving the management of toluene diisocyanate in Western Australia.

The Authority adopted the approach that its recommendations are to be implementable by relevant agencies and private companies, with a positive outlook towards future management of toluene diisocyanate.

1.3 CONDUCT OF THE INQUIRY

The Environmental Protection Authority appointed Dr Bruce Kennedy, Manager Industrial Development, EPA, to conduct the inquiry. Dr Kennedy was assisted by Mr Neil Hammer, Scientific Services Manager, Westrail; and Mr John Hanley, Senior Inspector, Explosives and Dangerous Goods Division, Mines Department. Mr Stuart Smith, of the Environmental Protection Authority, provided a valuable support function to the inquiry panel.

Terms of reference for the inquiry were developed by the Authority, and are presented in Appendix 1. The first meeting of the panel was convened on 23 June. This meeting identified the organisations to be invited to make submissions to the inquiry, which included those involved with; the incident, the transport and storage of toluene diisocyanate, the regulation of the transport and storage of toluene diisocyanate, and the management of emergency response to hazardous materials spills.

On 27 June relevant organisations were invited to make written submissions by 10 July. These organisations are listed in Appendix 2.

Oral submissions were invited from those who wished to make them. The object of inviting oral submissions was to clarify information presented in written submissions, and to gain further information required by the panel but not provided in the written submissions. Oral submissions were received by the panel between 14 July and 4 August. Those organisations which made oral submissions are listed in Appendix 3. Chemtrans, and the Plastics Institute of Australia (representing a number of companies) saw fit to send company personnel to Perth from Sydney. The panel also inspected the operations of Foamlite Australia in Jandakot.

2. TOLUENE DIISOCYANATE

The main use for toluene diisocyanate is in the manufacture of polyurethane foams, which are used for mattresses, furniture and insulation purposes. Other uses include the manufacture of surface coatings and elastomers.

Toluene diisocyanate is most commonly available, and used throughout Australia as an 80:20 mixture of 2,4-toluene diisocyanate and and 2,6-toluene diisocyanate. Chemical and physical properties and toxicological data for toluene diisocyanate are presented in Appendix 4.

2.1 QUANTITIES AND MOVEMENT OF TOLUENE DIISOCYANATE IN WESTERN AUSTRALIA

Toluene diisocyanate is not manufactured in Australia, and all supplies are imported from overseas. Toluene diisocyanate is shipped into Australia in bulk tank containers, or in 200 litre packages (drums) in sea freight containers. The latter mode is the most common into Fremantle. In addition, toluene diisocyanate is also transported from the Eastern States via the interstate rail system in bulk tank containers. 750-800 tonnes of toluene diisocyanate is imported into Western Australia annually.

Transport of toluene diisocyanate from the Kewdale rail terminal and the Port of Fremantle to users is by road. The Plastics Institute of Australia provided information to the inquiry about the routes which have been specified by the industry for this transport. In so far as possible, the routes chosen favour major highways and avoid built up areas and environmentally sensitive areas. The panel considered that all routes were adequate. However, the route from Chemtrans in South Guildford to Foamlite could be improved by taking the Great Eastern Highway bypass east to Roe Highway, thence to Leach Highway, rather than going south on Great Eastern Highway.

There is an increasing trend away from 200 litre drums of toluene diisocyanate to bulk containers, because of greater occupational health and safety benefits. Bulk toluene diisocyanate is transferred to storage facilities using standard non-leak couplings on hoses, and vapour return lines, to ensure that no operators are exposed to toluene diisocyanate.

2.2 INCIDENTS INVOLVING TOLUENE DIISOCYANATE

2.2.1 LOCAL

In Western Australia there have been two previous recorded incidents involving toluene diisocyanate. The first in November 1985 occurred at Foamlite Australia Ltd, Jandakot. The cause of this incident was an inoperative safety valve at the top of a storage tank, which caused the top of the tank to rupture with the loss of approximately 600 litres of toluene diisocyanate. The spill was neutralised with decontaminant present on-site.

The other incident occurred in November 1988, at Vita Pacific in Canning Vale. Spillage was caused by a broken flow meter at the control panel of the plant's foam machine and a broken sight glass. The spill occurred during the night and approximately 700 litres of toluene diisocyanate was lost.

The spill was neutralised with decontaminant located at Vita Pacific, other foam manufacturers and BASF Australia Limited (a supplier of toluene diisocyanate). During this incident nearby factories were evacuated.

Foam manufacturers within Western Australia as in other states have instigated a "self-help" group to maintain and improve the safety of handling toluene diisocyanate. The group meets regularly and invites relevant government agencies to participate.

2.2.2 INTERSTATE

Government agencies throughout Australia involved in the regulation and management of dangerous goods were contacted to determine if spills of toluene diisocyanate had occurred in the past. New South Wales reported one incident involving a leaking 200 litre drum of toluene diisocyanate. The inquiry was informed that this incident posed no significant environmental or health problems.

The only major incident recorded occurred in May 1982 on the Barton Highway Bridge over Ginniderra Creek, on the outskirts of Canberra, Australian Capital Territory. The spill occurred in an accident in which a semi-trailer had jack-knifed and caught fire. After recovery it was ascertained the load consisted of:

12 x 200 litre drums of toluene diisocyanate;

12 bags of chlorinated paraffin wax; and

2 x 200 litre drums of triethylene glycol.

It was estimated that approximately 1200 litres of toluene diisocyanate was lost.

Nine people were affected through inhalation and four were admitted to hospital. Most of the Fire Brigade officers involved in combating the fire suffered eye irritation.

The vehicle involved in the incident was not marked with dangerous goods class labels as required by the Australian Dangerous Goods Code. At the time of the incident the Australian Capital Territory did not have any legislation governing the transport of dangerous goods. The incident is currently subject to court action.

2.2.3 OVERSEAS

Agencies associated with the regulation and management of dangerous goods in the United Kingdom, Canada and United States of America (USA) were contacted to determine if they had records of any toluene diisocyanate spills. Information was received from the Hazardous Materials Advisory Council, Washington DC, USA.

Seventeen rail incidents, involving spills of toluene diisocyanate have been recorded in the United States since 1984, of which two were derailments. No injuries or deaths arose from the incidents however, substantial costs were incurred (1987 US $1,500,000) as a result of one spill of toluene diisocyanate.

3. REGULATORY REQUIREMENTS AFFECTING THE TRANSPORT OF TOLUENE DIISOCYNATE

3.1 STATUTORY PROVISIONS GOVERNING THE TRANSPORT AND MANAGEMENT OF DANGEROUS GOODS IN WESTERN AUSTRALIA

3.1.1 SEA

Conveyance of dangerous goods by sea is controlled by the Federal Department of Transport and Communications. Federal legislation in this area adopts the provisions of the International Maritime Dangerous Goods Code issued by the International Maritime Organisation (IMO). The handling of dangerous goods within ports in Western Australia is usually the province of a specific port authority or the Department of Marine and Harbours, where no specific authority exists.

3.1.2 AIR

All carriage of dangerous goods by air is controlled under the Federal Air Navigation Regulations administered by the Civil Aviation Authority. The legislation adopts the requirements of the International Civil Aviation Organisation and the Technical Instructions issued by that Organisation.

3.1.3 RAIL

Through its affiliation with Railways of Australia, the Western Australian Government Railways Commission (Westrail) adopts the "Railways of Australia

Code of Practice for the Transport of Dangerous Goods". This is in fact the "Australian Code of Practice for the Transport of Dangerous Goods by Road and Rail, published as the Commonwealth of Australia Gazette No P15 April 1987. This code is also referred to as the Australian Dangerous Goods Code. Westrail is the competent authority for its own rail system in Western Australia. The Australian Dangerous Goods Code embraces all dangerous goods as classified in the Code and by reference, the conveyance of radioactive substances, which are included in the Code of Practice for the Safe Transport of Radioactive Substances and Guidelines to that Code, prepared pursuant to the provisions of the (Commonwealth) Environmental Protection (Nuclear Codes) Act 1978. Class 1 explosives are dealt with in a similar manner, by reference to the Explosives Regulations 1963. Westrail adopts the Australian Dangerous Goods Code through its own enabling legislation, The Railways Act 1904 (as amended).

The Australian National Railways Commission also picks up the Australian Dangerous Goods Code. Australian National are principally centred in South Australia (and Tasmania). Their mainland rail system extends from Broken Hill in New South Wales to Parkeston (just east of Kalgoorlie) in Western Australia.

Private railways operated by mining companies in the north of the State are controlled under the Mines Regulation Act 1946 and the Mines Regulations. As the railways are constructed principally for the conveyance of ore, there is almost no transportation of dangerous goods over the lines. Bulk conveyance of diesel fuel occurs, but this substance is not dangerous goods for the purpose of transport.

3.1.4 ROAD

Conveyance of dangerous goods by road is controlled by the Dangerous Goods (Road Transport) Regulations 1983 made under the Explosives and Dangerous Goods Act 1961. These Regulations are administered by the Explosives and Dangerous Goods Division of the Department of Mines. The Regulations adopt the provisions of the Australian Dangerous Goods Code for all dangerous goods classes 2 through 9. Class 1 explosives are dealt with under the Explosives Regulations 1963. The Dangerous Goods (Road Transport) Regulations are independent of the Australian Dangerous Goods Code, however some standards and codes of practice referred to in the regulations are the same as those in the Code. The Explosives and Dangerous Goods Division is the designated competent authority for road transport in Western Australia.

3.2 CERTIFICATION REQUIREMENTS FOR DANGEROUS GOODS PACKAGES AND CONTAINERS

The Australian Dangerous Goods Code deals with the conveyance of dangerous goods in packages and in bulk. The distinction between packages and bulk is determined by the capacity of the container, or in the case of solid dangerous goods, the presence of those goods in a container in a specified undivided quantity.

Packages for dangerous goods must, generally, be approved for that purpose by competent authorities listed in the Australian Dangerous Goods Code. Dependent upon the packaging group of the substance, some minor quantities are not required to be packed in approved containers.

All bulk containers for dangerous goods are required to be approved.

Bulk containers may be approved by any of the competent authorities listed in the Australian Dangerous Goods Code, or by virtue of their compliance with the requirements of the European Agreements Concerning the Carriage of Dangerous Goods by Rail (RID) or the International Maritime Organisation (IMO). These agreements provide for testing and inspection agencies, such as Bureau Veritas, to certify tank containers. Portable tanks, and tank containers with these IMO/RID approvals may be transported from the point of import into Australia, to point of discharge, then forwarded to the port for export. In addition, competent authorities for rail require specific information on these containers and their contents, and destination and times of intended movement.

Bulk tank containers which conform to International Maritime Organisation (IMO) requirements for Type 1 containers, and mounted in a protective steel frame which meets International Standards Organisation (ISO) dimensions, are called ISO tank containers, tank containers, ISO containers, or isotainers. They are referred to as tank containers in this Report. The frame is referred to as an ISO-frame.

3.3 PROVISIONS FOR RECIPROCITY BETWEEN COMPETENT AUTHORITIES IN WESTERN AUSTRALIA AND IN OTHER JURISDICTIONS

To assist industry with the application of the Australian Dangerous Goods Code, individual State and Territory competent authorities have established the Australian Code for the Transport of Dangerous Goods Competent Authorities Sub-Committee. Industry can approach the Sub-Committee to obtain approvals, classifications, interpretations, and variance approvals. Individual State and Territory competent authorities which have adopted the Australian Dangerous Goods Code have agreed to accept and apply the decisions of the Competent Authorities Sub-Committee in their jurisdictions. This means that should one competent authority issue an approval for a container, other competent authorities will accept that approval. A competent authority may give an approval for a container which is at variance with the requirements of the Code, for reasons peculiar to the jurisdiction of that competent authority. This does not however compel other competent authorities to accept such an approval. Each competent authority reserves the right to withhold reciprocal approvals should it deem this necessary. This is not done lightly.

3.4 SPECIAL PROVISIONS RELATING TO THE TRANSPORT AND MANAGEMENT OF TOLUENE DIISOCYANATE

Major users of toluene diisocyanate in Western Australia participate in a mutual aid group which deals with emergencies involving the spillage of toluene diisocyanate. This groups assists the State government agencies responsible for combating dangerous goods incidents. A register of emergency contact personnel and response equipment is maintained by the group secretariat. Meetings of the group include representation by emergency services and regulatory authorities.

The companies transporting toluene diisocyanate from the railhead at Kewdale and the Port of Fremantle to users' premises have advised the emergency services and regulatory authorities of routes specified by the industry.

As noted in Section 2.1, the Plastics Institute of Australia advised the inquiry of the specific road routes used, and the panel considered that all routes were adequate although one could be improved.

The management of isocyanates, including toluene diisocyanate has been closely controlled by regulations promulgated in 1977, and enforced by the then Department of Labour and Industry (now the Department of Occupational Health Safety and Welfare). These regulations were superseded by the Occupational Health Safety and Welfare Regulation (1988), which has specific controls for isocyanates.

Isocyanates are controlled because of their flammability and toxicity. The occupational Exposure Standard (Time Weighted Average) has been set at 5 parts per billion in air. This extremely conservative standard has been set to prevent occupationally induced asthma.

The Standards Association of Australia currently has a Draft Australian Standard entitled "The Storage Handling and Transport of Polyfunctional Isocyanates", which is in the final stages of the Standards Association's approval procedures. The Draft Standard deals with hazards, operational and safety considerations and general requirements applicable to the storage, handling and transport of isocyanates, with particular emphasis on toluene diisocyanate. Chemical industry and government agencies have had a major input into the development of the Draft Standard.

In summary, toluene diisocyanate is recognised by industry and regulatory authorities as requiring particular precautions in its transport, storage and handling, because of its toxicity.

4. MANAGEMENT OF EMERGENCY RESPONSE FOR RAIL IN WESTERN AUSTRALIA

Rail transport of dangerous goods in Western Australia is managed principally by Westrail in the southern part of the State, with the Australian National Railways Commission carrying interstate consignments between Kalgoorlie and South Australia. The northern mining companies of Hamersley Iron Pty Ltd, Mt Newman Mining Co Pty Ltd, Goldsworthy Mining Ltd and Robe River Mining Co Pty Ltd are not involved in the transport of dangerous goods.

In order to ensure effective response to incidents involving hazardous materials, one of the basic assumptions is that sooner or later there will be such an incident. Emergency planning and training will limit the effects of such an incident on people and the environment.

4.1 WESTERN AUSTRALIAN TRANSPORT EMERGENCY ASSISTANCE SCHEME

In Western Australia emergency response procedures are set out in the Western Australian Transport Emergency Assistance Scheme. The Scheme is currently being revised (see Section 4.2).

The Scheme outlines the roles and responsibilities of various organisations, and the communications protocols between them, when responding to a chemical incident. The Scheme was developed originally for road transport incidents, but following the Environmental Protection Authority's assessment of the transport of sodium cyanide solution, Westrail have become a party to the Scheme. The Scheme is also used to combat spills at fixed premises.

The basic organisation of the Scheme comprises:

. The control authority, responsible for management of the entire incident (Police);

- the combat authority, responsible for the physical combat of the fire, leak or spill of dangerous goods (WA Fire Brigade); and

- support organisations responsible for the provision of resources and expert advice as needed.

The Australian Dangerous Goods Code provides requirements for correct labelling, placarding and documentation of consignments of dangerous goods. Under accident conditions, this information is the first step in the communication chain leading to timely response and recovery.

4.2 WESTERN AUSTRALIAN HAZARDOUS MATERIALS EMERGENCY MANAGEMENT SCHEME

The Western Australian Transport Emergency Assistance Scheme is currently being revised to take account of emergency management situations which involve substances other than dangerous goods, and non-transport situations. The new scheme is entitled the Western Australian Hazardous Materials Emergency Management Scheme. A simple title or "written logo" which reflects the purpose of the scheme could be considered in order to help promote awareness of the scheme amongst potential future operators. (An example of a "written logo" is "Worksafe Australia", used by the National Occupational Health and Safety Commission.)

As the incident took place when the WA Transport Emergency Assistance Scheme was in place, all references in this Report will be to this Scheme.

4.3 WESTRAIL

4.3.1 PLANNING

In planning for emergencies where rail accidents involve spillage or leakage of dangerous goods, Westrail responds under the WA Transport Emergency Assistance Scheme. Where the situation is beyond the resources of Westrail to stabilise and recover, the assistance of emergency response agencies is called up under the Scheme.

Westrail has emergency procedures which are compatible with the WA Transport Emergency Assistance Scheme. The key features of Westrail planning are:

- regular communication by radio between locomotive crews and Train Control Officers to verify status of trains. Train Controllers also monitor and control the train movements through track section signalling. Locomotive crews carry train manifest documents which identify dangerous goods and their position on the train;

- Area Managers, strategically located throughout the rail system at Forrestfield, Kwinana, Perth, Northam, Geraldton, Merredin, Kalgoorlie, Bunbury and Albany, who are trained to respond and take charge of Westrail operations in emergency conditions;

- support resources from civil and mechanical and electrical engineering units located throughout the rail system;

- expert advice from Engineering and Scientific Services Officers on incident management and recovery; and

. expert internal communications and security along all rail routes to provide continuous contact for timely action from responding organisations. The Train Controllers are the central communications points for all internal and external contacts during the emergency.

4.3.2 TRAINING

To provide this planning, Westrail has a training programme for operational and support personnel. Each staff member is given instruction in basic awareness of dangerous goods including recognition, classification, labelling, handling during transport and emergency procedures. Training reinforcement is provided by Safety Officers who regularly visit all operational areas.

A Westrail Dangerous Goods Committee is active in identifying and resolving operational issues as well as planning for future initiatives in safety and emergency procedures. The Committee is made up of union representatives, management and expert advisers.

4.3.3 RESOURCES

Under general emergency procedures for rail operations, each area has a plan which identifies local resources which may be used in support of the operation to recover the incident.

These resources may take the form of available equipment used in Westrail depots, such as hydraulic jacks, mobile cranes, fork lifts, truck, lighting plants and in some areas, freight containers loaded with a range of emergency rescue equipment and medical supplies. These containers are capable of being quickly transported to the incident site for use by emergency personnel, and are strategically located at Northam, Merredin and Kalgoorlie.

There are also available contacts in each area capable of providing support in the form of mechanical handling and earthmoving equipment, medical facilities and fire fighting personnel. These resources are documented in Westrail's Emergency Procedures Manual which has been widely distributed both within Westrail and to Police, State Emergency Services, Fire Brigades and Shire Councils along rail routes.

4.4 AUSTRALIAN NATIONAL RAILWAYS

Australian National supplied a copy of its Major Train Disaster - Medical Aid Plan and its Dangerous Goods Safe Handling booklet. Both documents outline procedures in the event of a spillage of dangerous goods.

The Medical Aid Plan outlines roles and responsibilities of railway officers, and contacts with outside agencies (eg. Police) in detail, for all areas in which Australian National operates, including Western Australia.

Australian National also has a designated role in the South Australian emergency response system.

5. LOCATION OF INCIDENT SITE

The spill of toluene diisocyanate occurred approximately 48 kilometres west of Forrest which is approximately 85 kilometres west of the Western Australia/South Australia border. Figure 1 illustrates the location of the incident site.

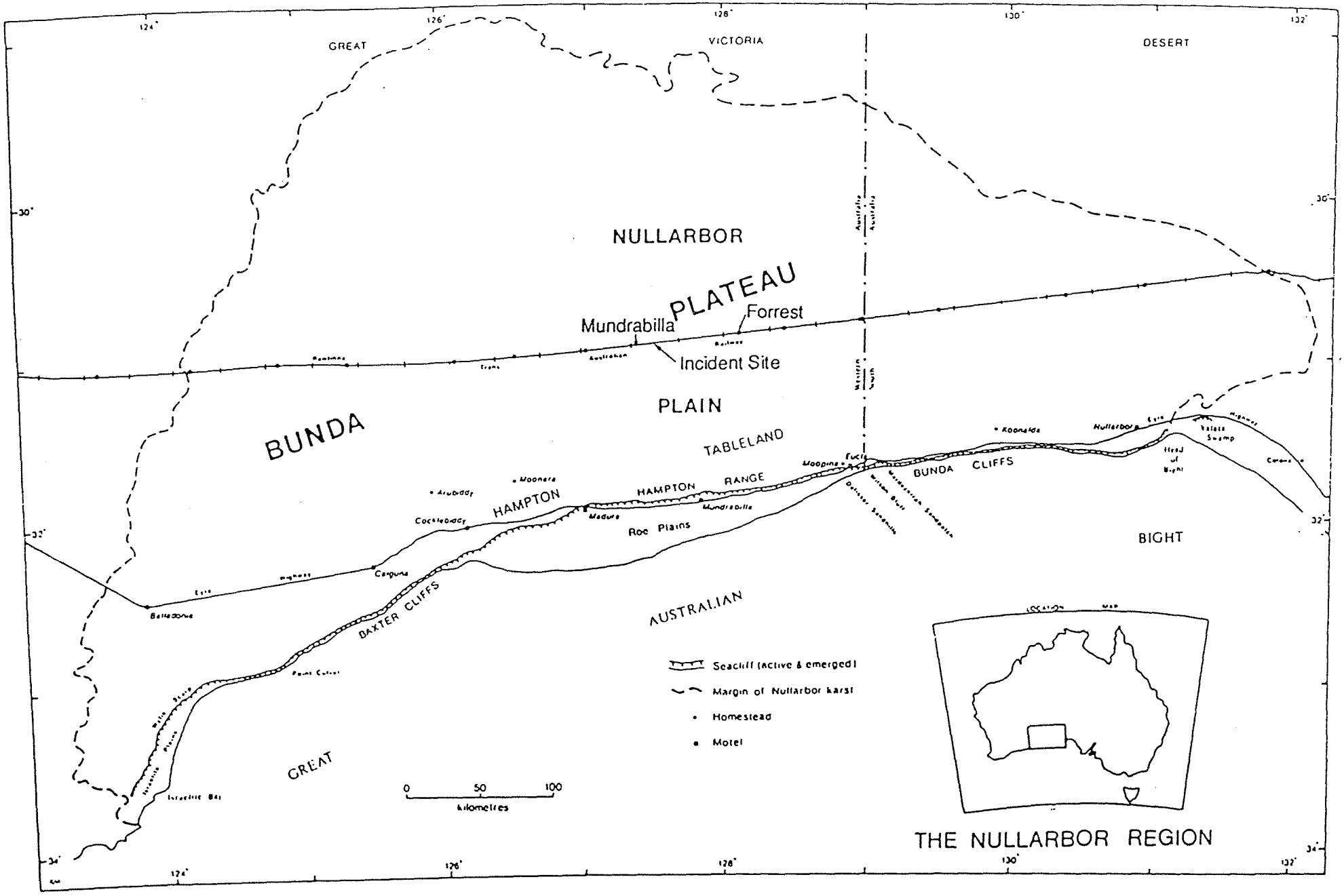

Figure 1: Location Map

5.1 ENVIRONMENTAL STATUS OF AREA NEAR INCIDENT SITE

The site of the incident is on the Nullabor Plain. The soils of the plain are weathered calcerous clay with concretionary calcium carbonate being a characteristic feature. These soils overlay variably weathered limestone. Vegetation of the plain is dominated by low shrubs tolerant to the alkaline soils.

The Australian Speleological Foundation has identified the caves and other features of the region as being of international scientific value in terms of geology, geomorphology, minerology, biology and ecology. These features are also of tourist interest (Australian Speleological Foundation, 1978).

6. INCIDENT

The purpose of this section is to provide a detailed coverage of the events and circumstances which lead to and followed the toluene diisocyanate spill near Forrest on 11 May 1989. The following account has been established by the Authority as a result of written and oral submissions. The accounts of different individuals sometimes varied markedly, and the inquiry sought to clarify discrepancies through questioning during oral submissions (and of other witnesses who did not make formal oral submissions).

There were variations in times quoted for various events. This was not helped by the fact that some organisations were working on Western Standard Time, some on Central West Time (45 minutes ahead of Western Standard Time, and commonly used in the incident area), and others on Central Standard Time or Eastern Standard Time. All times have been corrected to Western Standard Time to present a consistent approach.

The account which follows is sufficient for the purposes of the inquiry. It is not comprehensive, and due to the circumstances noted above, it is unlikely that the narration below will accord in every respect to the recall of all parties. The Authority has every confidence that the account is substantially correct. The Authority has every confidence that the inferences made in later sections are valid.

Monday 8 May

Olin Chemicals Ltd, the owners of toluene diisocyanate stored at Powell Duffryn Terminals Ltd in Matraville (Sydney) New South Wales, contracted with Chemtrans to transport product to Foamlite in Perth. The product was loaded at Powell Duffryn Terminals Ltd into a bulk tank container owned by Chemtrans. Chemtrans sub-contracted ASP Container Express to arrange conveyance of the container to Kewdale. This sub-contract was arranged because Chemtrans was unable to present enough containers for a full wagon load.

On 8 May 1989, bulk tank container ILMU1710027 was loaded with 19.82 tonnes of toluene diisocyanate at Powell Duffryn Terminals Ltd in Matraville. Chemtrans then conveyed the tank container by road to ASP Container Express Ltd at Cooks River rail terminal where it was loaded onto rail wagon VQLX-21. A general freight container was also loaded onto the same wagon.

Thursday 11 May

The derailment which resulted in damage to the container, and the consequent spill took place at approximately 4.30 am on Thursday 11 May, 1989, 48 kilometres west of Forrest. It involved eighteen rail wagons. It was dark at the time, as sunrise occurs at about 5.45 am at that time of the year in the area.

The specific circumstances which led to the derailment of the Australian National train are unknown. None of the submissions received, including that from Australian National, indicated the cause of the derailment. Other sources, however, have indicated that the primary cause was a seized axle bearing which overheated, resulting in fracture of the axle. The axle was not on the wagon carrying toluene diisocyanate.

The wagon carrying the tank container left the track and overturned onto its side, on the north side of the track. The force of this action was sufficient to cause the front twistlock mechanism to fail. (The twistlock mechanism ties the tank container to the wagon.) This resulted in the tank container parting from the wagon. Damage to the tank container indicates that both the wagon and container appear to have skidded along the ground, and the force of this was sufficient to buckle one of the longitudinal beams of the outer frame surrounding the container. When the beam buckled it was forced onto the vapour return pipe located adjacent to the beam, with sufficient force to partially shear the pipe where it joined the container body.

The tank container sustained minor damage to its outer insulation skin and ended up on its side. The container shell itself was undamaged. It was from the break where the vapour return pipe joined the container that the toluene diisocyanate leaked.

Immediately after the derailment, the train crew uncoupled the locomotive, and proceeded west to Mundrabilla, to obtain help.

Telecom employees engaged in installation of the West-East Optic Fibre Project were camped adjacent to the rail track at Mundrabilla, approximately 3 kilometres west of the derailment site. At about 5.00 am the Telecom employees were asked by the Australian National locomotive crew for assistance. They responded and on inspection of the derailment it was evident that 18 wagons were badly damaged and a large section of the track was torn up or blocked. On further investigation it was found that a section of aerial telephone wires had been brought down, isolating the site from the Australian National communications system. At 6.15 am Telecom commenced attempts to re- establish the Australian National train control and Forrest telephone circuits.

The Australian National Roadmaster, who was at Forrest, arrived at the scene at approximately 7.00 am and requested Telecom to provide a bulldozer for the earthmoving operation which would be required for a rail diversion. Six Telecom employees remained at the scene to assist in this task and the remainder returned to their workplaces 3-10 kilometres from the derailment. At this stage the leakage from the container had not been detected.

It is not clear who noticed that the container was leaking. It is also not clear when it was noticed. The submission from Australian National did not go into any details of the incident. It appears that the first indication that a bulk container was on the train was when the Roadmaster advised train control (Port Augusta, SA) at 9.00 am of a liquid spill. Australian National in Adelaide contacted Chemtrans, Perth, at 10.30 am Western Standard Time, informing them of the derailment. This call was a courtesy call only and included a list of wagon numbers. A check of the wagon numbers by Chemtrans from their consignment notes revealed that one of the wagons loaded a full tank container of toluene diisocyanate. They informed Australian National of this and facsimilied an Emergency Procedure Guide for toluene diisocyanate to Australian National in Adelaide and informed them that the site should be evacuated. (An Emergency Procedure Guide is illustrated in Appendix 5.) It was also reported that the contents of the container were "bubbling on the ground like acid".

Chemtrans Perth, in conjunction with Chemtrans Sydney, began to develop incident recovery procedures. The Sydney office faxed a Material Safety Data Sheet to Australian National, and gave advice on toluene diisocyanate recovery procedures, and advised of medical practitioners who could offer specialist advice. Arrangements were made to dispatch decontaminant from Perth and Adelaide to the site.

Chemtrans also made arrangements for emergency response teams from Perth and Sydney to attend the incident site. Both teams made arrangements to arrive in Forrest early the next morning, Friday 12 May (to have left that afternoon would have meant arrival at Forrest after sunset, but the aerodrome at Forrest is not suitable for night-time use).

The first indication to any Western Australian Government agency that a derailment had occurred was when Australian National informed Westrail at 7.00 am that there would be delays to east-west traffic, and that Westrail should plan accordingly. The first indication to any WA Government agency that a chemical spill had occurred was when Chemtrans advised the Explosives and Dangerous Goods Division of the Mines Department of the spill at 12.10 pm. This Division then notified the Emergency Operations Unit of the Police Department at 12.30 pm.

The Police notified the Western Australian Fire Brigade at 2.02 pm. The Fire Brigade immediately informed the Health Department, Environmental Protection Authority and Westrail of the incident. On being informed that Chemtrans, in conjunction with Australian National, had developed a response strategy for the recovery of the spill, each agency decided not to send a representative to the site, but remained on call should further advice or any action be required. Police communications attempted to contact the Eucla Police Station.

At the site a number of Australian National and Telecom workers had early symptoms of exposure to toluene diisocyanate. After midday Australian National contacted the Royal Flying Doctor Service. A medical doctor employed by the Royal Flying Doctor Service arrived at Forrest at about 2 pm. Some employees of Australian National and Telecom exhibited symptoms of toluene diisocyanate exposure such as eye and skin irritation, nausea, headache and shortness of breath. Treatment administered by the doctor included washing of skin and eyes to minimise ongoing skin irritation. Oxygen was also administered to some men.

To establish the likelihood of inhalation effects of toluene diisocyanate, the employees complaining of discomfort were questioned as to whether they had smelt toluene diisocyanate. The level at which toluene diisocyanate odour becomes apparent is higher than the safe worksite exposure level. Fifteen out of the eighteen men could smell the toluene diisocyanate although only seven were affected by eye irritation. Six of the casualties (4 Australian National and 2 Telecom) were evacuated by two Royal Flying Doctor Service aircraft to Kalgoorlie Regional Hospital for observation. They arrived at hospital at 8.00 pm. All were discharged within 24 hours of admission. Telecom advised the inquiry that they were having follow up medical screenings carried out for their employees.

The Police station nearest to the incident site is located at Eucla. The police there were advised of the derailment by Police Communications at 3.00 pm. They were also advised that specialist recovery teams were being despatched to the site and should arrive the following morning. Two officers departed Eucla for the site at 4.45 pm arriving at Forrest at 7.45 pm. One police officer remained at Forrest to control entry to the site whilst the other officer proceeded to the site to investigate and control the situation.

The Police, acting on advice from Chemtrans, declared an area of 2 km radius from the spill as the incident control site, and requested personnel to leave this area. They contacted the Bureau of Meteorology to determine expected wind directions for the next two days, and were advised that winds would be tending westward.

At 11.55 pm, an Australian National derailment crew from Kalgoorlie arrived at the Telecom camp near Mundrabilla. They had not been advised of the chemical spill, and consequently were not equipped to deal with the incident. No attempt was made by this party to deal with the spillage.

Friday 12 May

The Chemtrans recovery team departed Perth Airport at 4.00 am for Forrest and arrived at 7.40 am. Chemtrans liaised with the Police at Forrest and informed them that the team from Sydney was expected to arrive by aeroplane at 9.30 am. The team from Sydney was supplied by a company called SGS Australia Pty Ltd, under contract to Chemtrans. It was decided by the Chemtrans team to await the arrival of the SGS team before approaching the site.

Bad weather in Sydney (and the need to refuel at Whyalla because of bad weather in Adelaide) delayed the SGS team, who did not arrive at Forrest until 1.45 pm. At 2.45 pm both teams arrived at the site and began atmospheric sampling and testing to determine the levels of toluene diisocyanate vapour. By the time the recovery teams arrived at the site, no significant loss of toluene diisocyanate from the tank container was occurring.

Winds throughout the day were north-westerly to north-easterly. At the time of sampling, the winds were northerly. Toluene diisocyanate was detectable in the air in the vicinity of the container and spillage, at levels higher than 20 parts per billion. Readings within 50 metres, especially to the south, were 12 parts per billion. Under these circumstances, the team advised Australian National that the construction of a diversion line (on the southern side of the main track) could not be achieved safely until decontamination had been completed. This advice was given because the threshold limit value for safe occupational exposure has been established at 5 parts per billion.

An estimate was made of up to 10,000 litres of toluene diisocyanate lost. This estimate was based on the facts that the sheared vapour return pipe was centrally located on the top of the tank container (which had a capacity of 21,000 litres), and that the container was lying on its side. The spilt toluene diisocyanate was estimated to cover an area of about 100 square metres. After inspection of the container, it was concluded by the recovery teams that the extensive range of equipment brought with them was not suitable for blocking the leakage. The teams agreed that a wooden plug would be suitable. A plug was fashioned on the spot, the vapour return pipe was cut away, and the plug fitted to the opening.

Decontaminant from Adelaide arrived on site at 5.00 pm. This consisted of six 200 litre drums of an alcohol, water and ammonia mix, and one 20 litre pail of ammonia. Decontamination procedures started at 8.00 pm and were completed by 11.30 pm. The contents of the six 200 litre drums were applied to the spill area and left to react overnight. Further continuous air sampling took place until the readings of toluene diisocyanate at 20-50 metres south (and downwind) of the spill were negligible. Clearance was given to Australian National to complete construction of the diversion line in this area at 1.00 am.

Communications were hampered that day because of the "crash" of the Telecom computer in Perth. This disrupted telephone communications within the State and interstate.

Saturday 13 May

At 8.45 am the recovery teams returned to the site. At 9.00 am water was discharged onto the spill area and 5 litres of ammonia was added to speed any decontamination reaction. A small volume of ammonia was sprayed onto the container itself to decompose any toluene diisocyanate which may have deposited onto its surface. The tank container was then moved by Australian National crews to a point approximately 100 metres from the derailment site. It was placed in an upright position to facilitate reloading for onward transport to Parkeston.

Copious amounts of a dilute ammonia solution were pumped onto the tank container at 1 hour intervals throughout the afternoon. Part of the container insulation was removed. Neutralised toluene diisocyanate and decontaminant washings were removed from the area and buried nearby.

The diversion line was completed during the day.

At 12.30 pm Chemtrans advised the Police that the site was safe. Australian National positioned a flat top wagon to reload the container, but the reloading could not proceed because Chemtrans advised that lifting could not be achieved safely. Australian National removed the wagon involved in this unsuccessful operation because of train movements on the diversion track. During the night a train travelling on the diversion track derailed.

Monday 15 May

At 12.30 am Australian National were successful in rerailing the train which had derailed from the diversion, and put the damaged tank container on a wagon which was then transported by rail to Parkeston near Kalgoorlie. The container remained at Parkeston until consultations with Western Australian Government agencies on an acceptable means of transport from Parkeston to Perth were finalised.

Monday 22 May

A meeting was convened by Westrail to determine an acceptable means of transporting the remaining toluene diisocyanate to Perth. Westrail, Mines Department, the Environmental Protection Authority and Chemtrans were represented. It was decided that the damaged container was to remain at Parkeston until a second, undamaged container became available. The contents of the damaged tank were to be transferred to the second container and transported to Perth by Westrail. The emptied damaged container would be returned to Sydney. Chemtrans advised that the contents of the container had partly solidified owing to the low temperatures prevailing, and would require reheating.

Thursday 24 May

A second meeting was convened at the Department of Mines, with representatives from Chemtrans, Department of Mines and the EPA. At this meeting Chemtrans were requested to submit a procedure in writing, detailing their proposal. It was proposed by Chemtrans to heat the contents of the container on-site at Parkeston using mobile steam generators. Toluene diisocyanate would then be transferred from the damaged container to the second container, which would be railed to Perth. This proposal was found to be acceptable by the EPA and Mines Department on 25 May.

Monday 29 May to Thursday 8 June

On Monday 29 May equipment required for the transfer, which included a suitable pump, hoses and decontaminant were sent by Chemtrans to Kalgoorlie. On further inspection it was found that would not require heating for transfer. On Sunday 4 June the transfer was effected and on Monday 5 June the second tank container was consigned to Robbs Jetty by Westrail.

Westrail had previously determined that the transport of the tank container containing the remaining toluene diisocyanate could be undertaken safely in this instance, even though it had an air space above the liquid inside the tank ("ullage") greater than the maximum normally permitted. On Tuesday 6 June the damaged container was consigned to Chullora, NSW.

On arrival of the partly filled container at Robbs Jetty on Thursday 8 June Westrail contacted Chemtrans, who in turn requested that the toluene diisocyanate be conveyed to Kewdale Terminal. Chemtrans then conveyed the container from Kewdale to their premises in South Guildford, where the contents were reheated, sampled and tested prior to delivery to Foamlite Australia Ltd. The quantity delivered into storage at Foamlite was 11.86 tonnes. Given a total original payload of 19.82 tonnes, the quantity lost amounted to 7.96 tonnes, or approximately 6500 litres.

7. ANALYSIS OF INCIDENT

The purpose of this section is to analyse the sequence of events, draw conclusions and make implementable recommendations to reduce the probability of such an incident recurring.

7.1 CAUSE OF THE SPILL

The fundamental cause of the spill was the derailment. It is likely that no leakage of toluene diisocyanate would have occurred, but for the modification made to the tank container for loading and discharge operations. The pipework for the modifications was levered by the damaged frame surrounding the tank, so that it fractured at the point of entry to the tank, allowing leakage.

Chemtrans considered that a further contributing factor was that the front twistlock mechanisms, which hold the tank container to the rail wagon, failed. The tank container came into contact with the ground, and built up a pile of earth in front of it as it was propelled forward after derailing. Chemtrans considered that this caused the frame to distort, and thereby led to the impact on the pipework. Whilst a similar scenario could have occurred even if the twistlocks had not failed, it would appear that Chemtrans' proposition has merit. The twistlocks were designed to meet the international criterion of withstanding forces of up to 2G (ie. twice the force of gravity). It is relevant to note that for the transport of sodium cyanide solution in Western Australia, Westrail required a design criterion of 4G for twistlocks, which has been implemented.

In summary, if the frame had not bent, there would have been no effect on the extra pipework. As the frame did distort, it did affect the pipework, causing the leak. If the pipework had not been on the tank container during transport, no leakage would have occurred. The tank container itself remained intact, apart from some damaged insulation.

7.2 ENVIRONMENTAL EFFECTS OF THE SPILL

The incident resulted in the loss of 6500 litres of toluene diisocyanate onto the ground, just north of the rail tracks. The toluene diisocyanate covered approximately 100 square metres. Toluene diisocyanate vapours were evolved, and significant concentrations were recorded in close proximity to the container (above 20 parts per billion), and at 50 metres south of the container (12 parts per billion). Exposure to these levels of toluene diisocyanate is potentially harmful to human health (the Occupational Exposure Standard (Time Weighted Average) has been set at 5 parts per billion).

Some people at the site noted that the toluene diisocyanate "was bubbling on the ground like acid". This could have been due to reaction with water in the soil, or to the chemical escaping from the tank container. The latter explanation was ruled out by further inquiries, but the cause of any bubbling was not fully resolved. The lack of large amounts of moisture, and the low temperatures prevailing in the area at the time, appear to rule out a rapid reaction with water.

Nevertheless, the toluene diisocyanate on the ground began to turn white at the outer edges of the spill, indicating that toluene diisocyanate was reacting with water in the soil to form a polyurea.

Decontaminant was applied to the toluene diisocyanate, to form polyureas. After the reaction was completed, the polyureas were buried nearby. The Chemistry Centre has advised that the polyureas are insoluble and biologically inert. It is therefore expected that significant long term pollution will not result. It is inarguable, however, that short term pollution of both the site and the atmosphere did occur, to an extent which caused medical problems in personnel at the site.

7.3 IDENTIFICATION OF OWNER, CONSIGNOR, PRIME CONTRACTOR AND CONSIGNEE

It is important to identify the consignor, prime contractor, consignee and owner of the toluene diisocyanate involved in the spill in order to clarify issues of responsibility for the transport of dangerous goods.

Olin Australia Ltd was the owner of the toluene diisocyanate which was stored at Powell Duffryn Terminals Ltd. Olin contracted Chemtrans to ship the product to WA. Chemtrans Sydney forwarded the toluene diisocyanate to Chemtrans Perth utilising ASP Container Express Ltd as a subcontractor. State Rail Authority of NSW and Australian National and Westrail were the transport operators. The status, in terms of the Australian Dangerous Goods Code, of the organisations involved in the transport of the toluene diisocyanate was as follows:

Olin Australia Ltd	:	Owner/Consignor
Powell Duffryn Terminals Ltd	:	Loader
Chemtrans (Sydney)	:	Prime Contractor
ASP Container Express Ltd	:	Subcontractor to Chemtrans
Foamlite Australia Ltd	:	Consignee

For the purposes of their internal company procedures, Chemtrans Sydney arranged to forward the goods to Chemtrans Perth, who were responsible for raising the paperwork for billing Foamlite. Given these roles the Australian Dangerous Goods Code requires the following responsibilities of the above organisations.

Olin Australia Ltd (consignor): ensure a copy of the shipping document is provided to the Chemtrans truck driver and in this instance an Emergency Procedure Guide as well (Section 8.2.7.2 of the Australian Dangerous Goods Code).

Powell Duffryn Terminals Ltd (loader): ensure a copy of the shipping document and an Emergency Procedures Guide is provided to the driver (Section 8.2.7.2).

Driver of the road vehicle: ensure that dangerous goods are not transported by the vehicle unless he has received a copy of the shipping document and the Emergency Procedures Guide (Section 8.2.7.3).

Chemtrans (prime contractor): ensure that dangerous goods are not transported on the vehicle unless the driver has received a copy of the shipping document and the Emergency Procedures Guide (Section 8.2.7.3).

ASP Container Express Ltd (subcontractor): shall, at or before the time of loading onto a rail vehicle, ensure that the rail authority is provided with the shipping document (Section 8.2.7.6).

State Rail Authority (New South Wales) & Australian National: Whilst the Australian Dangerous Goods Code covers road and rail requirements in these matters, the sections dealing with detailed responsibilities are couched in terms of road transport requirements only, such that it is not required to provide train drivers with information about the presence of dangerous goods in a manner similar to that applying to drivers of road vehicles. Nevertheless, rail systems in Australia require provision of documentation, from which relevant information can be, and is, provided to train crews.

RECOMMENDATION 1

The Environmental Protection Authority recommends that provision of adequate documentation to train crews should be clearly formalised in Section 8 of the Australian Dangerous Goods Code.

7.3.1 COMPLIANCE WITH AUSTRALIAN DANGEROUS GOODS CODE

The provision and checking of documentation by each organisation in the chain, involving Olin Australia Ltd, Powell Duffryn Terminals Ltd, Chemtrans, ASP Container Express Ltd, State Rail Authority and Australian National was deficient. The result was that the Australian National train crew were not aware of the presence of dangerous goods on their train. This situation is not acceptable, if dangerous goods are to be properly managed. Each organisation must have proper management controls in place to ensure compliance with the provisions of the Australian Dangerous Goods Code.

None of the organisations involved in the chain of events identified above complied with their responsibilities as outlined in the Australian Dangerous Goods Code. Advice to the inquiry revealed that discussions between Olin Australia Ltd and Powell Duffryn Terminals Ltd have occurred since the accident, and procedures have been audited, with systems being put into place to ensure that this situation does not recur.

Chemtrans as prime contractor, also has a responsibility under the Australian Dangerous Goods Code, to ensure compliance with the notification procedures. This non-compliance by Chemtrans affected the interface between ASP Container Express Ltd and State Rail Authority (New South Wales).

The consignment note issued by ASP Container Express did not indicate the presence of dangerous goods on the wagon in question.

The normal procedure of endorsing the rail consignment note and "carding" the rail wagon with the appropriate information was not followed. The rail wagon cards carry traffic information, and would normally indicate whether the load was dangerous goods.

Neither the State Rail Authority nor Australian National checked the goods on their trains. It is suggested that both organisations ensure that they are always aware of all dangerous goods on their trains. It is known that the State Rail Authority's system broke down in this case. ASP Container Express Ltd and the State Rail Authority have since met to ensure proper procedures are followed by both parties in the future.

The inquiry was impressed with the frankness of those private and state organisations which made submissions addressing the deficiencies in documentation and procedures, and in their resolve to ensure that the situation should not recur, and commends them for their professional attitude.

The relevant competent authorities in New South Wales should ensure that the provisions of the Australian Dangerous Goods Code in relation to these matters be observed.

7.4 CERTIFICATION HISTORY OF THE TANK CONTAINER

The tank container used in the transport of toluene diisocyanate and involved in the incident was manufactured by Consani Engineering of South Africa, and approved by Bureau Veritas on 18 December 1986, as an International Maritime Organisation Type 1 (IMO1) container suitable for the transport, by road and rail, of toluene diisocyanate. A copy of the original Bureau Veritas certificate is presented in Appendix 6. The container was mounted in a steel framework of International Standards Organisation (ISO) standard dimensions. As noted in Section 3.2, containers when mounted in this framework are termed ISO tank containers, ISO containers, tank containers or isotainers. They are referred to as tank containers in this Report.

In September 1985 discussions between Flowline Transport and Terminals Pty Ltd Melbourne took place, with a view to adding a piping arrangement to tank containers used for toluene diisocyanate transport, to convert them from top loading to bottom loading and discharge. The modification made to the containers included a filler pipe and a vapour return pipe. Appendix 7 illustrates the detailed technical specifications of the containers, including the modifications. Approval for the use of modified tank containers on rail systems was given by the State Transport Authority of Victoria, and accepted by Australian National and Westrail.

Until July 1988, the container involved in this incident was owned by WA Haulage Terminal Pty Ltd and operated by Flowline Transport, until both companies were purchased by Chemtrans at that time.

Although these competent authorities gave approval to the modification, no details were given to Bureau Veritas, the initial inspecting authority for the International Maritime Organisation. On discussing this issue with Bureau Veritas representatives, they indicated that any damage to a container, modification or rework should be notified to Bureau Veritas. If this is not done the certification is cancelled.

The initial certification issued by Bureau Veritas was the basis on which the container was initially approved by competent authorities for the transport of dangerous goods throughout Australia. By making modifications to the container this certification was nullified. In this particular case, it is clear that no loss of toluene diisocyanate would have occurred if the modification had not been made, or if the integrity of the container during transport could have been guaranteed by either removing the loading/ discharge and vapour return pipes prior to transport, or designing the pipes so that they would break under stress at specially engineered points, so as to not affect the integrity of the tank. Bureau Veritas indicated to the inquiry that they expected that the modifications would have met their requirements for loading and discharge, but not transport. Therefore, unbeknown or unrealised by all parties was the implication that the approvals for modifications given by the State Transport Authority of Victoria, and accepted by Australian National and Westrail, were issued in place of the Bureau Veritas certification for transport within Australia.

Under International Maritime Organisation requirements, a certified container must be inspected every two and a half years. As this tank container had originally been certified on 18 December 1986, it was due for

its first inspection on 18 May 1989 (7 days after the incident). Chemtrans informed the inquiry that the tank container had been booked in for the inspection, and was on its last trip prior to that inspection. It is expected that the situation outlined above would have become apparent during the inspection.

Chemtrans, however, informed the inquiry that subsequent to the incident, on 19 July 1989, a meeting was convened in Melbourne to discuss the modifications which had been made to tank container ILMU 2049009, a "sister" to the container involved in the incident. The meeting was attended by the State Transport Authority of Victoria, Chemtrans, Bureau Veritas, BASF Australia Ltd and Terminals Pty Ltd. It is claimed that the meeting agreed that the modifications were acceptable, and the container suitable for continued use. Chemtrans subsequently took this container out of service.

The role of competent authorities in certifying containers and accessories should be examined in relation to International Maritime Organisation approved certifying agencies, to ensure compatibility of approval procedures.

RECOMMENDATION 2

The Environmental Protection Authority recommends that the competent authorities in Western Australia, Westrail (for rail), and the Department of Mines (for road), examine the procedures and approvals which they now employ for certification of containers, assess the reciprocity procedures which now prevail between competent authorities, and examine the relationships which prevail between approvals by international certification agencies and themselves, to ensure compatability and complementarity of all approval procedures.

The role of competent authorities in the management of dangerous goods transport, and in the certification of containers has been discussed in Section 3.

The above analysis also indicates that the modifications seriously compromised the integrity of the tank container for transport operations. Accordingly, the Environmental Protection Authority makes the following recommendation.

RECOMMENDATION 3

The Environmental Protection Authority recommends that to ensure tank container integrity during accidents in transport operations, the competent authorities investigate the practice of having external loading, discharge, and vapour return pipes fixed to containers.

The Environmental Protection Authority considers that, for example, blanked flange configurations, in which outlets/inlets are blanked off by a plate, offer a higher degree of integrity for the tank and its contents during transport. This configuration is employed by the tank containers used for transport of sodium cyanide solution in Western Australia.

7.5 EMERGENCY IMFORMATION PANELS

The container was correctly placarded with Emergency Information Panels placed on both sides of the container. In addition an Emergency Information Panel had been attached to one end of the container so as to meet road transport placarding requirements. After derailment the container was oriented on its side with one Emergency Information Panel underneath the container, the other facing upwards, and not visible to anyone on the ground. The end placard, which was not required by the Australian Dangerous Goods Code for rail, was the only ready indication of the contents of the container.

RECOMMENDATION 4

The Environmental Protection Authority recommends that the placarding requirements for tank containers for rail transport be consistent with those for road transport in Western Australia.

7.6 INTERMODAL TRANSFER OF TANK CONTAINERS

The transfer of tank containers between road and rail transport is a common occurrence. In its submission, the State Transport Authority of Victoria noted the particularly heavy weight of a full tank container of toluene diisocyanate, and made recommendations for its placement on rail wagons, to ensure no excess wagon axle loads. The Australian Dangerous Goods Code has requirements for maximum and minimum "ullage" (the air space above the liquid inside the tank container). These requirements result from safety factors, for if the tank is not sufficiently full, surges during transport can have a deleterious effect on the container.

The ullage requirements affect the net weight, and therefore the gross weight of the container. Road transport regulations affect weights allowed to be carried by road vehicles.

The Authority considers that road and rail competent authorities should review requirements for the intermodal transfer of tank containers to ensure compatibility of such containers for both road and rail. This matter should be addressed in the Australian Dangerous Goods Code.

7.7 COMMUNICATIONS

As detailed in Section 6, Australian National's telephone communications line was brought down and rendered inoperative as a result of the derailment. Significant delays in the provision of information relating to procedures such as evacuation of the site, the hazardous nature of toluene diisocyanate and the general recovery of the incident resulted.

The incident has illustrated that communication lines adjacent to rail lines are inappropriate because they are likely to be damaged in the event of a derailment. Telecom are in the process of installing an optic fibre network, which will be used by Australian National, and which is expected to be operational by the end of 1989.

Two essential considerations of communications are the equipment and the information required to be transmitted. The content of transmissions will be dependent on awareness of emergency response schemes and their requirements. Problems with equipment will affect the ability to transmit messages, and in some cases, the messages obtained by the receiver.

The derailment brought down Australian National's aerial cable telephone communications link, and rendered it inoperative. This was particularly important, given that Australian National's principal operations centre is in South Australia.

Nevertheless, messages were transmitted to Kalgoorlie and to Adelaide. Australian National Kalgoorlie informed Westrail at 7.00 am Thursday that a derailment had occurred, and that Westrail would need to adjust their train schedules. Australian National were not aware at this stage that a chemical was involved.

Australian National Adelaide informed Chemtrans Perth by the Telecom network that a derailment had occurred and that they should check their records to determine whether they had any freight on the train. This call, with subsequent investigations and actions by Chemtrans, instigated the response to the chemical incident.

The remoteness of the site, the need to use radio in country unfavourable to radio transmission, hampered communications. The "crash" of the major Telecom computer in Perth the following day (12 May 1989) rendered inoperative all interstate telecommunications except for one telephone line. When the response teams were at the site, communications followed the following chain:

Site	-	Forrest (private telephone)	-	Police radio
Forrest	-	Perth	-	Telephone
Perth	-	Sydney	-	Telephone

The difficulties meant that messages were difficult to pass on. The example quoted to the inquiry was:

Message: "Frame damaged, tank not loaded"
which emerged as: "Brain damaged, body not loaded".

This situation illustrates the necessity for back-up communications by transport operators, especially in remote areas. Most organisations tend to have their principal communications links with their major operational centres. In this case, Australian National's communications are centred in Adelaide. The loss of dedicated railway telephone communications, and the loss of interstate communications by Telecom meant that contact with the Eastern States was extremely difficult. It also points to the need for Eastern States based organisations operating in Western Australia to ensure a Western Australian based response capability (see Section 7.8).

RECOMMENDATION 5

The Environmental Protection Authority recommends that competent authorities ensure that operators transporting dangerous goods in remote areas of Western Australia have effective back-up communications systems, as part of their licensing requirements.

Where competent authorities are also operators (Westrail and Australian National) these authorities should ensure provision of such systems in remote areas. The Authority considers that the Australian Dangerous Goods Code should be amended to reflect these requirements.

The Environmental Protection Authority considers that good communication links, as well as back-up communications, for emergency response organisations should also be in place, in order to ensure effective and timely response.

RECOMMENDATION 6

The Environmental Protection Authority recommends that the control authority (Police) and the combat authority (Fire Brigade) carry out an assessment of communications equipment, to ascertain where improvements are necessary, and to implement such improvements, in order to overcome the difficulties which occurred in this incident.

7.8 EMERGENCY RESPONSE

In Western Australia emergency response procedures, including the notification of relevant organisations and Government agencies, are set out in the Western Australian Transport Emergency Assistance Scheme.

The Western Australian Transport Emergency Assistance Scheme has been used many times since 1984, and it has proved to be very effective. It is clear that the Scheme did not work effectively in this case, and it is instructive to determine why it did not.

The Western Australian Transport Emergency Assistance Scheme depends for its effectiveness on:

- documentation of dangerous goods loads;
- awareness of the scheme by transport operators;
- initiation of the scheme by calling the Police or Fire Brigade;
- good communications links;
- availability of expertise to advise on appropriate response; and
- availability of physical resources to recover the situation.

It is clear from the events described in this Report that Australian National were not aware of the Scheme. Australian National has supplied details of its internal response mechanisms to the inquiry. Australian National's own response mechanisms were frustrated by lack of knowledge of dangerous goods on the train, and the cutting of Australian National's east-west communications, given that their main response capability is Adelaide based. Reports of the confusion at the scene, and the exposure of Australian National and Telecom employees to toluene diisocyanate point to a lack of awareness of Australian National's scheme amongst Australian National's own employees. It would also appear that Australian National employees were not conversant with Emergency Information Panels for dangerous goods, as identification of the chemical came from Chemtrans Perth, despite the visibility of the panel on the end of the tank container.

It is clearly insufficient for interstate transport operators to rely on a response scheme peculiar to one State only, particularly if an incident occurs in another State. There is a need for Australian National to make itself aware of, and to be able to participate in the WA based scheme. Concurrently, there is a need for the coordinators of the WA scheme to ensure that operators such as Australian National are cognisant of the WA emergency response scheme.

A reason that Australian National may not have not been involved could be a perception on the parts of both Australian National and State Government agencies of a divide between Commonwealth and State agencies. A further contributory factor could be the notion that, for rail transport, Western Australia starts/ends at Kalgoorlie/Parkeston, rather than the Western Australian/South Australian border. Given that this divide should not exist, especially when it comes to the management of dangerous goods, and that Australian National is a commercial operating agency, subject to State laws in respect to its operations, it is essential to ensure that Australian National is brought under the umbrella of the Western Australian based response scheme.

It is clear from the past operation of the scheme and from the present incident, that the Scheme works best in and near Perth, with ready availability of control and combat personnel, advisory expertise, material resources and good communications. As the distance from Perth increases, these factors become less positive. In the transport of sodium cyanide solution, for example, the carriers of the product have instituted strict communications regimes, which have been found to be acceptable by the Environmental Protection Authority and the Mines Department. Resources have been provided at "nodal" points, should they be required. Accordingly, the Environmental Protection Authority makes the following recommendations:

RECOMMENDATION 7

The Environmental Protection Authority recommends that Australian National Railways should enter into a cooperative scheme of arrangement with the Western Australian authorities to ensure that a common basis for the application of emergency response applies throughout Western Australia.

Whilst State government agencies in Perth made themselves available to give advice, not one agency actually sent people from Perth to the site, although Chemtrans commented favourably on the readiness of each of these agencies to provide support. The local Eucla police acted as site controllers in accordance with the Western Australian Transport Emergency Response Scheme. The combat authority in this case was Chemtrans by agreement with the WA Fire Brigade.

RECOMMENDATION 8

The Environmental Protection Authority recommends that the State Emergency Service actively promote the appropriate emergency response scheme throughout country areas.

The Environmental Protection Authority is aware of the promotional work undertaken by State Emergency Service just prior to the introduction of sodium cyanide solution transport. However, this needs to be a continuing effort, and the State Emergency Service should develop a long term program to implement such a continuing effort, and report to the State Counter Disaster Advisory Committee on an annual basis on these efforts.

7.9 EMERGENCY RESPONSE TIMES

Significant delays occurred in notifying emergency response organisations. Australian National put derailment response procedures in place quickly, and informed Westrail of a derailment at 7.00 am on 11 May 1989.

Identification of dangerous goods only came after Australian National contacted Chemtrans (after 10.30 am). The response was essentially organised (by Chemtrans) by early afternoon, on Thursday, but because the aerodrome at Forrest operates in daylight only, starting for Forrest at that time was not practicable.

Decontamination of the site was not achieved until some forty hours after the event.

Early identification of dangerous goods, and presuming a similar sequence of events would have enabled the chemical to be decontaminated that day.

If the incident had occurred in or near a town, or in the metropolitan area, these response times would have been unacceptable. This clearly indicates the need to ensure that all parties are aware of their responsibilities under the existing emergency response arrangements (see Section 7.8).

7.10 AVAILABILITY OF INFORMATION ON CHEMICALS

It was found that some confusion existed over the correct name of the chemical involved in the incident. One point of concern was an early misidentification of the material as "cyanide" (noted in the Chemistry Centre submission), and the reference to "this form of cyanide", by the Royal Flying Doctor Service, instead of toluene diisocyanate. Toluene diisocyanate is not a cyanide (see Appendix 4). This raises the question of availability of adequate information on chemicals to the medical profession.

It also raises the issue of availability of medical personnel with expertise in treating cases involving chemicals. Chemtrans had arranged for a medical practitioner in Perth, who was experienced in the treatment of toluene diisocyanate exposures, to be on standby. There was no indication that his expertise was called upon. Improved information flows for medical personnel need to be recognised in the revision of the emergency response scheme.

RECOMMENDATION 9

The Environmental Protection Authority recommends that the emergency response scheme be revised to identify the availability of specialist medical expertise (in addition to general medical knowledge) for chemical exposures.

In Western Australia chemical databases exist which help identify a chemical from information presented on containers, and provide information on: emergency response procedures, potential health effects on exposure, first aid, and clean-up procedures. The principal chemical database is "Toxichem", developed by the Western Australian Fire Brigade. It appears that in this case Chemtrans, who assumed the role of combat authority (with permission of the Fire Brigade) used their own internal information sources. Whilst this was sufficient, the availability of information through the Fire Brigade needs to be recognised by all organisations involved in the transport of dangerous goods and by all emergency response organisations. It would be appropriate for major operators, including Westrail, to have access to such databases.

8. CONCLUSIONS

The Environmental Protection Authority concludes that:

1. The derailment was the result of an axle on a wagon seizing and shearing. Eighteen wagons came off the track.

2. The derailment did not rupture the tank container containing toluene diisocyanate.

3. The derailment damaged the steel frame surrounding the tank. The frame protected the tank container.

4. The damaged frame bent a pipe accessory which had been added to the tank container. The leverage extended on this pipe accessory caused it to shear where it joined the tank. This allowed toluene diisocyanate to leak from the container.

5. The Environmental Protection Authority has made recommendations to the effect that approval procedures should be revised to ensure that such modifications cannot be approved in the future for transport operations.

6. Australian National Railways did not know that there were dangerous goods on their train. Every organisation which handled the toluene diisocyanate did <u>not</u> either make out consignment notes or made consignment notes out incorrectly, or did not check to see that such consignment notes corresponded with the load of dangerous goods. Each organisation was in breach of the requirements of the Australian Dangerous Goods Code. These organisations have reviewed their procedures to ensure that this situation will not be repeated. The relevant authorities in New South Wales, where these breaches occurred, should ensure that such requirements are met.

7. Australian National should have mechanisms in place to ensure that they are aware of dangerous goods on Australian National trains.

8. It is clear that Australian National were not aware of the requirements of the Western Australian Transport Emergency Assistance Scheme. It would also appear that the employees at the site were not aware of Australian National's own response scheme.

   Difficulties occurred because:

   - the incident took place when it was dark.
   - no one realised for some time that a chemical had been spilt.
   - no one at the site knew what the chemical was, or its effects.
   - communication lines were brought down in the derailment.
   - telephone and radio communications remained very difficult for several days, because of lack of back up communications, difficult terrain for radio communications and the crash of the Telecom computer in Perth.
   - the identity of the chemical on the scene and off the scene only became evident when Chemtrans Perth identified the chemical.

- Chemtrans did not contact the Mines Department until 1 hour 40 minutes after receiving word from Australian National. The Mines Department contacted Police, who did not contact other agencies for 1 hour 32 minutes. Chemtrans were organising their own response, and the Police Department did begin attempts to contact the Eucla Police Station.

  Whilst these delays turned out not to be critical in this case, given the location of the spill, they do point to the need to tighten procedures in communications flows.

  Australian National staff invited Telecom staff to help them. This resulted in the exposure of many more people than would have otherwise occurred.

- Not one state government agency sent personnel from Perth to the site. The local Police Sergeant managed the incident and Chemtrans and SGS Australia Pty Ltd combated the incident effectively.

The Environmental Protection Authority has made recommendations concerning improved communications equipment for both transport operators and the emergency response organisations; ensuring that Australian National Railways are aware of emergency response procedures in Western Australia, that greater knowledge about the emergency response scheme is disseminated by the State government agency responsible, and that the scope of the scheme be increased to ensure availability of information to the medical profession.

9. ACKNOWLEDGEMENTS

The Environmental Protection Authority acknowledges the extensive assistance given by the Department of Mines and Westrail in releasing two senior officers to assist in the inquiry.

The Authority also acknowledges the cooperation of organisations in preparing and making submissions to the inquiry. In many cases, these submissions indicated shortcomings in the operations of those making the submissions. A prevalent attitude was the need to learn from the experience, so as to ensure better management of toluene diisocyanate and emergency response in the long term. The Authority commends these organisations for their positive attitude.

The Authority should also like to thank the Police Department for an invitation to attend the Police Debriefing held on 5 July 1989.

The inquiry panel inspected the facilities of Foamlite Australia Ltd, where toluene diisocyanate is used extensively, and thanks Foamlite for the visit.

10. REFERENCES

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CCINFO (1989) - CHEMINFO Database for Chemicals on CD ROM. Developed by Canadian Centre for Occupational Health and Safety.

APPENDIX 1

TERMS OF REFERENCE

INQUIRY BY THE ENVIRONMENTAL PROTECTION AUTHORITY INTO THE CAUSE OF, AND SUBSEQUENT MANAGEMENT OF A POLLUTION INCIDENT INVOLVING A SPILL OF TOLUENE DI-ISOCYANATE NEAR FORREST, WESTERN AUSTRALIA, ON 11 MAY 1989

TERMS OF REFERENCE

The Environmental Protection Authority is to conduct an inquiry into the causes of, and subsequent management of, a pollution incident involving the loss of toluene di-isocyanate near Forrest, Western Australia on 11 May 1989. The inquiry will investigate the cause(s) of the incident, the effectiveness of the response(s) to the incident, and make recommendations, with a view to improving the management of toluene di-isocyanate in Western Australia. The inquiry may comment on the management of other dangerous goods in Western Australia.

The inquiry will pay particular attention to the following 4 major issues:

1. TOLUENE DI-ISOCYANATE

   1.1 quantities of toluene di-isocyanate imported into Western Australia - entry point(s) and transport mode(s) and route(s), and management;

   1.2 properties of toluene di-isocyanate.

2. INCIDENT NEAR FORREST

   2.1 details of the shipment of toluene di-isocyanate involved in the incident near Forrest, including consignor, consignee, prime contractor, quantity;

   2.2 construction standards and certification history of the container involved;

   2.3 circumstances of the railway accident;

   2.4 the damage sustained by the container;

   2.5 the cause of damage to the container and the cause of loss of toluene di-isocyanate;

   2.6 the quantity of toluene di-isocyanate lost, and its distribution and fate in the vicinity;

   2.7 labelling, placarding and documentation requirements for the shipment;

   2.8 emergency notification and response provisions employed after the incident;

   2.9 any effects of the escaped material on the environment;

.../2

2.10 arrangements for transport and handling of remaining product from Forrest to Kalgoorlie, Kalgoorlie to Perth and within the Perth metropolitan region.

3. REGULATORY REQUIREMENTS AFFECTING THE TRANSPORT OF TOLUENE DI-ISOCYANATE

3.1 statutory provisions governing the transport and management of dangerous goods in Western Australia;

3.2 certification requirements for dangerous goods, packages and containers;

3.3 provisions for reciprocity between competent authorities in Western Australia and in other jurisdictions in Australia;

3.4 special provisions relating to the transport and management of toluene di-isocyanate.

4. MANAGEMENT OF EMERGENCY RESPONSE

4.1 provisions for emergency response for rail incidents involving dangerous goods in Western Australia.

APPENDIX 2

ORGANISATIONS INVITED TO MAKE WRITTEN SUBMISSIONS

ORGANISATIONS INVITED TO MAKE WRITTEN SUBMISSIONS

Australian National Railways Commission
ASP Container Express Ltd
BASF Australia Ltd
Bureau Veritas
Chemtrans
Department of Occupational Health, Safety and Welfare
Dow Chemical (Australia) Ltd
Dunlop Australia Ltd
Foamlite (Australia) Ltd
HBF Occupational Health Services
Health Department
Joyce Australia Ltd
Mines Department
Olin Australia Ltd
Police Department
Powell Duffryn Terminals Ltd
RFL Trans Tasman Ltd
Royal Flying Doctor Service (Eastern Goldfields)
State Emergency Service
State Rail Authority (NSW)
State Transport Authority of Victoria (V/Line)
Telecom
Vita Pacific Ltd
Western Australian Fire Brigades Board
Westrail

All of the above organisations, with the exception of RFL Trans Tasman Ltd, and Vita Pacific Ltd, either made a submission, or contributed to an industry submission.

Kalgoorlie-Boulder Town Council indicated verbally that they did not wish to make a submission.

The Standards Association of Australia provided a copy of the draft standard on handling of isocyanates

Specific information was sought and obtained from the following organisations:

Bureau of Meteorology
Chemistry Centre of WA
Department of Environment and Planning (SA)
Environment Protection Authority (Victoria)
Environmental Protection Section (ACT)
Fremantle Port Authority
Government Chemical Laboratories (QLD)
Hazardous Materials Advisory Council (USA)
State Pollution Control Commission (NSW)

APPENDIX 3

ORGANISATIONS WHICH MADE ORAL SUBMISSIONS

ORGANISATIONS WHICH MADE ORAL SUBMISSIONS

Bureau Veritas
Chemtrans
Department of Occupational Health, Safety and Welfare
HBF Occupational Health Services
Mines Department
Telecom

Plastics Institute of Australia, together with

BASF Australia Ltd
Dow Chemicals (Australia) Ltd
Dunlop Australia Ltd
Foamlite (Australia) Ltd
Joyce Australia
Olin Australia Ltd
Rhone Poulenc Chimie (Australia) Ltd

APPENDIX 4

PROPERTIES, TOXICOLOGY AND ENVIRONMENTAL EFFECTS OF TOLUENE DIISOCYANATE

PROPERTIES, TOXICOLOGY AND ENVIRONMENTAL EFFECTS OF TOLUENE DIISOCYANATE

IDENTIFICATION, CHEMICAL AND PHYSICAL PROPERTIES

	80:20 mixture of 2,4 toluene diisocyanate and 2,6 toluene diisocyanate
CAS No.	26471-62-5
UN No.	2078
ADG Code	6.1(a) Poison (Toxic) Substance
Synonyms	TDI Toluene diisocyanate Hylene NIAX Suprasec
Chemical Formula	$CH_3C_6H_3(NCO)_2$
Molecular Weight	174
Melting Point	20-22°C
Boiling Point	250°C
Vapour Pressure	68 Pa @ 25°C
Vapour Density	6 (air = 1)
Flashpoint	132°C
Density	1220 kg/m^3
Physical properties	Clear, faintly yellow liquid at room temperature. Darkens on exposure to sunlight.

TOXICOLOGICAL INFORMATION

The time weighted average occupational Exposure Standard in WA for exposure to 2,4-toluene diisocyanate is 0.005 parts per million.

Mutagenicity, Carcinogenicity and Teratogenicity (CC INFO, 1989)

No reports have been found to indicate that toluene diisocyanate produces teratogenic or mutagenic effects in humans or animals by ingestion. Toluene diisocyanate has been shown to be carcinogenic to animals but not by inhalation. The International Agency for Research into Cancer has listed toluene diisocyanate as possibly carcinogenic.

Health Effects of Short Term (Acute) Exposure

Inhalation: Vapour or mist levels above 0.05 ppm can cause respiratory tract irritation. Symptoms can include burning or irritation in the nose and throat, a choking sensation, coughing, shortness of breath and chest discomfort. 2,6-toluene diisocyanate may be more irritating than 2,4-toluene diisocyanate. Higher concentrations may cause chemical bronchitis with severe asthma-like wheezing, lung inflamation and fluid in the lungs. This has proved fatal in rare cases. Symptoms may not appear until several hours after exposure. Nausea, headache and insomnia may also occur and may last for several weeks, however, most people recover completely.

Eye Contact: Liquid splashes can cause watering of the eyes, severe irritation and possible clouding of the cornea. Vapours or mists can cause smarting, burning or prickling sensations. High-vapour levels can cause solid particles to form in eye fluid resulting in mechanical irritation hours after exposure.

Skin Contact: Skin contact with liquid toluene diisocyanate may cause skin irritation.

Ingestion: Swallowing toluene diisocyanate may cause irritation and corrosion of the tissues lining the mouth, throat and stomach.

Health Effects of Long Term (Chronic) Exposure (CCINFO, 1989)

Inhalation: Respiratory sensitisation may develop after repeated exposures to airborne toluene diisocyanate, however, it is uncertain whether some people can become sensitized on their first exposure to toluene diisocyanate. Sensitised people can experience symptoms of toluene diisocyanate exposure at levels below 0.001 ppm. Symptoms resemble asthma with wheezing, difficult breathing and/or coughing due to constriction of the airways, with loss of breath occurring more rapidly after each exposure. The number and severity of symptoms experienced may also increase. In severe cases, hospitalisation may be required. Some sensitised people may continue to show continued decline in lung function, cough, chronic bronchitis, breathlessness and wheezing for several years after removal from toluene diisocyanate exposure.

Both allergy-prone and non-allergy-prone people can become sensitised and cross-sensitisation from different isocyanates may occur. Toluene diisocyanate-sensitised people have shown sensitivity to other isocyanates. The level of airborne toluene diisocyanate causing respiratory sensitisation is unknown. It seems that the lower the exposure to toluene diisocyanate, the less likely sensitisation will occur. There is some indication that long-term exposures to toluene diisocyanate at levels as low as 0.002-0.003 ppm may result in some loss of lung capacity.

Skin: In rare cases repeated skin contact with toluene diisocyanate has caused skin sensitisation. There is also record of people who have inhaled toluene diisocyanate and developed skin rashes but had no direct skin contact with toluene diisocyanate.

ENVIRONMENTAL ASPECTS

Air Pollution

Materials formulated from toluene diisocyanate produce toxic pyrolytic by-products when burned. Toluene diisocyanate when burned will also give rise to noxious nitrogen oxides.

Soil and Water Pollution

When released into water. Toluene diisocyanate reacts to form carbon dioxide and polyureas. The long-term (chronic) aquatic hazard is minimal due to toluene diisocyanate's reactivity and the inertness of the polyureas which are formed.

The period of time that toluene diisocyanate will remain in the environment will depend on the presence of water. Temperatures will also affect the rapidity of the reaction between toluene diisocyanate and water. Environmental persistence and bioaccumulation are not relevant, due to toluene diisocyanate's reactivity. The degradation of polyureas formed after reaction with water will be long-term, but should pose no significant threat to the environment.

DEPARTMENT OF MINES
WESTERN AUSTRALIA

CHEMISTRY CENTRE

125 HAY STREET
EAST PERTH
WESTERN AUSTRALIA 6004

TELEPHONE (09) 325 5544
FACSIMILE (09) 325 7767

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Your Ref: N S
Our Ref: 89HF 56
Enquiries to:

Environmental Protection Authority
BP House
1 Mount St
PERTH WA 6000
Attn: Dr B Kennedy

REPORT ON THE REACTIVITY OF TOLUENE 2,4- DIISOCYANATE (TDI) WITH WATER AND WATER VAPOUR IN A SPILL SITUATION

Introduction

Following a spillage of toluene 2,4-diisocyanate (TDI) at Forrest on May 11 this year, your Department has asked for any information regarding the reactivity of TDI with water vapour, and its volatility in a spill situation.

In particular, atmospheric conditions such as availability of moisture (from rain or humidity), wind and temperature were to be considered as relevant issues to potential evolution of TDI and reaction by products at a spill scene.

The Chemistry Centre WA has conducted a review of the current literature available on the reactivity of TDI and a summary of this information is attached as Appendix One.

Result of Review

Two factors which must be considered in a spill situation are the high volatility of TDI and its high reactivity with water and other hydrogen containing substances. Furthermore, TDI and water have been found not to react in the vapour phase.

For these reasons it is important that a spill be contained (ie kept from spreading and allowing greater evaporation) and kept cool (ie not allowed to contact and react with water, which would generate heat and increase evaporation of unreacted TDI).

In ambient temperatures above 21.8°C, a neutral, absorbent material such as sand should be used to absorb the liquid TDI.

The absorbent material can then be neutralized with water. The reaction products are primarily polymeric urea and carbon dioxide gas. It appears the main problem with the reactivity of TDI with water is the vigourous reaction (ie generation of free TDI vapour from heat and mechanical agitation). The reaction products are in the main, innocuous.

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Neutralization with water then should proceed slowly (to avoid excess heat of reaction) and with minimal agitation of the TDI containing material, both of these steps to avoid unwanted generation of free TDI vapour.

Remaining small areas of contamination may be decontaminated using a solution of dilute ammonia and detergent.

Conclusion

In view of evidence found regarding TDI volatility and reactivity with water, it is recommended that clean up of TDI spills proceed as follows (AS 2508).

1. Contain spillage as far as possible.

2. A neutral absorbent such as sand should be used.

3. Transfer material to open topped labelled containers, if possible.

4. Neutralise carefully with water in a well ventilated area.

5. Decontaminate the area with a solution containing 8% ammonia and 2% liquid detergent.

J W HOSKING
DIRECTOR

24 July 1989

LP/ 5.20.(8)

APPENDIX ONE

THE REACTIVITY OF TOLUENE 2,4- DIISOCYANATE (TDI) WITH WATER AND WATER VAPOUR

INTRODUCTION

Toluene 2,4-diisocyanate (TDI) is available commercially as the 2,4 isomer with a small amount (2-3 percent) of the 2,6 isomer as an impurity. It is also available as a mixture with the 2,6 isomer in ratios 80:20 and 65:35 (ref 1).

TDI exists as a colourless to pale yellow solid or a water-white liquid which turns straw coloured on standing. It is soluble in many organic solvents and will react often violently with substances containing active hydrogen, including water (ref 1).

Properties of TDI

M.Wt 174.16 g
Specific Gravity 1.220
Flashpoint 132°C (OC) 127°C (CC)
Melting Point 21.8°C
Boiling Point 251.0°C (ref 1)

TDI will burn but is not considered a significant fire risk. On burning it will emit noxious fumes including nitrogen oxides (ref 1).

TDI is highly volatile. (Ref 2)

The health effects have been well documented, including its high toxicity by inhalation, moderate irritation to the eyes and mild irritation to the skin (ref 1).

Dealing with small spills

Protein-based foams are most effective, fluorochem foam least effective in preventing TDI vapour evolution from spills. The protein based foams react quickly to form a gel-like skin without gas evolution. (Ref 3)

Collect the solid into drums as far as is possible. Decontaminate the area of spillage with dilute ammonia and detergent. Collected spills may be incinerated by an approved Agent (ref 1).

REACTIVITY: In General and with liquid water

Urethanes are formed by the chemical interactions of polyglycols or polyols with diisocyanates. The reactive isocyanate radicals bind together large numbers of polyol molecules to form a polymeric mass. When water is added to the reacting chemicals CO_2 is released causing the fluid mixture to foam. (ref 5).

Toluene diisocyanates are soluble in acetone, ethyl acetate, ether, benzene, carbon tetrachloride, chlorobenzene, kerosene and various oils eg corn oil. They may react violently with compounds containing active hydrogen, such as alcohols, with the generation

.../2...

of enough heat to lead to self-ignition and subsequent release of toxic combustion products. Other such solvents that must not be mixed with toluene diisocyanates include water, acids, bases, and strong alkaline materials, such as sodium hydroxide and tertiary amines etc (ref 4).

Toluene diisocyanates react with water and most acids to produce unstable carbamic acids, which subsequently decarboxylate (raising the pressure in closed containers) to yield relatively chemically inert and insoluble polymeric urea. The reaction of TDI vapour with water vapour does not take place in the gasous phase. It was concluded that loss due to surface adsorption takes place first, since no diaminotoluenes or TDI-ureas could be detected in an environmental chamber. Toluene diisocyanates also react with (-NH-) containing compounds to form ureides or ureas. Each reaction pathway is important in terms of the health hazard potential associated with toluene diisocyanates, since both pathways are biologically as well as commercially significant, and occur at room temperature (ref 4).

Toluene diisocyanates dimerize slowly at ambient temperatures and more rapidly at elevated temperatures. Trimerization occurs at 100-200°C and, above 175°C carbodiimides form with the release of carbon dioxide (CO_2) (ref 4).

In most industrial situations, toluene diisocyanates are hydrolyzed by water to give the corresponding polymeric ureas and carbon dioxide. However, when toluene diisocyanates come into contact with water, without agitation, as in spills, a hard crystalline crust of polymeric ureas forms slowing down further degradation of the toluene diisocyanates, unless the crust is mechanically broken. The solid reaction products are insoluble and biologically inert (ref 4).

Toluene diisocyanates are highly reactive towards a large number of active hydrogen and basic nitrogen compounds. Thus, more than one reaction may occur in a system at a given time (ref 4).

Mixtures of TDI isomers, such as 80:20, may behave in a different manner to single 2,6- or 2,4-TDI isomers (ref 4).

Isocyanates react with carboxyl groups and form amines, acid anhydrides and ureas. (Isocyanates react with amino groups to form ureas which are also highly stable and unlikely to dissociate under biological conditions - ref 4).

Isocyanates form thiolic acid and esters when reacting with sulfhydryl groups in proteins. However, this reaction takes place at low pH only, whereas the products are unstable at pH 7 or higher (ref 4).

Theoretical reactivity of 2,4-TDI and 2,6-TDI and structures of oligomers contained in the products of conversion of 2,4-TDI into urethane and biuret derivatives has been discussed. (Ref 6)

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REACTIVITY: Water and Water Vapour

TDI reaction with water vapour has been studied to determine if this reaction is rapid enough to affect the atmospheric fate of TDI and to determine if toluene diamine (TDA) is formed (ref 7). Experiments conducted at 27±1 degrees, relative humidity 7-70% and TDI concentrations of 0.6, 0.2, 0.1 and 0.05 ppm showed no evidence for a gas phase reaction between TDI and water. TDI removal from air was not dependent on water vapour concentration and TDA was not formed in significant amounts. (Ref 7)

The effect of water vapour on atmospheric TDI was determined quantitatively (ref 8) at 24 degrees and 1 atmosphere pressure. A maximum reduction of 50% was obtained for initial TDI concentrations of 0.4 and 0.034 ppm. The data suggest that increased humidity would be only marginally useful as a control method. (Ref 8)

The kinetics and progress of the polymerization reaction of water with TDI were determined by monitoring the evolution of CO_2, the depletion of water and the depletion of TDI. In the early stages of polymerization the para-isocyanate group reacted with water to form a carbamic acid intermediate which rapidly decarboxylated to CO_2. (Ref 9)

Studies of TDI under simulated atmospheric conditions indicate that it is destroyed predominantly by OH radicals, without the formation of toluene diamine. Toluene diamine or methylene dianiline, if generated in the atmosphere from any source are also destroyed by OH radical attack. In soil and water, TDI and methylene diphenylene diisocyanate are converted to polyureas which are chemically inert and appear to cause no toxicological effects. The initial rate of reaction of TDI and methylene diphenylene diisocyanate with water is relatively fast, but in many cases the resulting polyurea products encapsulate agglomerations of the diisocyanates and rates of reactions decrease rapidly. (Ref 10)

The reaction of water with 2,4 TDI using the evolution of CO_2 to determine rates and the total amount of reaction has been described. (Ref 11). The effect of the time and sequence of addition of reagents was determined. The amount of CO_2 evolved / mole H_2O added did not depend on the catalyst, concentration, addition time of TDI, or H_2O concentration. (Ref 11)

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APPENDIX 5

EMERGENCY PROCEDURE GUIDE FOR TOLUENE DIISOCYANATE

EMERGENCY PROCEDURE GUIDE—TRANSPORT

TOLUENE DIISOCYANATE (TDI)

UN No	2078
HAZCHEM	2XE

Colourless to pale yellow liquid with a strong pungent odour.
May solidify below 15°C.
Reacts with water.
Carried in drums and small containers or in heated/insulated tankers.
Decontaminant should always be carried.

Environmental hazard—contain spillage.

HAZARDS

Fire	*Combustible liquid. Heat produces toxic vapours.*
Exposure	*Harmful or fatal if swallowed.* *Irritates or burns eyes, skin and respiratory tract.* *Inhalation or contact may result in allergic reaction and severe asthmatic condition. Lung damage may result.*

EMERGENCY PROCEDURES

If this happens ▼	Do this ▼
Spill or leak	Avoid breathing vapour and contact with skin and eyes. Evacuate people from the area; keep upwind. Send messenger to inform fire brigade; police and emergency contact. Tell them location, material and quantity. Wear self-contained breathing apparatus and full protective clothing including boots. Stop leaks, if safe to do so. Prevent spilled material from spreading or entering underground drains by banking with sand or earth.
Fire	Evacuate people from area; keep upwind. Send messenger to notify fire brigade, police and emergency contact; tell them location, material and quantity. Wear self-contained breathing apparatus and full protective clothing, including boots. Use dry chemical or foam. If water spray is used, it should be in a very large quantity. Cool fire-exposed containers with water spray. If fire gets out of control evacuate area and warn against entry. Prevent water run-off from entering drains or water storage.

READ OTHER SIDE ⟶

If this happens ⬇	Do this ⬇
Tanker/ Vehicle Accident	Evacuate people from area; keep upwind. Check for spills or leaks. Send messenger to notify fire brigade, police and emergency contact. Tell them location, material and quantity; indicate condition of vehicle and any damage observed. Do not move vehicle if movement could cause spillage. Warn other traffic.

FIRST AID

Inhaled	Remove to fresh air. If not breathing apply artificial resuscitation. Keep warm. Transport to hospital or doctor.
Eyes	Immediately hold eyes open and wash continuously with water for at least 15 minutes. Transport to hospital or doctor.
Skin	Immediately remove all contaminated clothing, including footwear. Wash affected areas with water for at least 15 minutes. Transport to hospital or doctor.
Swallowed	If conscious give water. Induce vomiting using Ipecac Syrup APF or finger down throat. Transport to hospital or doctor.

EMERGENCY CONTACT

Police and Fire Brigade: Dial 000. If ineffective, dial 1100 (exchange).

Organization	Location	Telephone*	Ask for

*Include area code in brackets

READ OTHER SIDE ⟶

BUREAU VERITAS INSPECTION CERTIFICATE
FOR TANK CONTAINER ILMU 1710027

Source: Chemtrans

Bureau Veritas

TANK - CONTAINER

INITIAL INSPECTION CERTIFICATE

BUREAU VERITAS U.S. Designation No 107-81-06 D.O.T. APPROVAL AGENCY

TANK-CONTAINER, CODE: (Owner / Operator) ILMU 171 002	7	BVCT: 867 638 G	
Max. gross weight: 30480 KG	Tare: 4460 KG	Payload: 26020 KG	Capacity: 21000 ℓ
OWNER: W A HAULAGE TERMINAL (PTY) LTD		OPERATOR: FLOWLINE TRANSPORT	
Model: TP I 2145 / Type: IMO 1	Serial n°: P4534 / Dimensions: 20' X 8' X 8'6"	Code:	Country: AU / Model: 2276

CAPACITY: Nominal: 21000 ℓ / Measured: 21260 ℓ

PRESSURE: Working: 4 BAR / Test: 6 BAR

APPROVALS OBTAINED:

- [X] IMO US/BV 867 638
- [X] AAR 600
- [ ] UK-DOT
- [X] RID/ADR F/2462
- [X] US-DOT IM 101
- [X] CSC F/BV/196/85
- [X] CTC IMPACT APPROVED

SUBSTANCES SUITABLE FOR TRANSPORT: ACCORDING TO APPLICABLE REGULATIONS TAKING INTO ACCOUNT CONSTITUTION OF TANK AND ITS EQUIPMENT AND IM TANK TABLE.

MANUFACTURER: CONSANI ENGINEERING LIMITED

MANUFACTURER'S STATEMENT: I the undersigned certify that the above mentioned tank-container (tank N° P4534) has been manufactured and inspected in the same way, as the basic prototype container homologated by BUREAU VERITAS under number CT SA/02/02/1802 homologation file BVCT 847453/G

CONSANI ENGINEERING (PTY) LTD.
P.O. BOX 1
7480 ELSIES RIVER.
Manufacturer's stamp and signature

CHARACTERISTICS

GENERAL ARRANGEMENT N°: CSTD197 REV 0

DESIGN CODE/SPECIFICATIONS: ASME VIII DIV 1
ASME SECTION IX

Design temperature: 93° C Pressure: 4 BAR

MATERIALS: Frame: ST52-3/BS 4360 GR 50 D
Tank: ASTM-A240-316TI

TANK: Nominal ⌀: 2205 mm Cpt. Nb. ONE

Nominal thickness: Shells: 4.8 mm / Heads: 5.0 mm — Equivt. Mild steel: 6.35 mm STANDARD

EQUIPMENT: - Insulation YES - Heater (pres. test) 4.5
- Pressure discharge - Gravity discharge (•) 3
(•) Number of shut-off devices

SAFETY DEVICES:

Relief valve: 2 Set: 4.4 BAR
Frangible disc: 2 Burst.P.: 4.4 BAR @ 60°C
- In parallel - In series X
Fusible element: N/A Temperature: N/A
Min Bank vent capacity: 20169 M³/H (15°C - 1 ATM)

PROTECTION/COATING:
Internal: PASSIVATION
External: FRAME PAINTED. TANK FULLY INSULATED.

TESTS: R = 30480 KG
Stacking: 6 HIGH 68580 KG/POST
Impact test: 6,93 G

MARKING: Drawing N°: 1916-1 REV B

MARKING AND STAMPING: HB ON FACE OF LEFT REAR (OUTLET END) CASTING AND ON MANUFACTURER'S IDENTIFICATION PLATE BV LABLE ON TANK END.

INSPECTIONS PERFORMED

This tank-container has been manufactured under BUREAU VERITAS survey in accordance with the prescriptions:

- [X] N.I. 178 CMI December 1978 of BUREAU VERITAS
- [X] Specification: US DOT IM 101 PORTABLE TAN
- [X] Code: ASME VIII DIV 1 / ASME SECTION IX

The inspections performed are subject to report: BVCT: G7-50 GTD LCP 86-11

Tension test at: 15000 KG PER POST = 2R/4
Hydraulic test at: 600 KPa
Performed on: 5/11/86

Inspection mark: I-I

REMARKS:
Corrosion allowance: NIL
ONE RIVET OF THE MANUFACTURER'S IDENTIFICATION PLATE WAS HARD STAMPED HB

FURTHER APPROVALS: UIC/SNCF IC/87

UNIT RELEASED: 18/12/86

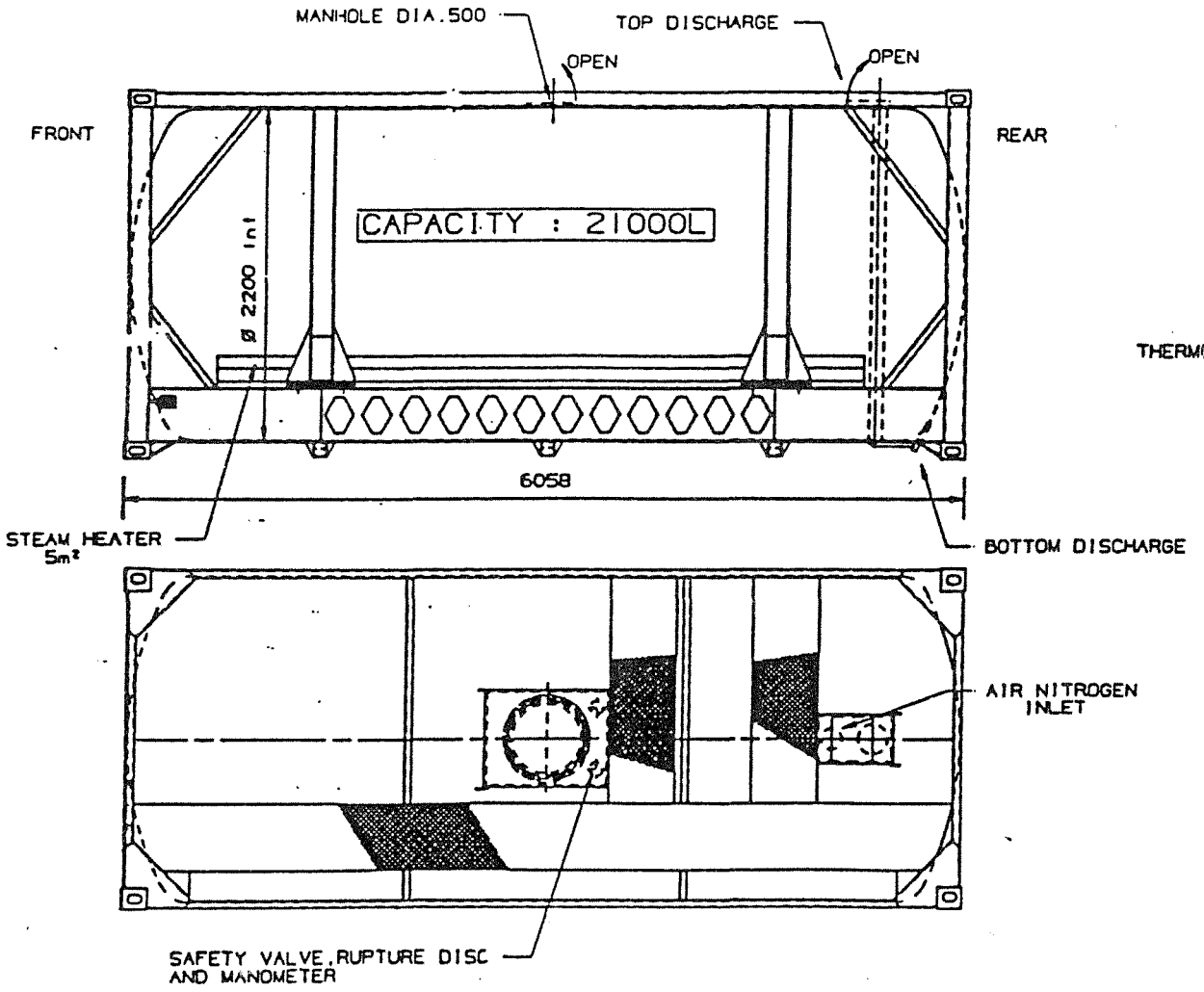
Issued at: PARIS on: 18 DEC 1986
Inspected by: G E ATTRILL Visa:
District/Office: HEAD OFFICE Stamp:

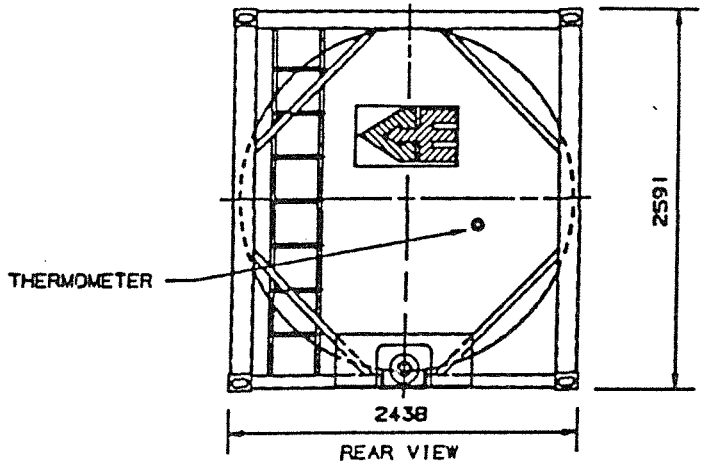
BUREAU VERITAS ADMINISTRATION 1828

BUREAU VERITAS - Head Office: 17 bis, Place des Reflets - La Défense 2 - 92400 COURBEVOIE - Industrial Branch - Tel. 291.52.91 - Telex 611135 F BVCMI

TECHNICAL DRAWINGS FOR THE TANK CONTAINER

Source: Chemtrans





TANK MATERIAL:
- W1.4571

INSULATION:
-LAGGING-POLYURETHANE 50mm NOMINAL
-CLADDING-ALUMINIUM

PRESSURE:
-WORKING 4 BAR
-TEST 6 BAR

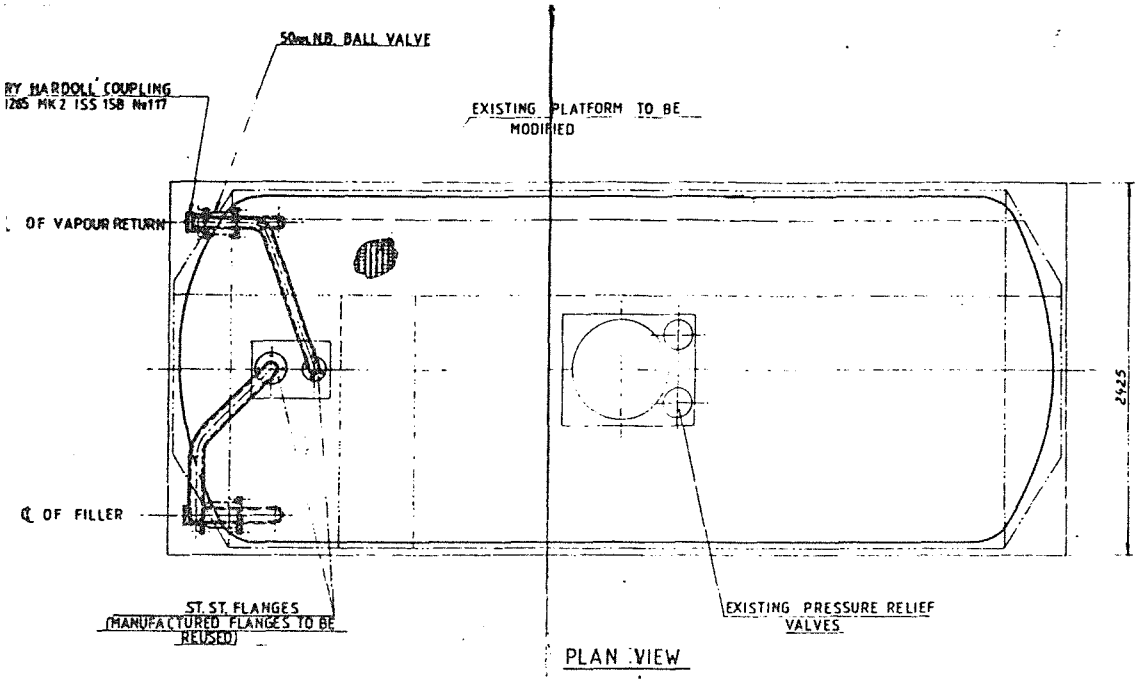
CONTAINER "Type IM101" Capacity 21000 Litres

CONSANI ENGINEERING (PTY) LTD

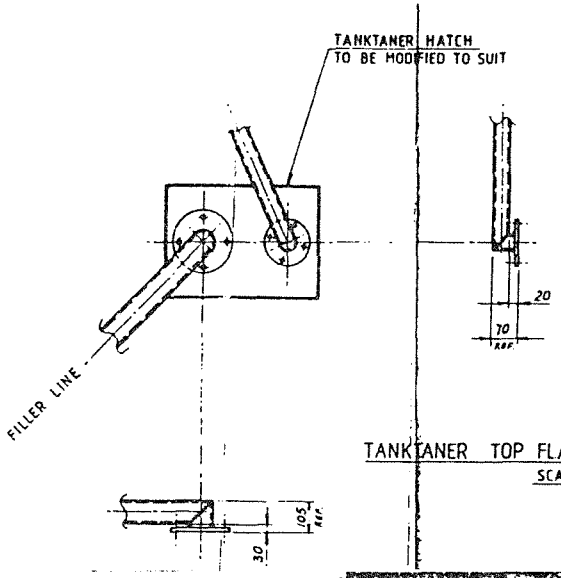
CONTAINER DIVISION

TANK CONTAINERS
CAPACITY:21000L

FILE No.	SCALE 1/33.3	DRAWING No.	REV
W.O.	DRAWN C.A.APPEL DESIGNED DATE 19/6/85	M14211	0



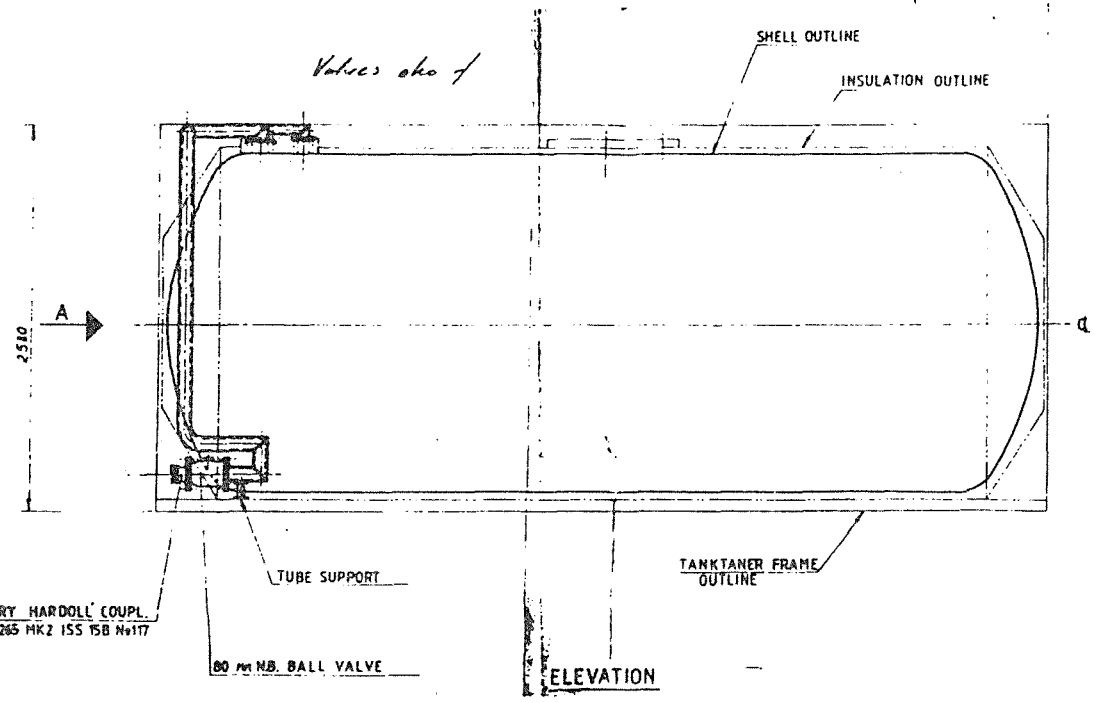
PLAN VIEW



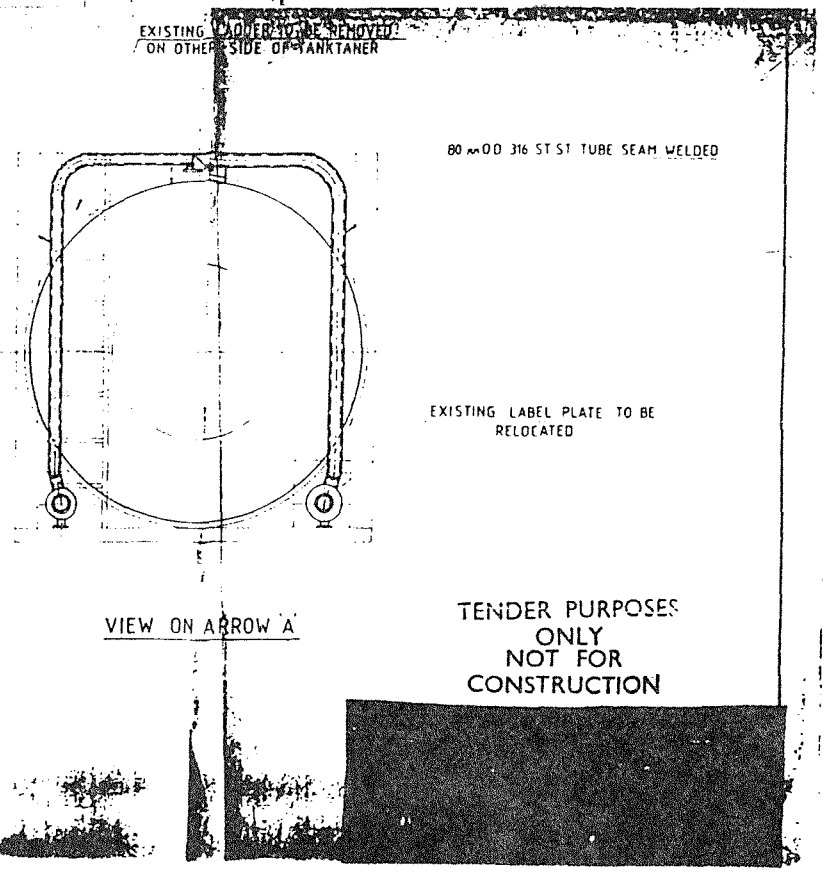
TANKTANER TOP FLANGE ASSY.— DETAILS

SCALE 1:10

50mm OD 316 ST ST TUBE SEAM WELDED



ELEVATION



VIEW ON ARROW 'A'

TENDER PURPOSES ONLY
NOT FOR CONSTRUCTION