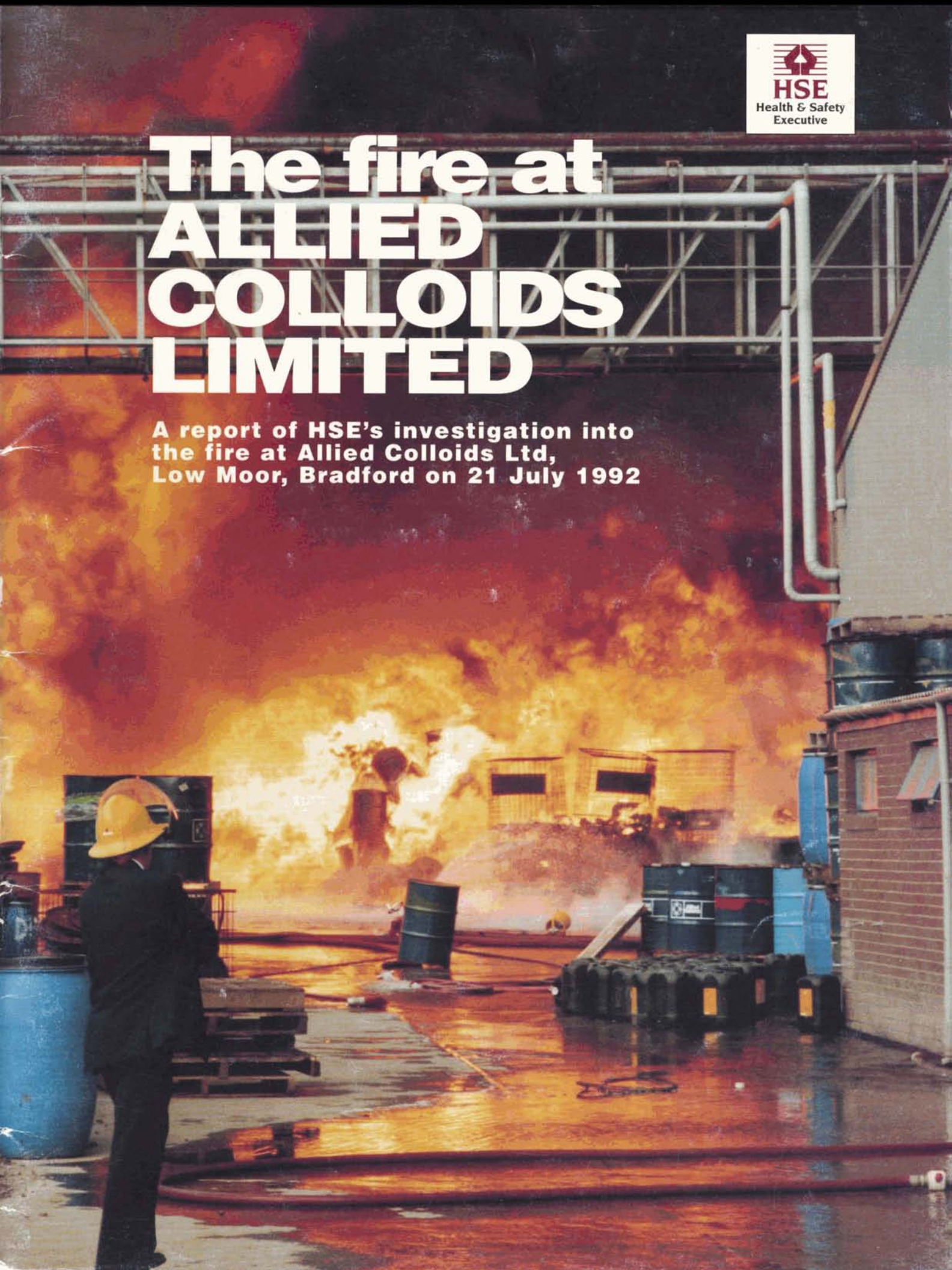

HSE
Health & Safety Executive

The fire at ALLIED COLLOIDS LIMITED

A report of HSE's investigation into the fire at Allied Colloids Ltd, Low Moor, Bradford on 21 July 1992

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HSE BOOKS

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Front cover: *The fire raging in X and J drum and container storage bays*
Courtesy of West Yorkshire Fire Service

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SUMMARY

1 At 1420 h on Tuesday 21 July 1992 a series of explosions leading to an intense fire broke out in a storeroom in the raw materials warehouse of Allied Colloids Ltd, Cleckheaton Road, Low Moor, Bradford, West Yorkshire. The fire spread rapidly to the remainder of the warehouse and external chemical drum storage.

2 Although none of the company employees were injured, 33 people, including three residents and 30 fire and/or police officers were taken to hospital where they were primarily treated for smoke inhalation. Six people were detained. Approximately 2000 local residents were confined to their houses and residents in eight properties immediately adjacent to the raw materials warehouse were evacuated. Firewater run-off caused significant river pollution. The incident gave rise to concern throughout Bradford, Kirklees and neighbouring areas and has been reported as a major accident to the EC as required by the SEVESO Directive. The total cost of company property damage was estimated at £4.25 million and substantial indirect costs were incurred.

3 The fire was preceded by the rupture of two or three containers of azodiisobutyronitrile (AZDN) about 50 minutes earlier. These were kept at high level in a storeroom within the raw materials warehouse and as far as can be determined were accidentally heated by an adjacent steam condensate pipe. AZDN is unstable when heated and has a self-accelerating decomposition temperature (SADT) in 25 kg packages of 50^{o}C. It is a flammable solid and incompatible with oxidising materials. HSE's investigation team concluded that powder released from rupturing drums came into contact with sodium persulphate and possibly other oxidising agents which were stored in the storeroom, causing delayed ignition followed by explosions and the subsequent major fire.

4 At Bradford Crown Court on 29 January 1993 Allied Colloids Ltd was convicted under the Health and Safety at Work etc Act 1974, Section 2 (two counts) and Section 3 and fined a total of £100 000 with costs of £62 324 awarded against them. The company was also prosecuted by the National Rivers Authority for causing pollution as a result of the escape to water courses of contaminated fire-fighting water run-off. They were convicted on 19 July 1993 at Bradford Magistrates Court under the Water Resources Act 1991, Section 85.

5 What happened at Allied Colloids is an example of an incident where a number of apparently unrelated errors, omissions and failures (some of them relatively minor in nature) in various parts of the organisation resulted in a major fire that had serious safety, environmental and financial consequences.

6 The fire caused considerable local anxiety. In view of this HSE undertook to publish the findings of the investigation. For the sake of brevity this report

concentrates on the defects which brought about the incident and the emergency actions taken, and omits reference to many perfectly satisfactory arrangements identified during the investigation.

7 The investigation revealed several lessons to be learnt not just for this particular company, but for the chemical industry in general and others. These are listed below.

Lessons

1 Warehouses and other premises where chemicals are stored should be designed and operated in accordance with current legislation and guidance published by enforcing authorities and industry. In particular, attention should be paid to the need for segregation of incompatible substances, the warehouse management system, safe operating procedures, fire detection and fighting methods as well as recording systems for ensuring the safe operation within the storage facility.

2 Companies should not neglect non-production departments, or warehouses in particular, when providing health and safety resources. Equal priority should be given to assessing risks in all areas and activities and resources allocated accordingly.

3 Safety policy statements should be re-appraised immediately following any significant company re-organisation and the revised policy statement should be issued to all employees promptly. The written job descriptions of managers should incorporate responsibility for safety and should correspond with the managerial duties described in the safety policy.

4 Companies should regularly monitor and audit their safety performance in storage facilities as well as compiling statistical data on accidents, ill health and incidents.

5 Targets for good safety performance in storage facilities should be set by companies as part of a safety planning strategy.

6 Safety related maintenance or engineering requests should be specifically identified and given the necessary priority. Engineering management should monitor outstanding requests to ensure that they are dealt with within an appropriate timescale.

7 Managers, supervisors and operators of chemical warehouses should receive adequate training in their duties and specifically in respect of the placement and segregation requirements for chemical storage. Records should be kept of the training given to each individual member of staff.

8 Companies should summon the emergency services immediately when incidents

occur which have the potential to escalate. This procedure should be incorporated in the emergency plans.

9 At major hazard sites equipped with public warning sirens agreement should be reached between the company and the emergency services on the circumstances in which the alarm can be sounded and who can order its sounding. This procedure should be written into the off-site emergency plan. Companies should ensure that means of public warning are effective and reliable and that back-up power supplies are provided if necessary.

10 Statutory off-site emergency plans should state clearly the immediate actions needed to prevent or mitigate environmental contamination during or after a major accident, and which body has responsibility for undertaking them. There should also be provision for giving advice and necessary information to relevant bodies and the public.

11 Companies should ensure that they are able to advise emergency services and other relevant public authorities of the potential toxicity of products of combustion from mixed chemical fires on their premises.

12 It is recommended that HSE in conjunction with other interested parties should develop guidance on the control of fire water run-off at major hazard sites.

13 Sites where fire water run-off could create a major environmental accident should consider with relevant bodies how best to contain fire water run-off or to mitigate any effects run-off might have.

14 Major hazard sites should pay particular attention to site congestion, not merely because of risks created during normal operation but when planning extension of or modifications to existing plant.

THE COMPANY AND SITE

8 Allied Colloids Limited, part of the Allied Colloids Group PLC, was founded in 1935 and moved to its present site in Low Moor, Bradford in 1953. The company produces speciality chemicals, notably polymers for use in effluent and water treatment, in the manufacture of paper, paint, textiles and agricultural pesticides. It stores and handles a wide range of hazardous chemicals and is a top tier major hazard site (see paragraph 113).

9 One thousand nine hundred people are employed at the Low Moor site which occupies an area of 13 hectares (32 acres) being bounded by Cleckheaton Road, New Works Road and Chapel Road. The Atlas Interlates Division which manufactures pesticides and the Fine Chemicals Division occupy a further five hectares on adjacent sites. The entire complex is located within Bradford

Metropolitan Council and its southern boundary borders on Kirklees Metropolitan Council. (See map at the back of this report).

10 Residential housing is located immediately to the north, east and south west of the site while further industrial development exists in the south and north west.

11 For security reasons substantial perimeter fencing marks the site boundary. Access on to and egress from the site can only therefore readily be gained through the perimeter gates identified on the site plan (See map at the back of this report).

The raw materials warehouse: X-Bay and J-Bay

12 The raw materials warehouse (RM warehouse), the seat of the fire, was opened in July 1989 at the west end of the site. To the east of the warehouse were two external chemical drum storage areas known as X-Bay and J-Bay and the finished goods warehouse incorporating H-Bay. To the south was the 'fire block' where drums of flammable liquids were stored and beyond that, about 150 m from the RM warehouse, were six bulk storage tanks of acrylonitrile, a highly flammable toxic liquid, and a bulk storage tank of methyl chloride, a liquified flammable gas. The RM warehouse abutted the site boundary fence and was only 100 m from the nearest housing in Short Row.

13 The RM warehouse and X-Bay which were destroyed in the fire were originally intended for the storage of non-flammable raw materials, in particular bagged solid materials and some flammable finished goods. Subsequently important changes occurred in storage practice (see paragraph 83 'Storage arrangements'). On the day of the fire the RM warehouse contained 936 tonnes of chemicals, X-Bay stored 712 tonnes and J-Bay stored 1050 tonnes. A total of approximately 450 different chemicals were being stored. Six people worked full time in the RM warehouse.

14 Within the north east corner of the RM warehouse were two fire resisting store-rooms - No 1, designed for oxidising products, and No 2, originally designed for flammable products. Later, these became widely known as No 1 and No 2 oxystores. Each store had floor dimensions of 8.5 m by 5.6 m with block work walls extending on all sides to the underside of the pitched steel roof of the building. This roof consisted of PVC coated galvanised sheet steel 0.7 mm thick with a 60 mm inner glass wool insulation lining. The joint between the block work walls and the underside of the roof was sealed by 1.5 m wide slabs of a low density vermiculite-type fire insulation material.

15 Both oxystores were provided with two louvred ventilation grilles, measuring 1220 mm square and positioned in the rear wall to provide high and low level ventilation. There was also a roof light in each oxystore measuring approximately three metres by one metre. (See diagram on p6 for other dimensions and the racking layout.)

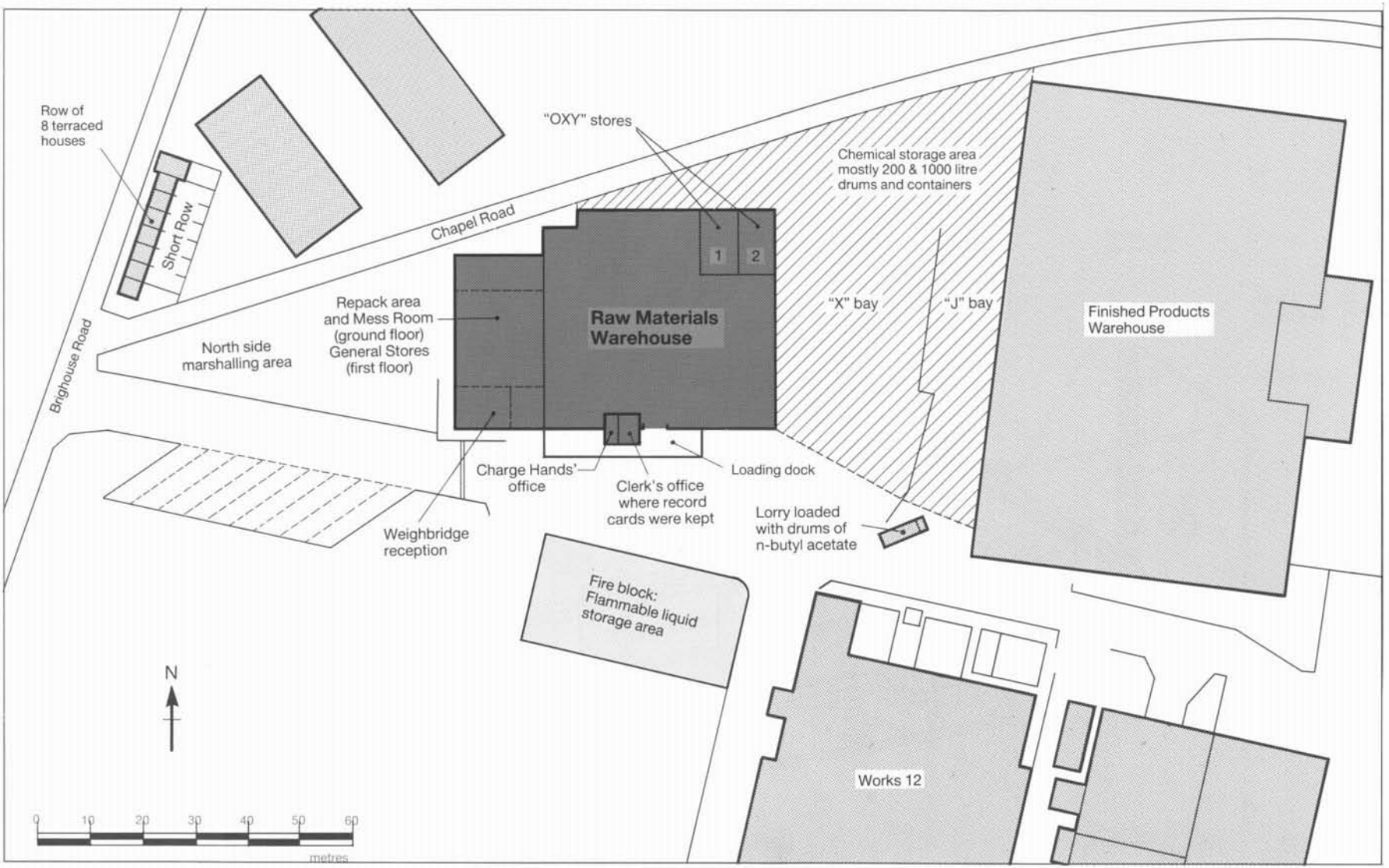


Figure 1: *Schematic plan of raw materials warehouse and surrounding area.*

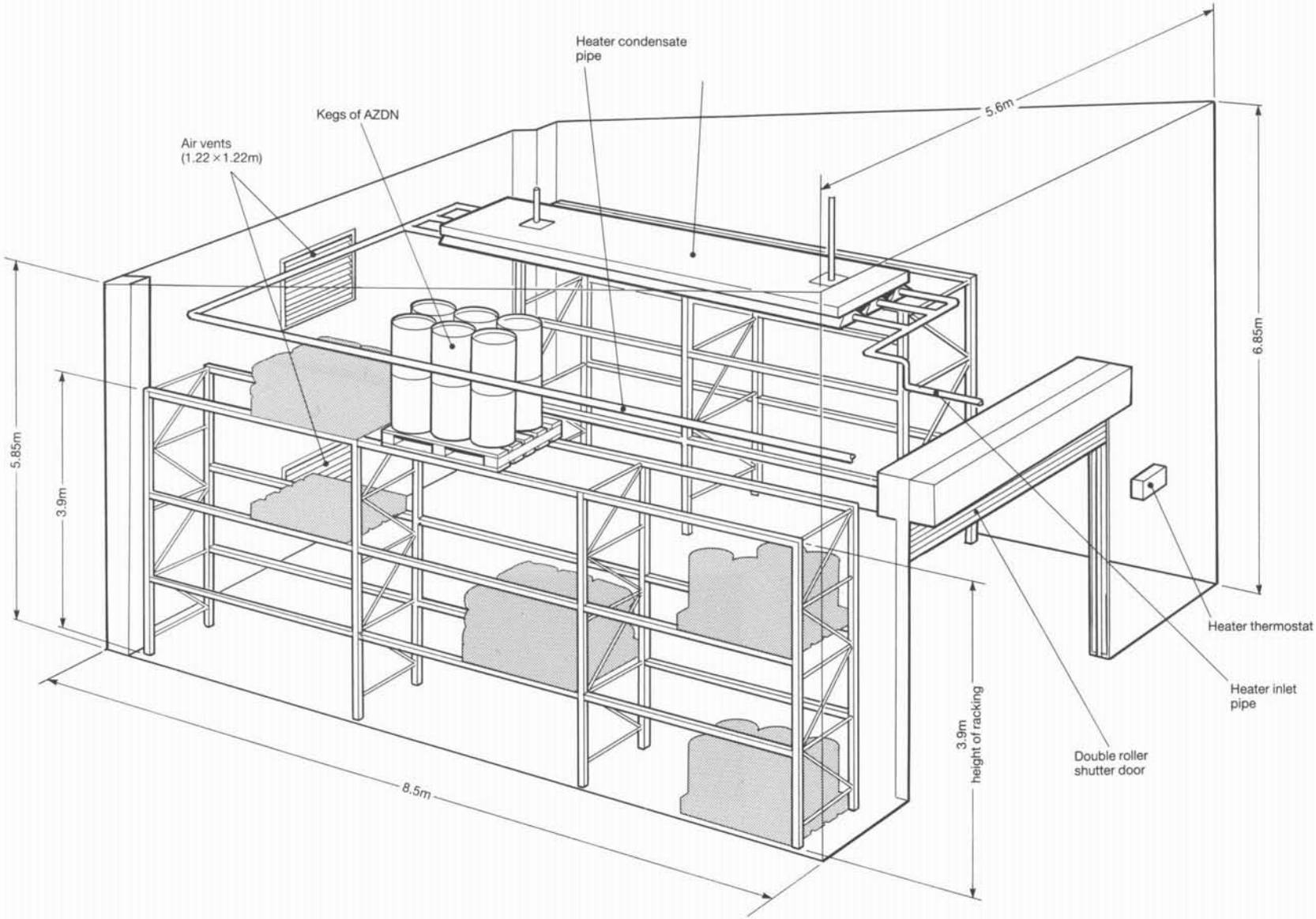


Figure 2: *Oxystore No 2.*

16 No 2 oxystore was originally designed for frost sensitive products, therefore when it was constructed it had a steam heating system consisting of a six metre long radiant panel type heater installed at high level. The heater was supplied with steam at around 4 bar through a 40 mm line with an isolation valve and a 40 mm solenoid piston valve controlled by a flameproof thermostat mounted on the right hand door pillar within the storeroom. The condensate return line was in 20 mm pipe and ran along the left hand wall five metres above floor level, ie corresponding to a pallet load on the top shelf. During heater operation, the temperature of this unlagged pipe has been calculated to be 90^{o} +/- 5^{o}C.

17 Entry to No 2 oxystore was through two independent roller shutter doors giving an aggregate fire resistance of six hours. The doors were designed for fork-lift truck entry and the inner door was normally in the raised position, thereby reducing the effective fire resistance to three hours. Neither of the doors had a fusible link closure device to automatically close the doors in the event of fire. It should be stated that such devices are not a requirement although they are desirable in stores of this kind.

18 In the main warehousing area there were a number of steam heater blower units. None were located in the oxystores.

Figure 3: *Raw materials warehouse before the fire. The closed roller shutter door of Oxystore No 2 can be seen.*

THE FIRE

19 The major chemicals stored in No 2 oxystore on 21 July 1992 is shown in the table, with approximate quantities:

Name	*Acronym*	*Class*	*Package type*	*Size*	*Quantity in tonnes*
Azodiisobutyronitrile	AZDN	Flammable solid	Fibreboard kegs	25 kg	1.9
Ammonium persulphate	APS	Oxidising	Plastic sacks	50 kg	12.0
Sodium persulphate	SPS	Oxidising	Plastic sacks	50 kg	5.2
Other oxidising agents (mainly nitrates)	-	Oxidising	Kegs and sacks	various	6.0

Other chemicals were stored in smaller quantities.

20 At 0900 h on the morning of 21 July an order was received for four fibreboard drums (kegs) of AZDN and seven bags of SPS. The warehouse man fulfilled this order from the stocks held in No 2 oxystore by 1000 h. He closed the roller shutter door.

Figure 4: *The loading bay side of the raw materials warehouse with collapsed walls and canopy, and molten flaming chemicals flowing down the ramp. Courtesy of West Yorkshire Fire Service.*

Figure 5: *Fork-lift truck caught in the inferno in J-Bay, and burst metal drums in the foreground. Courtesy of West Yorkshire Fire Service.*

21 Earlier that morning it had been raining and although rain gave way to sunshine, the warehouse floor had become wet because of the movement of the lift trucks. An electrician was asked to switch on the steam heated blower heaters to dry out the moisture. After looking at the control panel he left, having failed to override the thermostat. Although the contactor for the heating system in No 2 oxystore was in the same panel, the electrician said he had not touched it.

22 At around 1330 h a lift truck operator was working outside the rear of the RM warehouse when he noticed what he thought was white smoke coming from the lower vent of No 2 oxystore. He immediately set off the fire alarm at the front of the building and raised the alarm using the emergency internal phone number. The internal fire team turned out, together with five senior managers, including the safety manager.

23 A member of the fire team was the first to look into the store while others were arriving. He raised the electric roller shutter door a short distance and saw that two or three kegs of AZDN had ruptured, spilling their contents onto the floor and lower shelves, creating a dust cloud. There was no fire. The situation was further assessed by the safety manager, shift chemist and others, with the roller shutter door being opened approximately a metre high and then closed. The vermiculite-like ceiling insulation slab was damaged above the AZDN kegs.

A piece about 300 mm long had broken off and was lying on the floor. A circular indentation corresponding to a keg lid was visible in the slab remaining in position.

24 The internal fire crew unrolled their hoses, after putting a fire appliance by the nearest exit door on X-Bay. The situation was judged to be under control and some of the company staff who had come to the scene dispersed. The temperature within the store was described as ambient (around 18-20^{o}C). Those remaining at the scene discussed how the spillage could be best cleared up.

25 After referring to the supplier's hazard datasheet for AZDN a decision was made not to use water and a type H vacuum cleaner for toxic dusts was thought to be suitable. There was a delay while confirmation of this course of action was sought from the suppliers by telephone and a vacuum cleaner was obtained. At around 1410 h some employees in the Allied Colloids' office block saw what they thought to be white smoke issuing from the ventilators at the rear of RM warehouse. This probably indicated that a further AZDN keg had ruptured and dust was leaking out.

26 Around 1415 h the shift chemist looked into the store through the roller shutter door. In addition to the dust contamination he heard a loud hissing noise. A plume of smoke or vapour was coming out from a bag of SPS located roughly below the split AZDN kegs. He knew that something was seriously wrong with the bag but before he could get a hose to douse it with water, the plume of vapour ignited and became a jet of flame about 300 mm long. Within a second or two the flame was followed by a flash which was transmitted all around the room.

27 The shift chemist started to make his escape but within about four paces heard a bang and was blown over. Everyone in the vicinity of the store was now running from the scene. The safety manager was on the loading dock at the time and recalls hearing a whoosh and the sound of falling debris. He ran into the warehouse to find people running from the scene and looked into the storeroom through a door opening which he estimated to be around one metre high. Inside the store on the floor about two thirds of the way to the back wall was an intense burning mass like a large firework. Attempts were made to tackle the blaze but further minor explosions occurred and employees were driven back.

28 The last person in the warehouse saw fire escaping from the junction between the walls of No 1 oxystore and the underside of the roof.

29 Those at the scene of the incident had fled in the direction of the gatehouse at No 9 Gate. The fire service was called at 1422 h and the first appliance arrived from the local Odsal Fire Station only a short distance away by 1428 h. Thick black smoke and flames were escaping from the roof in the vicinity of the store-room and the quantity of smoke rapidly developed as the fire gained a swift hold, spreading to the external drum storage at X Bay. A 25 km/hr wind was blowing

at ground level from slightly north of west (280^{o}) causing the black cloud of smoke to drift eastwards, affecting the traffic flows on the M606 and M62 over two miles away. Eventually the smoke could be seen from Leeds City Centre, some 16 km away.

30 The site emergency plan was activated and employees from many parts of the works were instructed to congregate at the permanently manned Gate 5 exit on the south side of the site. As the fire developed it was recognised this area could be affected by smoke and the employees were moved to the enclosed car park of Atlas Interlates Division across New Works Road. Later they were moved to a public house car park to the west. This involved the wire fence of Interlates car park being cut as there was no convenient exit in that direction. There was no risk of those in the car park becoming trapped.

31 Some employees, eg in Finished Goods and the Drumwash Department made for Gate 7 only to find that this unmanned and normally closed gate was locked. Although a clear route existed away from the fire to Gate 1 they were released by cutting through the perimeter fence. With this exception all employees were evacuated from the site smoothly.

THE EMERGENCY

32 Following the arrival of the first fire-fighting appliance at 1428 h more appliances came until at the peak of the incident there were 36 fire appliances and 173 fire-fighters led by the Deputy Chief Fire Officer. Considerable difficulties were experienced in obtaining an adequate water supply as the water mains in the area were incapable of supplying the fire-fighting needs of a large fire. The company had been aware of this and there had been discussions with the fire service but a suitable alternative had not been provided. Water was obtained from Royds Hall Dam (900 m to the west) and Rigbys Wire Works (500 m to the north east).

33 Foam was also used at the fire, including all of the stocks held by the company. It was applied to X and J-Bays before they were involved in the fire to prevent or slow fire spread from the RM warehouse to drums stored externally. However, foam was unsuitable for cooling the finished goods warehouse and drums of flammable liquids held in the fire block storage area. These operations consumed substantial quantities of water. The company fire crew remained on the scene fighting the fire and were also engaged in cooling drums on the fire block.

34 Fire officers had made early contact with the company's incident controller and had strongly advised the sounding of the emergency siren provided by the company to warn the public and employees in the event of a major accident. This advice was initially not acted upon. However further discussion and the continued escalation of the incident led to the siren being sounded at 1455 h.

It continued to operate until 1540 h when power to the whole site was cut off by the electricity board because the fire was threatening the main sub-station. The loss of power also caused a shut down of the company's effluent pumps and the escape of contaminated fire water from the site boundaries.

35 The fire was finally contained at about 1740 h. Power was restored to the site at 2045 h, which enabled the siren to be sounded to stand down the emergency, but this caused some initial confusion to those on site and to some members of the public.

36 Police control received an emergency call at 1428 h and an officer was despatched from Odsal Police Station at 1432 h. He quickly requested reinforcements and public address cars were requested at 1517 h and deployed at 1522 h. These toured the area, warning residents to stay indoors and close

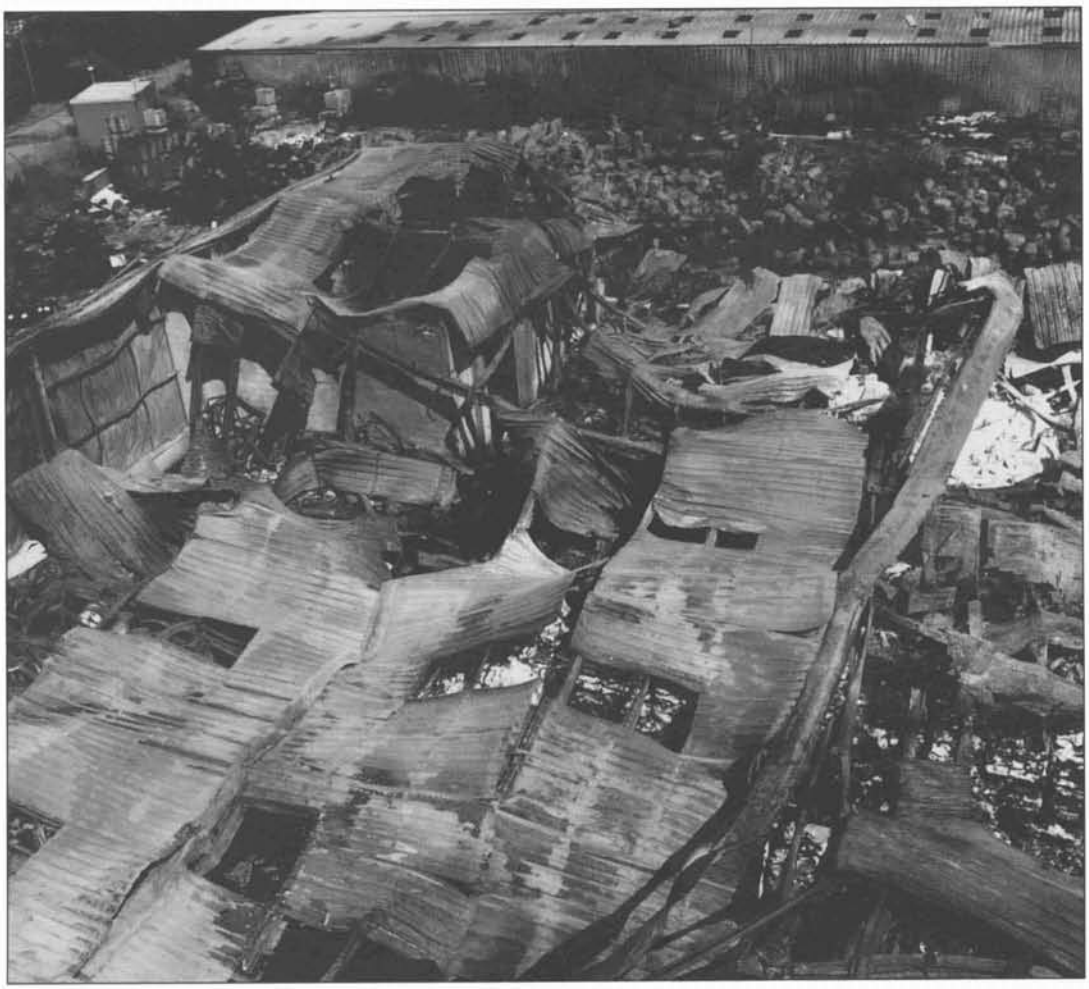


Figure 6: *The burnt out raw materials warehouse showing collapsed roof, and remains of the oxy-stores at the top left of the building. The scorched finished goods warehouse lies behind the open drum storage areas (X and J-Bays).*

windows and doors. As the fire developed and rush hour traffic began the police experienced increasing traffic flow problems, not only on the local service roads but on the M606 and M62. The dense smoke cloud resulted in visibility being reduced to a few metres within the immediate vicinity of the factory.

37 Although upwind of the fire, the police decided to evacuate the eight properties in Short Row, because of their proximity to the RM warehouse - the nearest house was only 100 m away. This was achieved by 1632 h. The residents were allowed back at 1945 h but most decided to stay away overnight because of the noise of fire service pumping appliances.

38 At 1445 h smoke from the fire alerted the Bradford Metropolitan Council's environmental health officers. The first of many enquiries from the public was shortly thereafter received, and the council emergency planning officer was notified. Initial arrangements began for possible large scale evacuation to a nearby sports centre. Neighbouring local authorities offered assistance. The Bradford Council response was co-ordinated by senior officers, including the chief executive. The Lord Mayor visited the Council Emergency Control Centre at City Hall.

39 The fire service finally stood down on 8 August, 18 days later because of the on-going risk of re-ignition during the cleaning up operations.

Figure 7: *Burnt out entrance to raw materials warehouse with solidified chemicals from storage inside. The door of the office where the records were kept is to the right.*

INJURIES AND DAMAGE

40 Despite the scale of the incident no company employees were injured. Only one employee, the fork-lift truck driver who was the first to notice the escaping AZDN dust, reported that he felt unwell and was seen by the works nurse. He sought no further treatment.

41 Three members of the public were taken to Bradford Royal Infirmary, one being detained overnight. A local disabled resident suffering from a lung condition experienced an acute asthma attack and was admitted to hospital for a week. The attack appears to have been triggered by smoke inhaled before the warning siren alerted his mother to close the windows.

42 Shortly after the fire it was reported that 33 people had been taken to Bradford Royal Infirmary, including approximately 20 fire service staff. Six were admitted and kept in overnight, including two police officers. One officer, who had been directing traffic at the junction of Cleckheaton Road and New Works Road, directly in the path of the smoke, was subsequently absent from work for four months and one year later had still not made a full recovery. A total of 29 police officers reported ill effects.

43 Formal notification of absence from work of more than three days was subsequently submitted to HSE in respect of four fire officers and one police officer.

44 The RM warehouse was largely gutted. The remaining parts of the structure were so badly damaged that they were later demolished. X-Bay and J- Bay which contained drums and other containers of chemicals were completely burnt out. There was also considerable damage to the finished goods warehouse although the structure and contacts were left basically intact.

45 Hundreds of steel and plastic drums were destroyed in X and J-Bays and a few of the drums became projectiles during the fire. One was projected through the roof of the finished goods warehouse.

46 Several fork-lift trucks and a lorry loaded with 16 tonnes of n-butyl acetate, a highly flammable liquid, were destroyed. An empty solvent road tanker standing outside the warehouse without a driver when the fire started was moved at an early stage and did not become involved in the conflagration. Residents reported burning fragments being lifted by the updraft falling on neighbouring property. None of these started any further fires.

47 The serious potential for escalation of the incident was evidenced by numerous plastic drums on the fire block which were damaged by radiant heat. The fire service made a considerable effort to cool these containers of flammable liquids during the course of the fire and successfully prevented their ignition. The fire

Figure 8:
Plastic drums on the fire block flammable liquid storage area showing heat radiation damage and effects of pressurisation.

caused some drums to melt partially or balloon out as a result of overpressurisation. Had drums in this area ignited, the fire would have spread across the fire block in the direction of the bulk storage tanks containing 600 tonnes of acrylonitrile, the 40 tonnes methyl chloride tank and production areas.

POLLUTION EFFECTS

48 Although the ground level wind speed gradually abated during the afternoon, falling from 25 km/hr to 16 km/hr, the black cloud of smoke drifting eastwards gave rise to general concern about environmental pollution and the toxicity of the smoke cloud. Although Allied Colloids Ltd had publicly stated on the day of the incident that the smoke was non-toxic, it was in fact smoke from a burning cocktail of over 400 chemicals and only some of them would have been completely destroyed by the heat of the fire. In such circumstances it would be impossible to determine the constituent materials and confirm or allay public concern. The CIMAH siren was intended to warn residents to keep their windows and doors shut and to stay inside. Motorists at the Hartshead Moor M62 service

Figure 9: *The smoke plume from the west. Courtesy of West Yorkshire Police.*

area were also warned to keep their windows shut in case the smoke was toxic. In addition to the smoke, clear sticky deposits which were alkaline in character fell on surfaces up to 400 m from the site. Soot particles from the smoke cloud were found as far away as 10 km.

49 As the smoke cloud abated members of the public questioned the effects on garden vegetables and property. HSE liaised with Bradford and Kirklees Environmental Health Departments which took samples of vegetation, vegetables and firewater run-off. The samples were taken to both independent and company laboratories where they were analysed over the next few days. Inevitably there was a delay while the tests were being conducted, particularly for some of the complex tests, eg dioxin. When the test results became known they did not indicate any unsafe levels of dioxins and polyaromatic hydrocarbons in vegetables and other vegetation.

Figure 10: *Smoke and flames rising from the Allied Colloids fire. Courtesy of West Yorkshire Police*

50 During the days following the fire, precautionary advice was given to residents by the local authority's environmental health officers and the company not to eat fruit or vegetables from the vicinity of the factory where they may have been contaminated. The public was also warned to keep away from the Spen Beck watercourse because of the presence of toxic substances. Bradford Council erected warning signs near the beck to this effect.

51 The fire service notified Yorkshire Water Services and National Rivers Authority (NRA) of the incident at 1545 h, warning them to expect a large volume of water run-off from the fire-fighting operation, and thereafter updated them on several occasions. As the water flowed away from the immediate area of the fire it carried with it large volumes of unburnt chemicals from ruptured drums and other damaged containers. Most of this contaminated water ran into the drains

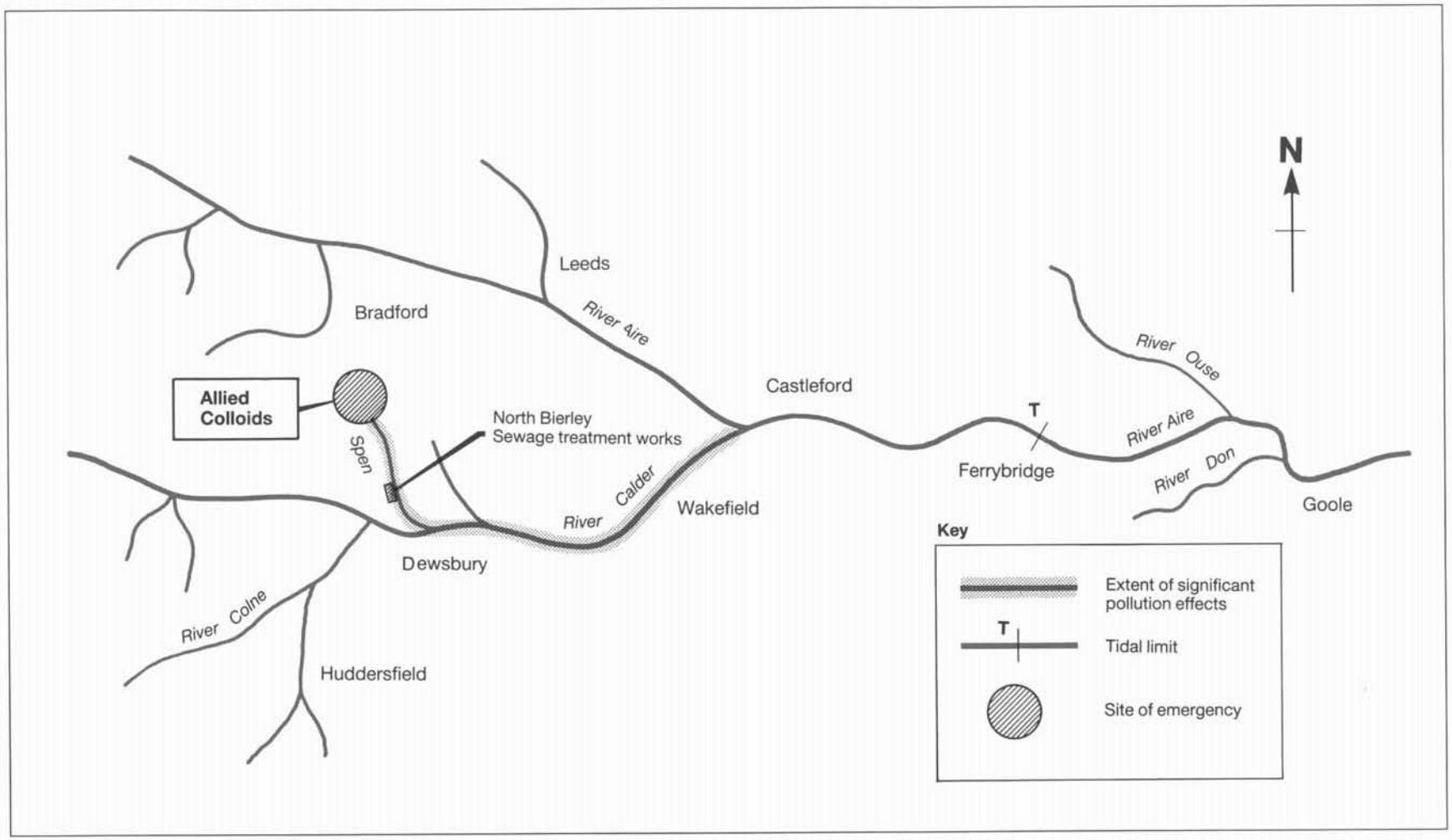


Figure 11: *Water courses in the vicinity of Allied Colloids.*

and then to North Bierley sewage treatment works, but a small proportion entered Spen Beck directly. At the sewage works the water, together with the raw effluent which is the normal flow, were diverted into the storm water tanks. This was done to protect the sewage treatment beds which would otherwise have been poisoned and put out of action for up to six months.

52 By 1730 h the storm water tanks were full and the water company had no alternative but to allow them to overflow into Spen Beck. This continued for 24 hours taking heavily polluted water into the River Calder followed by the Rivers Aire, Ouse and Humber.

53 The NRA monitored the biological activity of Spen Beck and the Calder and Aire Rivers over a period of three weeks. The first dead fish were sighted three days after the fire in the Calder. This and later observations confirmed that serious damage had been caused to aquatic life over a 50 km stretch of waterway. In addition to dead and distressed fish counts the NRA monitored the effect on invertebrate life and carried out other tests including a generic test of toxicity to micro-organisms.

54 The water entering the rivers was characterised by heavy suspended sediment, very large biochemical oxygen and chemical oxygen demands (BOD and COD) and very high levels of detergents and solvents. This meant that fish and

Figure 12: *Sludge which flowed into sewers and rivers, causing pollution. Courtesy of West Yorkshire Fire Service.*

invertebrates were killed not only by the chemicals but also by the crude industrial and sewage effluent which needed to be released when the storm water tanks overflowed. By extrapolating the numbers of fish killed on the sections of the rivers where counts were done, the NRA estimated the total number of fish killed to be about 8000 in the Calder downstream of Wakefield and 2000 in the portion of the Aire that was affected. Invertebrate populations were also significantly affected, with large numbers of hog water lice and leeches killed and survivors showing behavioural abnormalities.

55 The number of fish is not considered large for the length and size of waterways affected because their initial water quality was not high. Spen Beck had no fish life and was classed in the lowest category (Class 4). Although it is difficult to accurately monitor fish kill and assess environmental impact it is likely that fish stocks, where present, were severely reduced or eliminated from nearly 40 km of the Calder (a river whose quality was improving) and there was additional damage for a further 15 km down the Aire. In terms of the proportion of the population of the fish and other aquatic life destroyed, the incident had serious environmental consequences. The NRA had been striving to improve water courses in the area to at least Class 2 in order to provide a fishery; this accident seriously set back its attempts.

56 The Joint Nature Conservation Council (JNCC) on behalf of the Department of the Environment (DoE) assisted HSE during the investigation by assessing the environmental consequences of the accident.

HSE'S INVESTIGATION

57 HSE's area office based at Leeds was first informed of the fire by Allied Colloids Ltd at 1505 h. Further information was obtained and it became apparent that an investigation on a considerable scale would be required. The area director activated the area's major incident plan. Two inspectors from HSE's area office's chemical group and a specialist (chemical) inspector prepared to leave immediately but because of the considerable traffic congestion were unable to reach the site until 1730 h.

58 By the next day, 22 July 1992, an HSE investigation team was assembled; it was led by chemical group inspectors and supported by three specialist inspectors and two scientists, plus experts on fire and explosions from the Research and Laboratory Services Division (RLSD).

59 As a precautionary measure a formal notice was served on the company under Section 20(2)(e) of the Health and Safety at Work etc Act 1974 to leave the RM warehouse undisturbed. The notice was deferred until the fire service had completed extensive damping down operations and the structure was made safe to allow HSE forensic examination. This did not begin until 30 July, nine days

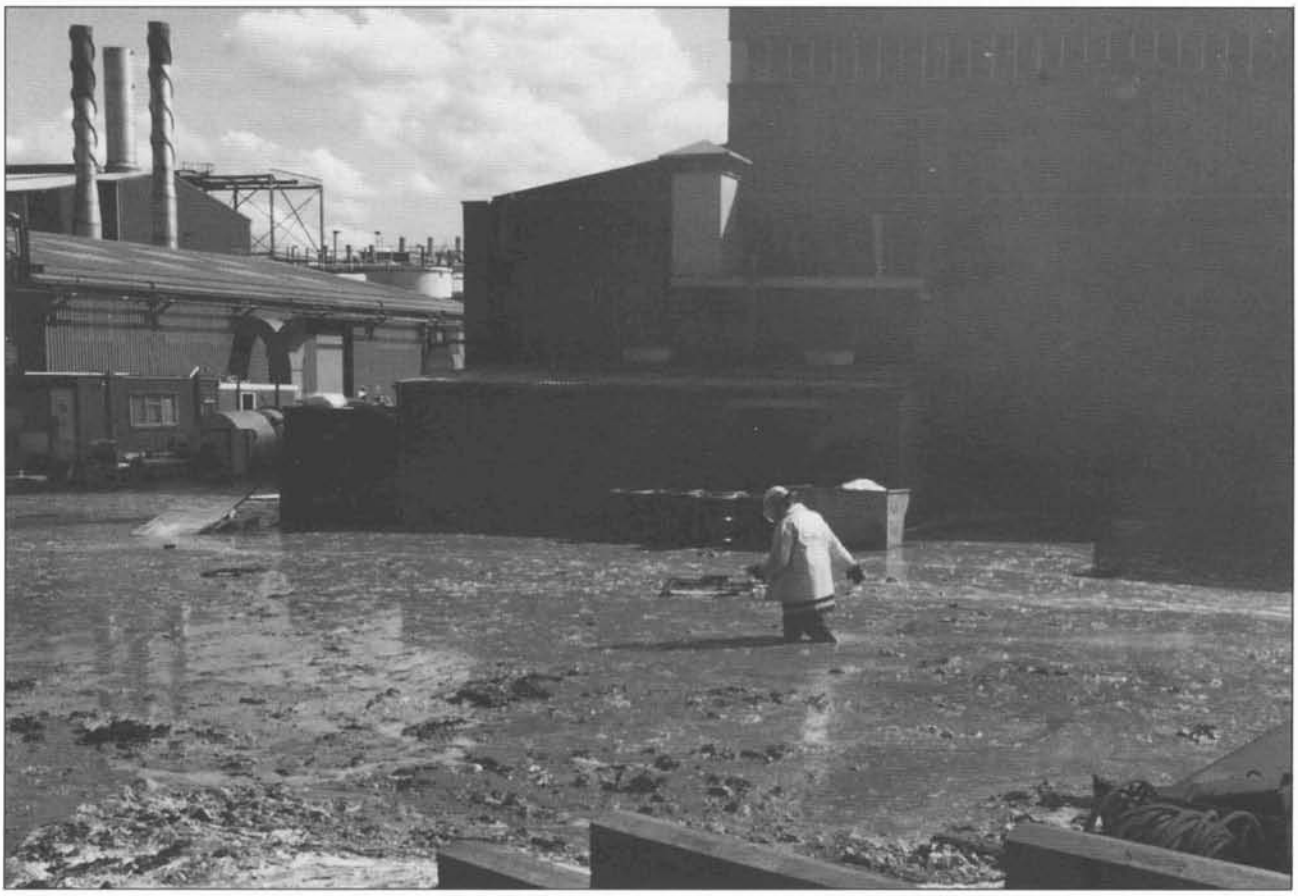


Figure 13: *Sludge-like mixture from fire-fighting water and materials from the fire affected areas which flowed downhill to the centre of the site and beyond. Courtesy of West Yorkshire Fire Service.*

after the fire, for safety reasons. By that time the notice had been amended to cover only the area around the two oxystores within the RM warehouse to allow the collapsed roof to be removed and to allow clearance of the remaining chemicals within the warehouse to begin. In itself this was a hazardous operation leading to a number of small outbreaks of fire and an incident where fumes were released from damaged drums of phosphorus pentoxide.

60 Although there were numerous witnesses in the warehouse at the time the fire broke out who were able to provide good evidence of the initiating events, the complexity of the investigation was increased by the inability to gain access to the damaged structure. There was also considerable initial uncertainty over the list and quantity of chemicals involved in the incident. Investigation therefore immediately concentrated on the role of AZDN and samples were taken from two kegs in a batch of four which had been removed from the warehouse store on the morning of the fire. A further formal notice was served taking these kegs into possession and they were sealed so that samples could be removed by RLSD. The subsequent analysis did not reveal any contamination or unusual feature about the AZDN within the kegs.

61 The numerous employees who had been directly involved with the incident were identified and interviewed. The information gathered led to further interviews with other employees and senior managers who were identified as having responsibility for the company's health and safety performance. Altogether a total of 35 statements were taken.

62 From the start of the incident two process safety chemical specialists from HSE's local technical support group (the Field Consultant Group - FCG) were attached to the incident investigation team. Initially, their efforts were concentrated on gaining an appreciation of the range and quantities of chemicals involved and how and where they were stored. Of importance in this initial assessment was a consideration of the residual safety of the incident site as spilt chemicals and damaged containers were in abundance. Due to the reports of hindered movement of staff as a result of locked gates during the incident, an appraisal of the exits needed from the site and other associated fire precautions (fire drills, training etc) was carried out.

63 The scientific investigation by RLSD examined the properties and interaction between the materials stored in Oxystore No 2 and the nature of the products of combustion and the general spread of the fire. Extensive studies were carried out on a number of samples of AZDN from the site, all of which indicated the material was within the manufacturer's specification, and confirmed its flammability and ease of decomposition under thermal and impact stimuli. The experimental work also indicated significantly enhanced burning rates for AZDN in the presence of peroxydisulphates (persulphates).

64 The RSLD investigation also examined potential sources of heat capable of raising the temperature of part of the contents of one or more AZDN kegs to the point where sufficient material would decompose and cause that package to fail. It looked at the failure characteristics of the kegs (namely the failure pressure and velocity of the projection of fragments) and the spread of the fire through the warehouse. A technique known as computational fluid dynamics was used to help quantify the heat sources. The nature and location of combustible materials and building fire resistances were ascertained and used as the basis for examining how the fire spread.

65 Allied Colloids Ltd did not recognise any trade union for negotiating purposes although each department had a joint health and safety committee. Two employee representatives were contacted in the early stages of the investigation and acted as employee links with HSE's investigation team.

66 The intense local media interest centred not only upon the cause of the fire but upon a wide range of issues including the effects of air and water pollution, the similarities between AZDN and cyanide and the toxicity of the smoke. HSE press statements were issued on 22 July, 23 July and 30 July to keep the public informed and many interviews took place.

67 There was much public concern and many calls were made to the HSE office by members of the public, although most calls were received by the Bradford Environmental Health Department (which drafted in extra staff to deal with them) and by Kirklees Council. The company also set up a help line and issued several press statements. Members of the public were interviewed by HSE inspectors to assess the off-site effects and a number of households including two on Short Row were visited. A meeting of the Community Liaison Group (see paragraph 110) was also attended by a member of the investigation team.

68 There were several demands for a public enquiry and concern was formally registered with HSE by Mr Bob Cryer, (MP for Bradford South), Mrs E J Peacock, (MP for Batley and Spen), local councillors, the chief executive of Bradford Metropolitan Council and other organisations and individuals. On 30 July HSE announced that it would make public the results of its investigation. On 31 July Mr Cryer, MP came to HSE's area office to meet the investigation team. A further commitment was given in October that HSE would publish the findings of the investigation following the completion of any formal enforcement action that might ensue.

69 The Emergency Planning Unit of West Yorkshire Fire and Civil Defence Authority hosted a meeting to discuss the functioning of the statutory off-site emergency plan. HSE spoke to those concerned with the pollution and off-site effects, including the two local authorities, local health authorities, NRA, the Department of the Environment and Joint Nature Conservation Council.

70 HSE also met and considered representations from the chief executive of the City of Bradford Metropolitan Council in relation to such matters as emergency warnings, planning consultation zones and the scope of the CIMAH Regulations (see paragraphs 113 to 117).

71 It is estimated that the investigation phase took 250 staff days of HSE time at a cost of £55 000 in staff time alone.

72 As well as co-operating fully with HSE, the company also set up its own internal investigation team on the day of the fire. It conducted a number of experiments with a view to explaining the initial events of the fire, including possible sources of ignition. A computer generated three dimensional model proved useful in assisting witnesses in their recollection of the events.

73 Other formal investigations were carried out by the West Yorkshire Fire Service, NRA, JNCC and the City of Bradford Metropolitan Council in relation to their spheres of interest.

CAUSE

74 HSE investigations concentrated initially on the identification of the exact cause of the fire. The inquiry focused on AZDN and upon the two oxystores in the RM warehouse containing oxidising chemicals. It was soon established that the stores were not being used solely for their original purpose. No 1 oxystore contained not only 4.4 tonnes of organic peroxides (a class of compounds which possess oxidising properties and are capable of undergoing violent decomposition) but also 0.8 tonnes of VAZO-67 (2,2'-azobis [2-methylbutyronitrile]), a flammable solid with similar properties to AZDN. No 2 oxystore contained 25.4 tonnes of chemicals, of which nearly 21 tonnes were persulphates (see paragraph 19). Persulphates, which are oxidising agents, were stored together with 1.9 tonnes of AZDN. Azodiisobutyronitrile (AZDN) is a self-reactive substance which is thermally unstable and is capable of undergoing violent decomposition at relatively low temperatures (the self-accelerating decomposition temperature for a 25 kg package is 50^{o}C). It is a flammable solid, and the ignition of a dispersion of the dust in air can result in an explosion. AZDN (and other flammable solids) as well as oxidising agents such as persulphates are incompatible and should not be stored together.

Figure 14: *Drum storage areas at X and J-Bays looking towards finished goods warehouse. Contaminated water can be seen flowing from the area.*

75 Despite the original intention that X-Bay was intended for non-flammable materials, in practice it contained a large quantity of combustible materials in drums, including some toxic materials and approximately 67 tonnes of highly flammable liquids.

At the time of the fire stocks in various storage areas were as follows:

Site	*Tonnes*	*Comment*
Oxystore No 1	5.7	Including 4.4 te organic peroxides and 0.8 te VAZO 67 (flammable solids)
Oxystore No 2	25.4	Including 1.9 te AZDN and 23 te oxidising agents
Other parts of RM warehouse	905	Including 45 te solid acrylamide (toxic)1.9 te self reactive flammable solids and 325 te inorganic salts
X-Bay	712	Including approximately 67 te highly flammable liquids and 10.4 te benzyl chloride (toxic liquid)
J-Bay	1050	Mainly aqueous mixtures of organic polymers (and some alcoholic formulations), plus lorry with 16 te highly flammable liquid

76 The incident started when two or three kegs of AZDN ruptured. These were stored on the top shelf of the racking, close to the steam condensate return line and a roof light panel. The sun would not have been shining directly on the kegs and it is concluded that a malfunction of the steam heating system or operator error caused the condensate pipe to be hot. Adding weight to this theory is the knowledge that the floor had become wet during the morning and that an attempt was made to turn on the steam blower heaters to dry the floor; the controls for No 2 oxystore heating panel were in the same control box to which the electrician had been called. (See paragraph 21).

77 If the AZDN had been stored separately from oxidising substances it is unlikely that the incident would have developed further. As it was, powder from the ruptured kegs was scattered over the lower shelves which consisted of two beams which were not completely boarded out. Knives were used for quality control sampling and for removing outer shrink wrapping from bags of oxidising substances and persulphate may have spilled from inadequately resealed or accidentally cut bags. AZDN in contact with persulphate is likely to have been ignited by impact, possibly from a lid and associated metal ring closure from one of the damaged AZDN kegs falling onto a bag, or to the floor. A keg lid falling from the top shelf would create sufficient impact energy in theory to ignite the mixture.

78 Tests with AZDN conducted by RLSD have indicated that it is impact sensitive and that the ease of ignition and rate of flame spread are both significantly increased when AZDN is mixed with sodium, potassium or ammonium persulphate.

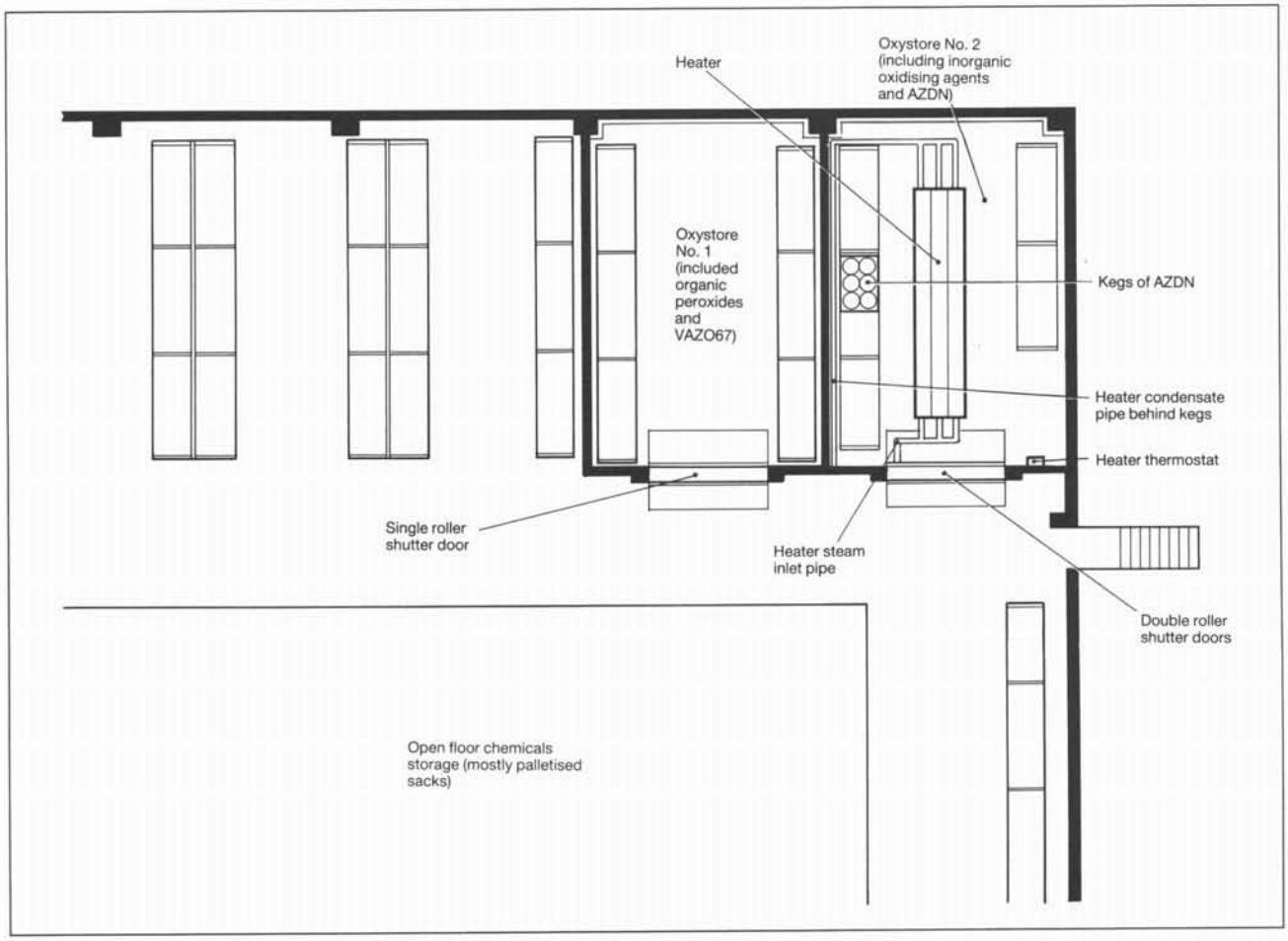


Figure 15: *North east corner of raw materials warehouse.*

79 After the ignition there was probably a small dust explosion followed by a second and larger dust explosion which knocked the shift leader off his feet. One of these explosions lifted the roof and the fire transferred quickly to No 1 oxystore where about 4.4 tonnes of organic peroxide were stored together with 0.8 tonnes of the flammable solid VAZO 67. This would have generated an extremely intense fire which would rapidly spread to some of the combustible raw materials in the rest of the warehouse. Factors contributing to the rapid spread were the open outer door of oxystore No 2 and the lack of a fusible link or other suitable closure device on the inner roller shutter door. Also mixed dusts from earlier weighing out operations in the warehouse which had accumulated on ledges and wall tops may have ignited, causing a linear spread of flame. No fire protection sprinklers were provided.

80 Examination of the oxystore 200 mm thick blockwork walls after the fire revealed that they had not been fully keyed into the building support pillars, and in one place adjoining X-Bay a sizeable area of infill wall section had fallen out. This and the presence of stored chemicals up to and against the warehouse wall added to the rapid spread to X-Bay, where there were a number of flammable materials. These included 25 tonnes of highly flammable recoverables (wet xylene from process areas, containing on average of 90% xylene for reprocessing) and possibly 42 tonnes of other flammable liquids. Although the store was nominally built to a standard specified in BS476 (*Fire tests on building materials in structures*), this standard is not designed to cater for explosions or the intense furnace type heating to which the walls and other building components were exposed.

81 Most of the materials on J-Bay were of low combustibility but a parked lorry loaded with 16 te of n-butyl acetate (highly flammable) was ignited at an early stage which contributed to the fire spread to J-Bay. The principal mechanism of fire spread was by direct ignition, assisted by the strength of the wind and radiated heat. One feature of the fire was a slow moving flaming river of molten chemicals originating from the RM warehouse and augmented by material from X and J-Bays which flowed downhill towards the centre of the site.

82 Incidents with AZDN were not unknown at the plant. In 1982 there was a small flash when dry AZDN was fed into a charging vessel. After this incident it was mixed with water to form a slurry before feeding. A similar incident happened in 1990 within a process vessel. More significantly an incident had happened previously in the original RM warehouse, when a keg of AZDN on racking burst without causing a fire. Initially the proximity of a steam pipe was blamed but the manufacturers who investigated eventually concluded that this was too far away. The incident was not reportable and did not become known to HSE.

STORAGE ARRANGEMENTS

83 Before the construction of the RM warehouse in 1989 raw materials were chiefly the responsibility of individual departments, although certain common materials, including AZDN, were kept in an open plan warehouse at the centre of the site by the General Chemicals Department. A segregation policy existed with AZDN being separated from organic peroxides and other oxidising materials.

84 During 1987/88 a new RM warehouse was planned as part of ongoing work to upgrade warehousing throughout the site.

85 This planning was done initially by the administration director in isolation without any assistance from engineering or safety specialists within the company. The original drawings showed a simple open shed. At a late stage the building section of the engineering department and safety department were consulted

and changes were made including two three hour fire resisting stores for oxidising materials and frost sensitive flammable products. Advice on external access for the stores, spill retention and electrical zoning was given, but while some advice was adopted, other recommendations were not. There is little information on how decisions on safe design were reached and no final accurate 'as built' plan existed for the warehouse when it opened in July 1989.

86 After planning permission was sought HSE was consulted by the planning authority. Enquiries with the company met with the response that no substances subject to the CIMAH Regulations (currently in force - see the Appendix) would be held. HSE made no adverse comment about the application and planning permission was granted shortly afterwards.

87 No 1 oxystore was designed for oxidising substances and No 2 oxystore was designed for frost sensitive flammable products including finished goods. The fire resistance of the two oxystores was also subject to requirements from the insurance company which specified a fire resistance variously reported as between three and six hours. Although the manufacturer's data sheet on AZDN recommended sprinklers, these do not appear to have been considered and were not provided.

88 The RM warehouse manager appointed in July 1989 prepared and submitted documents to the safety department for comments. In particular there was a segregation table giving classes of substances (ie flammable, corrosive, oxidising etc) and an indication whether segregated storage was required. AZDN and VAZO 67 were categorised as oxidising agents. This was a crucial error. These substances are flammable solids and must not be stored with oxidising agents with which they form a 'gunpowder' type mixture. There were other mistakes in the documents and the information was general in nature and not site specific to the RM warehouse.

89 On 1 January 1990 a new logistics department became operational with the objective of improving stock control and distribution. The RM warehouse therefore became the responsibility of the logistics director. As the site had expanded, not only had health and safety problems arisen but there were also difficulties with the control of stock levels, stock ageing because of inefficient rotation, damage and deterioration of containers and their labels and associated problems of quality control and customer satisfaction. The open nature of the storage areas around the RM warehouse, particularly the fire block area, meant it was not possible to prevent the production department's lift truck operators entering the zone. Contaminated flammable materials sent for storage on the fire block before disposal, reprocessing or solvent recovery presented a particular problem.

90 During 1991 the storage room uses were changed because the demand for space for oxidising substances had grown, especially for persulphates. The flammable products were removed to the fire block outside and the oxidising substances were split between the rooms (now called oxystores) with the peroxides kept in No 1 oxystore and persulphates in No 2. Deliveries of palletised materials would be set down on the warehouse loading dock and then taken into the building by lift truck. The driver, a warehouse employee, would place them where similar materials had been stored previously or in accordance with guidance from his foreman. He would complete a slip of paper giving the storage rack number which would be handed to his stock controller who would enter the information on a card system kept in the warehouse office. On a daily basis information on quantities but not location would be transferred to the main office computer system. A monthly stock-taking exercise was also carried out.

91 During March and June 1991 a member of the safety department visited the RM warehouse to check inventories. The warehouse manager, who had been responsible since the warehouse opened, was informed of the need to comply with HSE guidance on the storage of chemicals. He discussed alterations with the electrical department and then submitted an internal works order on 30 September 1991 requesting Zone 2 flameproof lighting, temperature monitoring equipment, smoke detectors and the disconnection of the heater in No 2 oxystore. At his only visit to the warehouse an employee of the electrical department did not disconnect the heater but merely turned the thermostat to zero. The internal works order was placed in the low priority pile of outstanding work and at the time of the fire 10 months later none of the work had been started.

92 On 12 February 1992 HSE published updated guidance on the storage of packaged dangerous substances. The company was aware of this publication and its predecessor but the in-house storage guidance (see paragraph 88) was not updated. In any event these documents first prepared in mid-1989 were not passed on to the manager's successor on his appointment in May 1992 nor were warehouse staff from the senior foreman down aware of the documentation. Chemicals continued to be stored where they had always been kept, or if space was not available, somewhere else.

93 Some, but not all, of the instances of incompatible chemical co-storage were found during a site wide drum storage survey initiated by the environmental manager in January 1992 to look primarily at such issues as liquid spill retention. In April AZDN and VAZO 67 were found stored in No 1 oxystore together with oxidising agents while in No 2 oxystore organic peroxides were in similar juxtaposition to flammable solids and other substances. Interim action resulted in a minor reorganisation of the stores, but by the time the fire occurred there had not been enough time to act on the full survey report *Improving the environmental safety of drum storage* which was circulated 11 days before.

94 Annual internal health and safety inspections called safety audits were carried out by the safety department on the site. The RM warehouse was inspected in April 1990 and August 1991 and the reports commented on segregation, training, data sheets, and procedures. The August 1991 report was generally positive and stated that the segregation of hazardous materials to avoid dangerous reactions or accidental mixing had been completed. It is not known if this was erroneous or if conditions changed after inspection.

95 The company's insurers carried out periodic six monthly inspections. Additionally, an inspection by an insurance broker was conducted on 13 and 14 January 1992. Although the subsequent report and the latest insurer's report commented positively on a number of health and safety matters, both were critical of high accident rates and an unsatisfactory safety culture.

96 Even though it had been looking at several proprietary audit schemes for a number of years the company did not carry out formal safety auditing either through its own safety department or through external consultants.

97 Out of the 125 employees in the logistics department, no-one was a chemist or qualified in safety. No general management safety training was offered to managers in the department, except for a quarter day course for the logistics director which introduced the Safety, Health and Environment Policy, which he attended in late 1991. Although two three day courses on the management of safety were run by safety consultants the course was confined to managers in the production and engineering departments and nobody in the logistics department was aware of them.

98 Although the logistics director was unaware of any training being offered to supervisors within his department, two supervisors had started a course in January 1992, leading to a Certificate in Supervisory Management. No separate records were kept of the health and safety training given to supervisors or more senior management staff.

99 New warehouse hands were given induction training of about two days which included such aspects as terms and conditions and general health and safety. Specific job training, given by chargehands and foremen, was recorded in the training record. There was no training on the principles of chemical storage and segregation. There was an awareness of health and safety data sheets, although they were of variable quality and format. None of the warehouse hands were aware of any documents relating to placement or segregation of chemicals.

100 A start had been made in June 1991 in the writing of job descriptions, training manuals and updating training records for employees. When the employee concerned was transferred to other duties in April 1992 this work ceased.

MANAGEMENT OF HEALTH AND SAFETY

101 Allied Colloids Ltd is part of Allied Colloids Group PLC which is a multi-national company with its headquarters at Low Moor, Bradford.

102 The company has a large safety department which included four sections dealing respectively with general safety, chemical engineering, occupational health and environmental safety. Before the incident the safety manager reported to the research director and both sat on the Board Safety Group together with the engineering director, technical director and two production managers. The Board Safety Group which met without either written agenda or minutes had been chaired by the deputy managing director up to his death in May 1992 and another director, his successor, never effectively took up his appointment because he was on long term sick leave. Therefore the Board Safety Group did not meet after April 1992.

103 At the time of the fire the company had two Safety, Health and Environmental Policies (SHEP) in existence; that which was current at the time of the fire was signed by the managing director in June 1987, and therefore pre-dated the establishment of the logistics department. The deputy managing director was named as the director "with overall responsibility for co-ordinating safety matters through which the direction of the policy is channelled to line and service departments". Although he signed the policy the managing director had no further specific responsibilities written into the statement for health and safety. Other directors were given 'ultimate' responsibility for the formation of departmental policy and the delegation of duties. It is noteworthy that the warehouse/transport manager had stated responsibilities which were confined to materials handling equipment only.

104 On 29 October 1991 the managing director signed a revised SHEP after discussion with the Board Safety Group. This was distributed to all directors but no further. Consequently managers below director level were unaware of its existence. Its formal launch was delayed for unknown reasons and was scheduled for May 1992. The sudden death of the deputy managing director meant the launch was postponed again and at the time of the fire there was effectively no current policy statement in force. The policy statement was revised after the fire and formally launched in October 1992.

105 In the unpublished version of the new policy statement existing at the time of the fire there was a chart of safety responsibilities. A significant omission from the chart was the logistics department and the post of logistics director. It was therefore unclear which group board director had the ultimate responsibility for health and safety standards within the logistics department.

106 Significant improvements in the revised policy included a section on the risk assessment of new processes, environmental implementation standards,

auditing procedures and health and safety improvement programmes. Each department was going to be requested to prepare an annual programme detailing objectives and targets in relation to health and safety. Such a programme was not in existence in the logistics department at the time of the fire. No formal safety auditing scheme had been adopted at the time of the incident (see paragraph 96).

107 Job descriptions for managers in the logistics department existed which were preliminary documents prepared by management consultants before the department was established. They had not been updated, and did not include safety. Elsewhere the inclusion of safety in job descriptions was patchy.

108 Directors were not asked to make reports on the safety performance of their departments, nor were they set targets for safety, eg for improved accident figures, or for progress towards the insurance company/brokers reports' recommendations. No example has been found of a director or manager (outside the safety department) being set objectives related to safety as part of his or her job appraisal.

109 As Allied Colloids Ltd did not recognise trade unions there were no statutorily appointed health and safety representatives; nevertheless each department had a joint health and safety committee meeting at approximately monthly intervals. There was no formal connection between these committees and the central Company Council where a wide range of issues is discussed including safety. The minutes of the Company Council dated 23 May 1991 included reference to egress from the site and in the minutes of 7 April 1992 to the fact that the warning siren was not audible throughout the site and recommended an additional siren to be installed. At the time of the fire there were two operational sounders for the site (and a third ready for installation), but only one operating point.

110 The company also operates a Community Liaison Group which meets quarterly. The local community is represented by its MP, three ward councillors, representatives from Low Moor and Oakenshaw Community Associations, the headmaster of the local school, a number of local residents, HM Pollution Inspectorate, Bradford Metropolitan Council Health and Housing Department, and the community constable. Additionally, public information on the risks and emergency procedures associated with the site were distributed in February 1992 within the public information zone which approximated to a radius of 300 m from the site boundary. (See paragraph 117 and the Appendix.)

HEALTH AND SAFETY LEGISLATION

111 The premises occupied by Allied Colloids Ltd are subject to the Health and Safety at Work etc Act 1974, the Factories Act 1961 and various regulations

made under both Acts to deal with specific risks. HSE is the enforcing authority for health and safety legislation on the premises. Of special relevance to the incident is the following legislation (more details are given in the Appendix).

Health and Safety at Work etc Act 1974 (HSWA)

112 HSWA imposes general duties on employers towards employees, members of the public and others. Responsibilities are also given to directors, managers and other individuals. Those employing more than five people must prepare a written health and safety policy detailing the organisation and arrangements for managing safety in their premises. Since the accident regulations important to all senior managers which elaborate on this requirement have come into force: The Management of Health and Safety at Work Regulations 1992.

Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH)

113 These Regulations are designed to prevent or mitigate the effects of major accidents to both people and the environment. The requirements operate at two levels.

114 The top tier requirements (regulations 7 to 12) applied from the outset to Allied Colloids Ltd by virtue of the storage of 600 tonnes of acrylonitrile. Further substances came within the scope of regulations 7 to 12 when the Second Amendment to the Regulations came into force on 31 March 1991, ie after the construction of the RM warehouse. These substances are defined by their properties and Allied Colloids Ltd attracted the application of the Regulations because they had very toxic, toxic and oxidising substances in excess of the qualifying quantities.

115 Some of the oxidising and toxic substances concerned were stored in the RM warehouse. Notification was sent to HSE on 27 March 1991 that substances in specified categories were kept on site. An amended notification dated 2 July 1991 classified AZDN as explosive and persulphates and organic peroxides as oxidising. The on-site and off-site emergency plans had been modified to take account of the Second Amendment substances and at the time of the fire information to the public had been issued. The safety report for these notified substances was not required under these Regulations until 1 June 1994.

Notification of Installations Handling Hazardous Substances Regulations 1982 (NIHHS)

116 Allied Colloids Ltd was subject to the NIHHS Regulations because of the storage of acrylonitrile, methyl chloride and trimethylamine. None of the installations subject to NIHHS were affected by the fire.

Planning controls

117 At Allied Colloids Ltd a consultation distance for land use planning purposes of 300 m from the boundary was designated around the main Low Moor site and 150 m around the adjacent Atlas pesticide factory, also operated by Allied Colloids Ltd. These distances were reviewed in August 1991 and confirmed as valid for the circumstances prevailing on site. Before the RM warehouse was built, the company applied for planning permission, and the planning authority consulted HSE (see paragraph 86 for further details).

Fire Certificates (Special Premises) Regulations 1976

118 Certification as to means of escape and other general fire precautions is usually the responsibility of the fire authority. However, these Regulations make HSE the body responsible where inter alia premises handle substantial quantities of specified hazardous materials. The Regulations applied to Allied Colloids Ltd because they store more than 50 tonnes of acrylonitrile.

119 A fire certificate dated 10 February 1982 applied to the premises at the time of the fire. Work was needed by HSE to update it to take account of recent developments. The fire certificate was of no significance in relation to the occurrence of the accident.

Classification, Packaging and Labelling of Dangerous Substances Regulations 1984 (CPL)

120 The CPL Regulations apply to most of the substances kept in and around the RM warehouse and in particular to all of the substances in oxystores 1 and 2. Most, if not all of these substances were purchased by Allied Colloids from various suppliers who were obliged to package and label substances in accordance with these Regulations. AZDN was suitably packaged and labelled as an inflammable solid. The label warned of the risk of explosion and warned against allowing the temperature to exceed 30^{o}C (allowing a safety margin below the SADT of 50^{o}C).

Guidance

121 In order to assist employers to comply with relevant legislation HSE produces much guidance (see the recommended guidance section at the back of this book).

LEGAL PROCEEDINGS

122 HSE decided to institute proceedings against Allied Colloids Ltd. Consideration was given to a wide range of possible charges both in respect of the company and in respect of the role played by individual directors and senior members of management. However, it was concluded that the events were primarily due to

cumulative management failures and omissions which together represented a corporate failure. It was therefore appropriate for charges to be laid against Allied Colloids Ltd alone.

123 In view of the seriousness of the fire, application was made at Bradford Magistrates Court on 30 November 1992 for the charges to be heard on indictment in the Crown Court.

124 On 29 January 1993 at Bradford Crown Court Allied Colloids Ltd pleaded guilty to the following charges:

(a) Failing to ensure so far as was reasonably practicable, the safety at work of employees in that they failed to make arrangements to ensure the safe storage of AZDN in oxidising store No 2, thereby contravening Section 2(1) of the HSWA;

(b) Failing to ensure so far as reasonably practicable, the safety at work of employees in that they failed to make arrangements to ensure the safe storage of VAZO-67 in oxidising store No 1, thereby contravening Section 2(1) of the HSWA;

(c) Failing to comply with Section 3(1) of the HSWA in that they failed to conduct their undertaking in such a way as to ensure so far as was reasonably practicable the health and safety of people not in their employment in that adequate arrangements were not made to eliminate or mitigate the effects of fire and explosion from dangerous substances stored in and around the RM warehouse.

125 Allied Colloids Ltd was fined £30 000 on each of the Section 2 charges and £40 000 on the Section 3 charge, a total of £100 000. HSE was awarded costs of £62 324.

126 In giving his judgement the judge stated that the fire could have had devastating consequences to employees and nearby residents, but he remarked that the company had taken steps since the accident to put their house in order in relation to storage. In deciding on the level of penalty he stated that when dealing with dangerous chemicals, particularly in a residential area, fines should be imposed that would be felt and noted.

127 On 19 July 1993 Allied Colloids Ltd was convicted at Bradford Magistrates Court under Section 85 of the Water Resources Act 1991 in a prosecution brought by the NRA for causing poisonous, noxious or polluting matter to enter controlled waters, namely Spen Beck and the River Calder and Aire from its premises at Low Moor, Bradford. The company was granted an absolute discharge although costs of £15 503 were awarded against them, along with a compensation order of £5000 towards restocking the fishery.

HSE AND ALLIED COLLOIDS LTD

128 The main aims of HSE's inspection regime at the factory premises were:

(a) to conduct planned preventive inspections with particular emphasis on those parts of site defined as major hazard installations;

(b) to investigate significant accidents, incidents and dangerous occurrences in order to discover the underlying causes, particularly in respect of management systems failures contributing to the event;

(c) to collate information on the company's performance from the above activities and to present this as evidence to senior management periodically to justify improvements that HSE wishes them to achieve in their management of site health and safety.

129 In accordance with this inspection strategy between 1 January 1987 and the time of the fire on 21 July 1992, 122 different types of visits had been paid of which 40 were to investigate accidents, incidents and dangerous occurrences. Additionally 48 preventive inspections had been carried out on the site, many of them concentrating upon issues associated with major hazard installations. During its short life the RM warehouse had not been visited for a preventive inspection.

130 Since 1988 five enforcement notices (prohibition and improvement) had been served on Allied Colloids Ltd, two of which required further safety training. None related to chemical storage. On 20 January 1992 an improvement notice under CIMAH regulation 12 was issued requiring information on major accident hazards to be supplied to the public near the plant (see the Appendix) by 22 February 1992. All notices were complied with.

131 Many of the inspection visits resulted in letters requiring specified improvements to be made. In respect of the management of health and safety, inspectors had given advice on the need for formalised safety monitoring systems and for improved management training in safety. In March 1990 several production managers attended a one day seminar at the Leeds HSE area office on 'Safety monitoring in the chemical industry'. Indeed the company had been evaluating various proprietary health and safety management systems since 1990 but at the time of the fire had not reached a decision on which one to select. On 31 January 1992 an inspector had written to the company informing them that HSE would be giving priority during the year to the effective implementation of safety auditing and monitoring procedures and to the revision of the health and safety policy statement. The follow-up was overtaken by the fire.

CONCLUSION AND LESSONS TO BE LEARNT

132 Although the fire gave rise to many aspects of concern it is important to record that there were successes. No employees suffered injury or became trapped in the conflagration and the emergency services successfully contained the fire within the storage areas. Off-site, nobody was directly affected by the initial incident and of those affected by the subsequent smoke all but three members of the public were rapidly discharged from hospital. The worst affected were members of the fire service and police who worked valiantly to protect the public. For an event on such a scale the overall cost to human health and safety was mercifully light and the environment is expected to recover through restocking and, in time, natural recovery.

Lessons

133 The crucial error leading to the fire was the incorrect categorisation of AZDN and its consequent storage with oxidising agents with which it was chemically incompatible. The same mistake was made with VAZO 67. Although a written segregation policy for packaged chemicals existed it was incomplete in several critical aspects - crucially not relating specifically to the actual storage areas within the RM warehouse as there was no record or diagrammatic plan of where chemicals with particular hazardous properties were stored. There was also a failure to implement advice first published by HSE in 1986 entitled *The storage of packaged dangerous substances* which contained guidance resulting from investigations elsewhere of earlier major warehouse fires.

- Warehouses and other premises where chemicals are stored should be designed and operated in accordance with current legislation. Guidance on safe operating procedures and safe storage is published by enforcing authorities and industry. In particular, attention should be paid to the need for segregation of incompatible substances, the warehouse management system, safe operating procedures, fire detection and fighting methods and recording systems for ensuring the safe operation within the storage facility.

134 The identity of the logistics department was unrecognised in both the original and revised Safety, Health and Environment Policies. The job descriptions for managers and the director in the logistics department were unsatisfactory, incomplete and outdated. It was therefore impossible to appraise the performance of individual managers against the existing job descriptions. The absence of corporate recognition led to the logistics department being treated as a Cinderella in terms of health and safety resources for improvements. The absence of safety matters within job descriptions contributed to training opportunities which were available to the managers of other departments being neither provided or sought. It was therefore not surprising that management in the logistics department made little attempt to give the priority it deserved to implementing new improved standards and conditions.

- Companies should not neglect non-production departments and warehouses in particular when providing health and safety resources. Equal priority should be given to assessing risks in all areas and activities and resources allocated accordingly.

- Safety policy statements should be re-appraised immediately following any significant company re-organisation and the revised policy statement issued to all employees promptly. The written job descriptions of managers should incorporate responsibility for safety and should correspond with the managerial duties described in the safety policy.

135 No system existed for objective monitoring of safety performance in the logistics department despite a general recognition that there were serious deficiencies in safety standards throughout the raw materials storage areas. Targets were not set for improved safety performance nor were action plans drawn up for health and safety improvements despite the recommendations of highly critical insurance company reports.

- Companies should regularly monitor and audit their safety performance in storage facilities in addition to compiling statistical data on accidents, ill health and incidents.

- Targets for good safety performance in storage facilities should be set by companies as part of a safety planning strategy.

136 Steam heating pipes and panels in No 2 oxystore of the RM warehouse were not effectively isolated from the steam supply after the primary purpose of the storeroom was changed from frost sensitive flammable products. Equally, positive action to provide suitable protected electrical equipment, temperature monitoring equipment and smoke detectors had not been taken. The internal works order raised 10 months before the fire had not been actioned.

- Safety related maintenance or engineering requests should be specially identified and given necessary priority. Engineering management should monitor outstanding requests to ensure that they are dealt with within an appropriate timescale.

137 Flawed as it was, the segregation policy for chemicals was not effectively implemented as warehouse staff were unaware of the policy and training and instruction did not cover the segregation of the incompatible chemicals.

- Managers, supervisors and operators of chemical warehouses should receive adequate training in their duties and specifically in respect of the placement and segregation requirements for chemical storage. Records should be kept of the training given to each individual member of staff.

138 Fifty minutes elapsed between the first incident, involving the rupturing of AZDN fibreboard drums (kegs), and the summoning of the emergency services. Both the fire service and police considered that they should have been called immediately. Although it is necessary for companies to have their own facilities for dealing with minor incidents, spillages and leaks, it is important that if there is a risk of the incident getting out of hand, the emergency services are called without delay.

- Companies should summon the emergency services immediately when incidents happen which have the potential to escalate. This procedure should be incorporated in the emergency plans.

139 When a major accident arises which is not immediately brought under control it is important that members of the public are warned as soon as possible. There are various ways of warning the public, including sirens of the type used by the company. All methods suffer from disadvantages although in the majority of cases sirens are favoured by emergency planners. The use of sirens does not exclude any other method from being employed. Guidance booklet HS(G)25 *CIMAH: further guidance on emergency plans* is currently being revised and will include more detailed advice on the choice of warning systems for the public. Allied Colloids employed a siren, but there were delays on 21 July 1992 in its sounding which meant that members of the public were not alerted to the risk as soon as they could have been. The question also arose as to who should sound the warning siren. Although the emergency services took charge of managing the emergency they did not have the authority to order the sounding of the siren. The siren operated for approximately 50 minutes. When power to the site was cut off it was prematurely silenced.

- At major hazard sites equipped with public warning sirens agreement should be reached between the company and the emergency services on the circumstances in which the alarm can be sounded and who can order its sounding. This procedure should be written into the off-site emergency plan. Companies should ensure that means of public warning are effective and reliable and that back-up power supplies are provided if necessary.

140 During and after the fire there was a considerable debate about the toxicity of the smoke emitted and there was a lack of authoritative accurate advice for residents, farmers and others who were directly affected. The incident identified a need for agreement on the sampling of fall-out residues, contaminated fire water and the constituents of the smoke itself. Analytical techniques and the interpretation and use of their results need to be considered. A strategy should be prepared to ensure that prompt advice to people off-site is given on all aspects of contamination.

- Statutory off-site emergency plans should state clearly what immediate actions are necessary to prevent or mitigate environmental contamination

during or after a major accident and which body has responsibility for undertaking them. There should also be provision for giving advice and necessary information to relevant bodies and the public.

141 During the early stages of the fire there was a severe shortage of information from Allied Colloids Ltd on the toxicity of the smoke. This seriously hampered the police and fire officers tackling the emergency who had to make rapid judgements on motorway and other road closures, evacuation and protective clothing among other issues. In the aftermath of the fire inspectors also suffered from a lack of toxicity data when faced with questions from members of the public and the media.

142 Some of the work published already assumes that for pesticides and other toxic materials, the original substance will dominate the risks in the event of a fire. It also assumes that the additional amount of carbon monoxide, hydrogen cyanide etc generated by the burning toxic substance is small when compared with that given off by the burning building and stored packaging material. However, when a chemical burns in air it reacts to produce decomposition products. The risk from these products cannot be assumed to be negligible as their nature depends upon the temperature attained during combustion, the duration, the abundance of the air supply and even the state (gas, liquid or solid) of the substance. Therefore, for a single substance many differing decomposition products are to be expected by virtue of the variations in these and other parameters. When many substances are involved chemical interactions in the fire produce additional complexities and the fire plume can be fairly described as containing a 'cocktail' of chemical products.

143 For the RM warehouse and other areas destroyed by the fire the company supplied lists of about 400 substances, many of which were identified initially only by an internal code number or their proprietary trade names.

- Companies should ensure that they are able to advise emergency services and other relevant public authorities of the potential toxicity of products of combustion from mixed chemical fires on their premises.

144 Tens of millions of litres of water were needed to extinguish the fire and this mixed with chemicals released from ruptured drums and other containers. Most of the contaminated run-off found its way into water courses causing serious environmental effects. Currently there is no explicit guidance on the containment of contaminated fire-fighting water run-off. Containment is of interest to HSE, DoE, NRA, water authorities, emergency services, HM Pollution Inspectorate, local authorities, MAFF and of course industry. In their emergency plans companies should consider how best to cope with the risks of fire water run-off, but there is also a need for broader guidance on when containment is appropriate and on the design specifications for containment lagoons or areas.

- It is recommended that HSE in conjunction with other interested parties develops guidance on the control of fire water run-off at major hazard sites.

- Sites where fire water run-off could create a major environmental accident should consider with relevant bodies how best to contain fire water run-off or to mitigate any effects run-off might have.

145 Both before and after the fire West Yorkshire Fire Service expressed concern at its lack of statutory power to require major hazard sites to ensure that adequate supplies of fire-fighting water is available. It should be noted that Section 13 of the Fire Services Act 1947 places an obligation on the fire authority itself to ensure the provision of an adequate supply.

146 Considerable concern was expressed by emergency authorities and members of the public alike about the geographical site restrictions and consequent congestion of the Low Moor site together with the danger of escalation if the fire had spread to production facilities and other areas of chemical storage.

- Major hazard sites should pay particular attention to site congestion, not merely because of risks created during normal operation but when planning extension of or modifications to existing plant.

APPENDIX

Legislation

Health and Safety at Work etc Act 1974

1 Objectives of the Act are to secure the health, safety and welfare of people at work and to protect other people from risks arising from work activities.

2 Employers of more than five people must prepare a written health and safety policy.

3 The Act also provides that in certain circumstances (eg personal connivance or neglect) an individual director, manager, secretary or similar officer shall also be guilty of an offence and liable to be punished.

Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH)

4 The CIMAH Regulations implement the European Community SEVESO Directive and have been amended twice since they came into force on 1 April 1985. Their purpose is the prevention of major accidents and to limit their consequences to people and the environment. The Regulations apply to hazardous substances at certain sites which use or store specified quantities of hazardous substances. The requirements operate at two levels, the more stringent being the so-called top tier requirements, regulations 7 to 12.

The Regulations can be summarised as follows:

5 *Safety reports (regulations 7, 8 and 9)*

Manufacturers are required to produce a written safety report which must contain details of the dangerous substances, installation, management system, potential for major accidents and the condition or events which would be significant in bringing about measures taken to prevent, control, and minimise the effects of major accidents. These reports must be updated every three years or if there are changes at the installation.

6 *Emergency plans (regulations 10 and 11)*

There are separate requirements for on site and off-site emergency plans to be prepared by the manufacturer and local authority respectively. These are intended to mitigate the effects of major accidents and prepare the responses to them.

7 *Information to the public (regulation 12)*

Manufacturers are also required to ensure that people who might be in the area where they could be affected by a major accident are informed of the nature of the hazards and the action they should take for their own safety in an emergency. HSE designates a public information zone (similar to the consultation zone - see below) within which the manufacturer is required to disseminate the information.

Notification of Installations Handling Hazardous Substances Regulations 1982 (NIHHS)

8 These Regulations pre-date CIMAH and require notification by companies of hazardous quantities of specified substances above certain thresholds.

Planning controls

9 Land use planning controls are imposed on and around every site subject to the NIHHS Regulations or to the top tier requirements of CIMAH. If sites store or keep hazardous substances in notifiable quantities, the local planning authority consults HSE on the risk to people living or working nearby the proposed site. A consultation zone is designated for each notifiable site. When developments within the consultation zone are proposed the local planning authority consults HSE for an opinion on the risk which the notifiable installation would present to people at the new development if it was built. HSE has a special unit at Bootle, the Major Hazard Assessment Unit (MHAU) which provides a specialist risk assessment service for land use planning purposes.

10 Seven weeks before the fire on 1 June 1992 new Department of the Environment Regulations came into force placing further controls on hazardous development. These are contained in the Planning (Hazardous Substances) Regulations 1992 administered by Hazardous Substances Authorities - usually the local planning authority. The Regulations contain a list of substances and thresholds which is similar but not identical to the NIHHS Regulations. When a company wishes to store or keep specified quantities of hazardous substances they must apply for hazardous substances consent whether or not planning permission is also required. The Regulations also enable control to be exercised over changes which could increase the risk to people off-site. There were transitional procedures for existing sites whereby they could claim deemed consent for substances kept and notified before 1 June 1992.

Highly Flammable Liquids and Liquified Petroleum Gases Regulations 1972

11 These Regulations apply to the storage and use of highly flammable liquids in factories. In particular, regulation 5 requires that highly flammable liquids should be stored safely.

Classification, Packaging and Labelling of Dangerous Substances Regulations 1984 (CPL)

12 The purpose of the CPL Regulations is to protect both users (at work or in the home) and transporters of dangerous substances. Any dangerous substances to which the Regulations apply for supply or conveyance must be suitably packaged and properly labelled.

Management of Health and Safety at Work Regulations 1992

13 These Regulations set out broad general duties which apply to almost all work activities in Great Britain and offshore and came into force on 1 January 1993, ie after the fire at Allied Colloids Ltd. They are aimed mainly at improving health and safety management and can be seen as a way of making more explicit what is required of employers under the HSW Act. Their main provisions are designed to encourage a more systematic and better organised approach to dealing with health and safety.

RECOMMENDED GUIDANCE

1 HSE *Storage and use of sodium chlorate and other similar strong oxidants* CS3 1985 ISBN 011 883523 8

2 HSE *The storage of flammable liquids in containers* HS(G)51 1990 ISBN 07176 04810

3 HSE *The storage and handling of organic peroxides* CS 21 1991 ISBN 011 885602 2

4 HSE *The storage of packaged dangerous substances* HS(G)71 1992 ISBN 011 885989 7

5 HSE *Health and safety in retail and wholesale warehouses* HS(G)76 1992 (NB published after the fire at Allied Colloids Ltd) ISBN 011 885731 2

6 HSE *Control of Industrial Major Hazards Regulations 1984 (CIMAH): further guidance on emergency plans* HS(G)25 1985 ISBN 011 883831 8

7 HSE *Successful health and safety management* HS(G)65 1991 ISBN 07176 0425 X

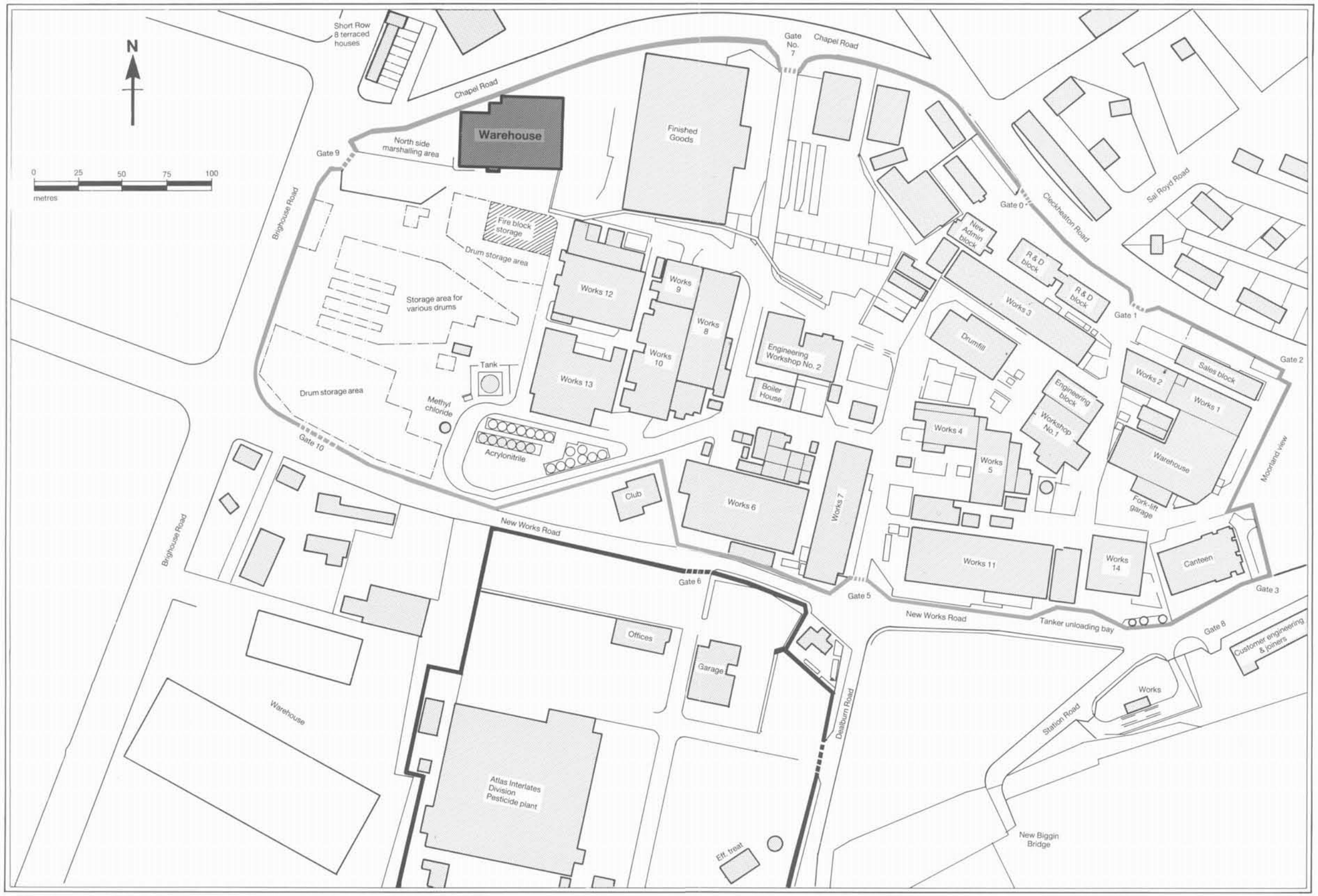
Guidance produced by industry etc

8 Chemical Industrial Association, London. *Guidelines for safe warehousing: guidelines for safe warehousing of substances with hazardous characteristics*

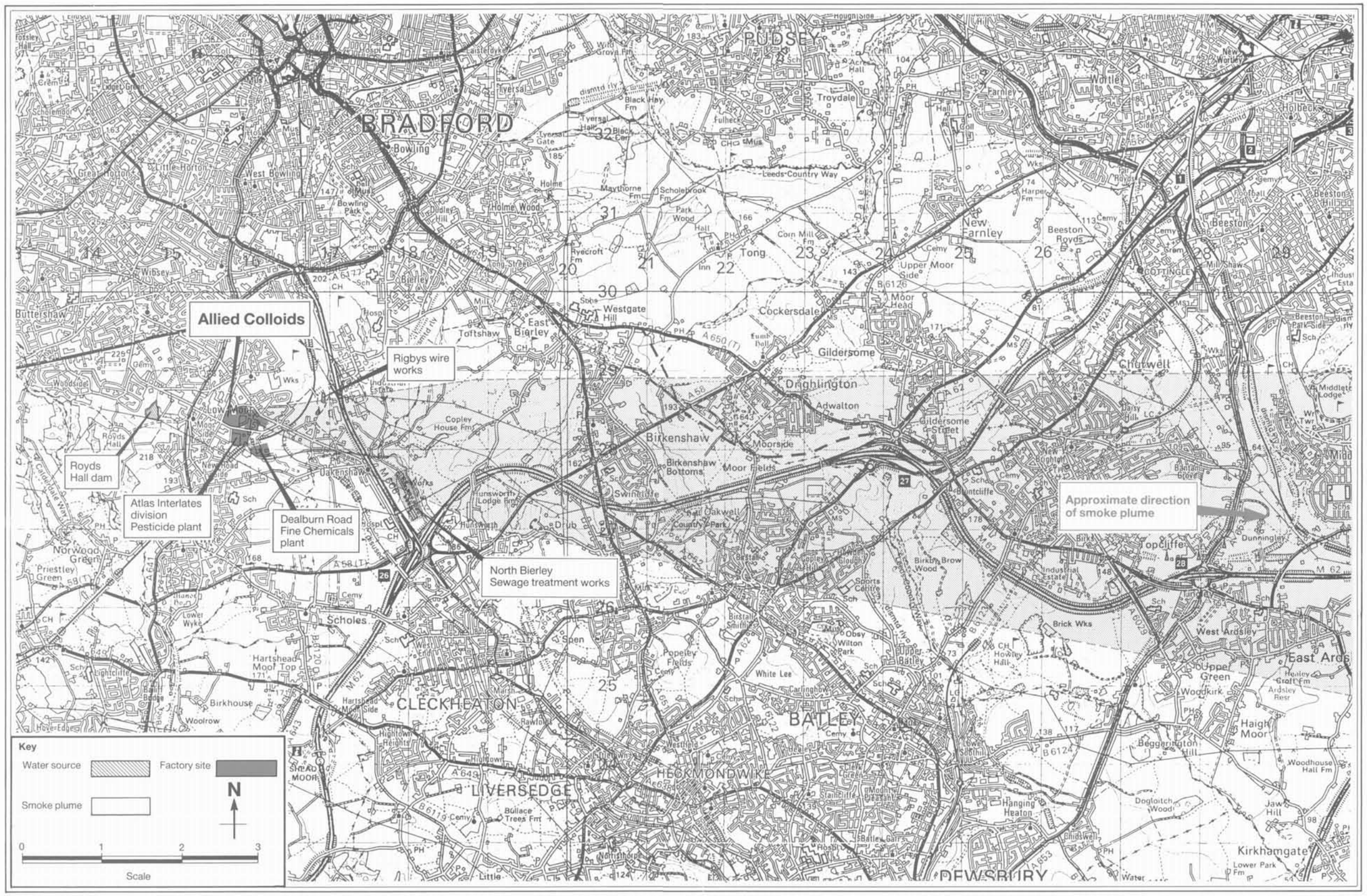
9 European Council of Chemical Manufacturers' Federations (CEFIC), Brussels *A guide to safe warehousing for the European chemical industry*

10 United Nations Environment Programme *Storage of hazardous materials: a technical guide for safe warehousing of hazardous materials* ISBN 9280 712381

11 British Chemical Distributors and Traders Association *Guide to warehouse operators - when CIMAH safety report is required*



Plan of Allied Colloids site and the surrounding area



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