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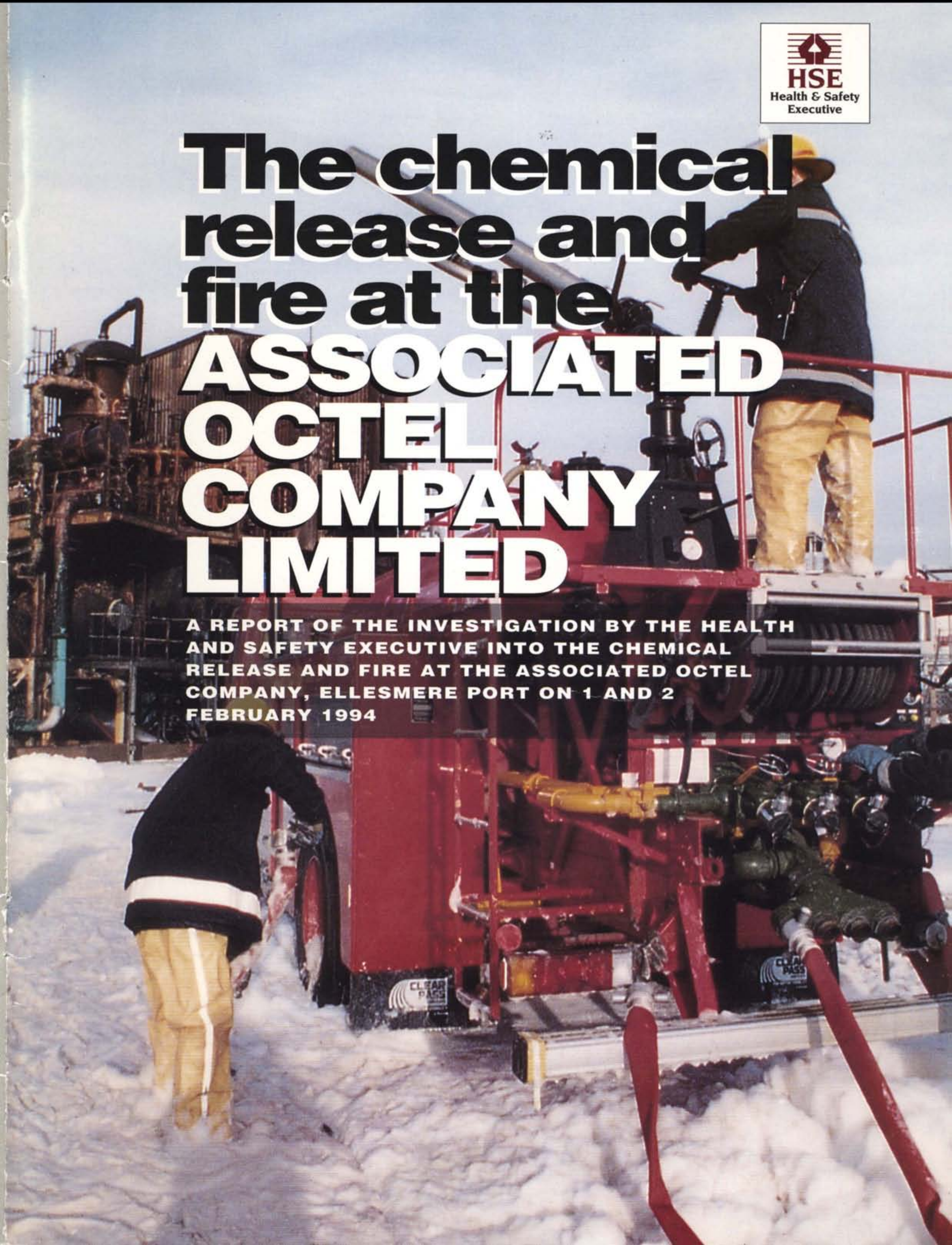
The chemical release and fire at the ASSOCIATED OCTEL COMPANY LIMITED

A REPORT OF THE INVESTIGATION BY THE HEALTH AND SAFETY EXECUTIVE INTO THE CHEMICAL RELEASE AND FIRE AT THE ASSOCIATED OCTEL COMPANY, ELLESMERE PORT ON 1 AND 2 FEBRUARY 1994



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A REPORT OF THE INVESTIGATION BY THE HEALTH AND SAFETY EXECUTIVE INTO THE CHEMICAL RELEASE AND FIRE AT THE ASSOCIATED OCTEL COMPANY, ELLESMERE PORT ON 1 AND 2 FEBRUARY 1994

HSE BOOKS

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SUMMARY

1 At about 8.23 pm on 1 February 1994 there was a release of reactor solution from a recirculating pump near the base of a 25 tonne ethyl chloride (EC) reactor vessel at the factory of The Associated Octel Company Ltd, Oil Sites Road, Ellesmere Port, Cheshire. The reactor solution was highly flammable, corrosive and toxic, mainly consisting of ethyl chloride, a liquefied flammable gas, mixed with hydrogen chloride, a toxic and corrosive gas, and small quantities of solid catalyst, aluminium chloride. A dense, white cloud soon enveloped the plant and began to move off-site.

2 The on-site and external emergency services were called in accordance with pre-arranged procedures for dealing with major incidents involving chemical release. Over the next one and a half hours action was taken to isolate the leak, to suppress the further release of vapour and to prevent the cloud spreading.

3 In spite of these attempts a pool of liquid continued to collect and at 10.08 pm the flammable vapours of ethyl chloride ignited, causing a major pool fire which was most intense at the base of the reactor. As the incident developed there were also fires at flanges damaged in the fire, including jet flames at the top of two large process vessels on the plant. Although these vessels and the reactor were protected by a fire-resistant coating, there was concern at one stage that the vessels might explode and the damage extend to chlorine storage vessels on the adjacent plant.

4 No serious injuries, ill health or environmental effects resulted from the release and fire but this was a serious incident at a major hazards site. The plant itself was extensively damaged, requiring a complete rebuild. Investigation of the immediate cause of the leak was hampered because plant and equipment had been subject to an intense fire and some critical components destroyed.

5 The leak occurred at a point between fixed pipework and the discharge port of a pump recirculating liquids to the reactor, as a direct consequence of either (a) a corroded securing flange on the pump working loose; or (b) the failure of a PTFE flexible connection ("bellows") connecting the pump discharge to the pipe. The Health and Safety Executive (HSE) believes the first of these possible causes was the more likely. The most likely source of ignition was an electrical control box to a compressor nearby.

6 The incident might have been prevented or its severity greatly reduced if a more detailed assessment of the inherent hazards and risks of the plant had been carried out by the company beforehand. Such an assessment would have alerted Octel to the possibility and consequences of a substantial leak at the recirculating pumps. A more extensive range of precautions could have been taken, including provision for remotely isolating significant inventories of dangerous substances on the process plant and a more structured arrangement

for identifying, inspecting and maintaining the critical components of the plant. Instead, these failings led to a serious incident which destroyed the plant and precipitated much local concern in an area of high concentration of chemical plants.

7 HSE served a Prohibition Notice prohibiting the Associated Octel Company Ltd from restarting production of ethyl chloride until the company had demonstrated that "the major accident hazards had been identified and that appropriate precautions had been taken to limit the consequences to persons and the environment". The EC plant was rebuilt and recommissioned during January 1995. There were important detailed design changes to the pumps and pipework involved, including the fitting of remotely operated shut off valves on pipework with vessel connections below liquid level, as well as increased instrumentation and alarms on the plant and containment provided for a major release from the EC plant. The three main process vessels involved in the fire were replaced and protected with the latest insulation cladding which had an improved specification. Improved safety management arrangements have been introduced for managing maintenance and for achieving improved commitment and communications on health and safety within the company.

8 On 2 February 1996 the company pleaded guilty in Chester Crown Court to contravening Sections 2 and 3 of the Health and Safety at Work etc Act 1974 for failing to provide and maintain plant and systems of work which were safe and without risks to health. As a result, the company put at risk the health and safety of employees and other people, in particular the fire fighters involved. The company were fined £150 000 (£75 000 on each of the two charges) and were ordered to pay full costs of £142 655. The payment of costs in this case is now subject to Appeal by the company.

9 In view of the nature of the incident and public concern HSE undertook to publish the findings of its investigation. For the sake of brevity this report concentrates on the cause of the incident, the emergency response and the precautions which should have been taken to prevent it but omits reference to many perfectly satisfactory arrangements identified during the investigation.

10 There are a number of lessons to be learned from this incident which are of general relevance to the chemical industry and to those involved with the planning and provision of emergency response. These relate to the risk assessment of chemical plant, along with its design, operation and maintenance, as well as lessons in handling a major industrial emergency. They are discussed from paragraph 121 onwards.

THE COMPANY AND SITE

11 The Associated Octel Company Limited ("Octel") is a chemical manufacturing company which occupies a number of sites in Great Britain and abroad. The majority of the company's shares are owned by The Great Lakes Chemical Corporation of the United States. The Ellesmere Port site has been in operation for over 40 years and is the main manufacturing location. The prime activity is the production of motor fuel anti-knock compounds. The main chemicals processed or produced on-site are tetra ethyl lead, tetra methyl lead, sodium, chlorine and ethyl chloride. Other hazardous chemicals are also stored and handled.

12 About 1650 people are employed at the site which occupies an area of approximately 87 acres. Within 1.5 km of the site there are large residential areas, the main shopping areas of Ellesmere Port and many public amenities such as schools, council premises and the Ellesmere Port Boat Museum (see Appendix 1). The nearest residential development is about 250 metres from the south west boundary of the site. The whole site lies within the Borough of Ellesmere Port and Neston in the northern part of Cheshire. The factory is located in a large industrial complex with several major chemical plants nearby. Immediately to the north of the site is the Manchester Ship Canal and the Mersey Estuary. The latter is an internationally important habitat for wild fowl and is a Site of Special Scientific Interest.

13 There are four main manufacturing units on the Ellesmere Port site which are:

(a) Chlorine plant - the electrolysis of brine in membrane cells produces chlorine, hydrogen and caustic soda. The chlorine is liquefied and stored, before being used on-site or exported.

(b) Sodium and chlorination plants - sodium and chlorine are produced by electrolysis of sodium chloride. Chlorine is burned with hydrogen to produce hydrogen chloride. Ethyl chloride is produced on the EC plant by reaction of hydrogen chloride and ethylene (which is piped onto site).

(c) Lead alkyl plant - tetraethyl lead and tetramethyl lead are produced by reaction of ethyl chloride or methyl chloride with a lead-sodium alloy.

(d) The compound blending and container operations - various anti-knock compounds are made by blending tetraethyl lead, tetramethyl lead or mixes of the two with dibromoethane and/or dichloroethane.

These units form an integrated manufacturing site with each being an essential part of the production cycle. The management structure is described at paragraph 102 onwards.

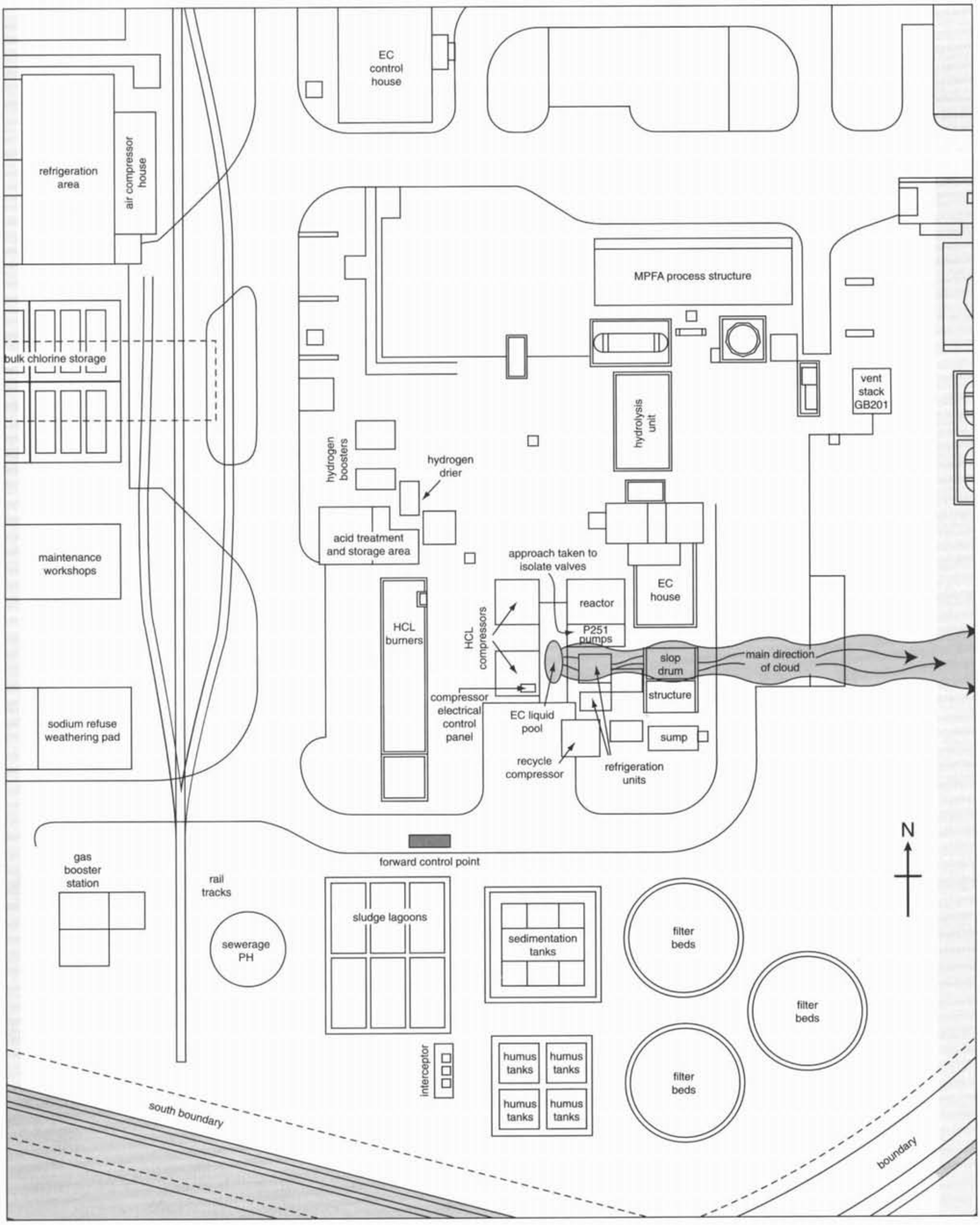


Figure 1: Plan of area around EC Plant

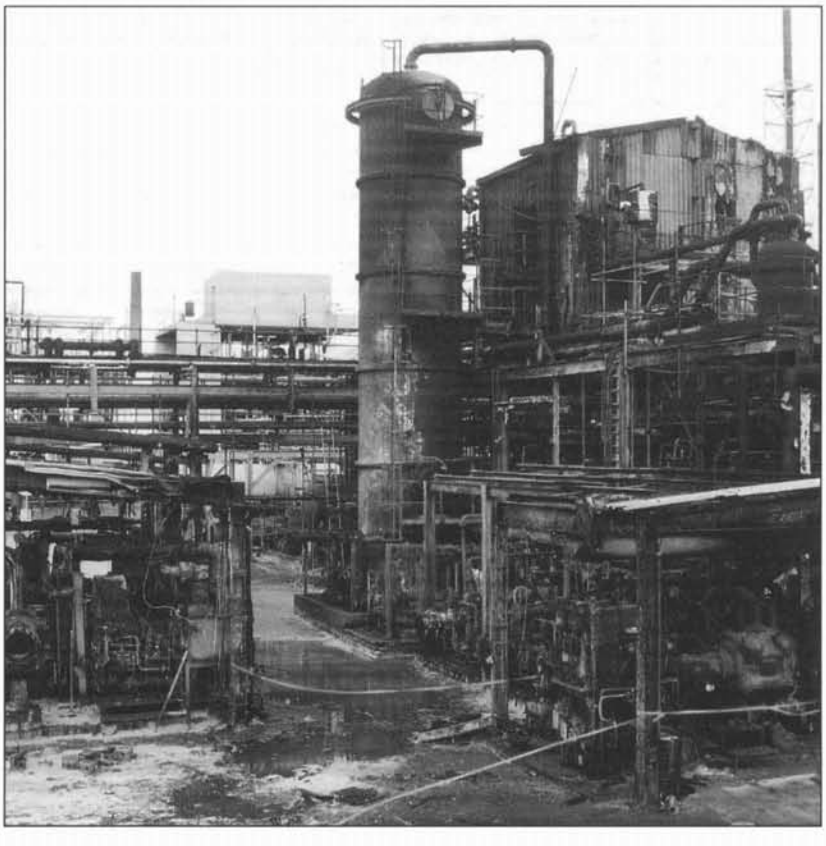
THE PLANT AND PROCESS

The sodium and chlorination plants

14 The EC plant was part of the chlorination plant and was located close to the south east corner of the site. Chlorine from the sodium cell hall was liquefied and most of it used in the EC production plant. The chlorine storage area, which fed the EC plant, comprised 17 pressurised vessels of 27 tonnes capacity of which two were kept empty, and six pressurised vessels of 12 tonnes capacity. The nearest chlorine storage vessel was about 40 metres from the EC reactor.

15 The EC plant was constructed in 1972. It occupied a relatively small area of the site, about half the size of a football pitch. A general view of the plant is shown at Figure 2. The reactor stood in a brick bund designed to contain small spillages and drain them via a pipe and gulley to a soakaway and evaporation area approximately 10 metres away. The area on which the plant stood was tiled and gradually sloped towards the evaporation area. Since mid-1992 the reactor and two further large process vessels, V255, known as the slops drum, and V256, the stabiliser feed drum, had been clad with an intumescent fire protection coating. This type of coating expands in a fire to form successive layers of insulating protection and was designed to provide a minimum of two hours

Figure 2
Photograph of general view of EC production plant



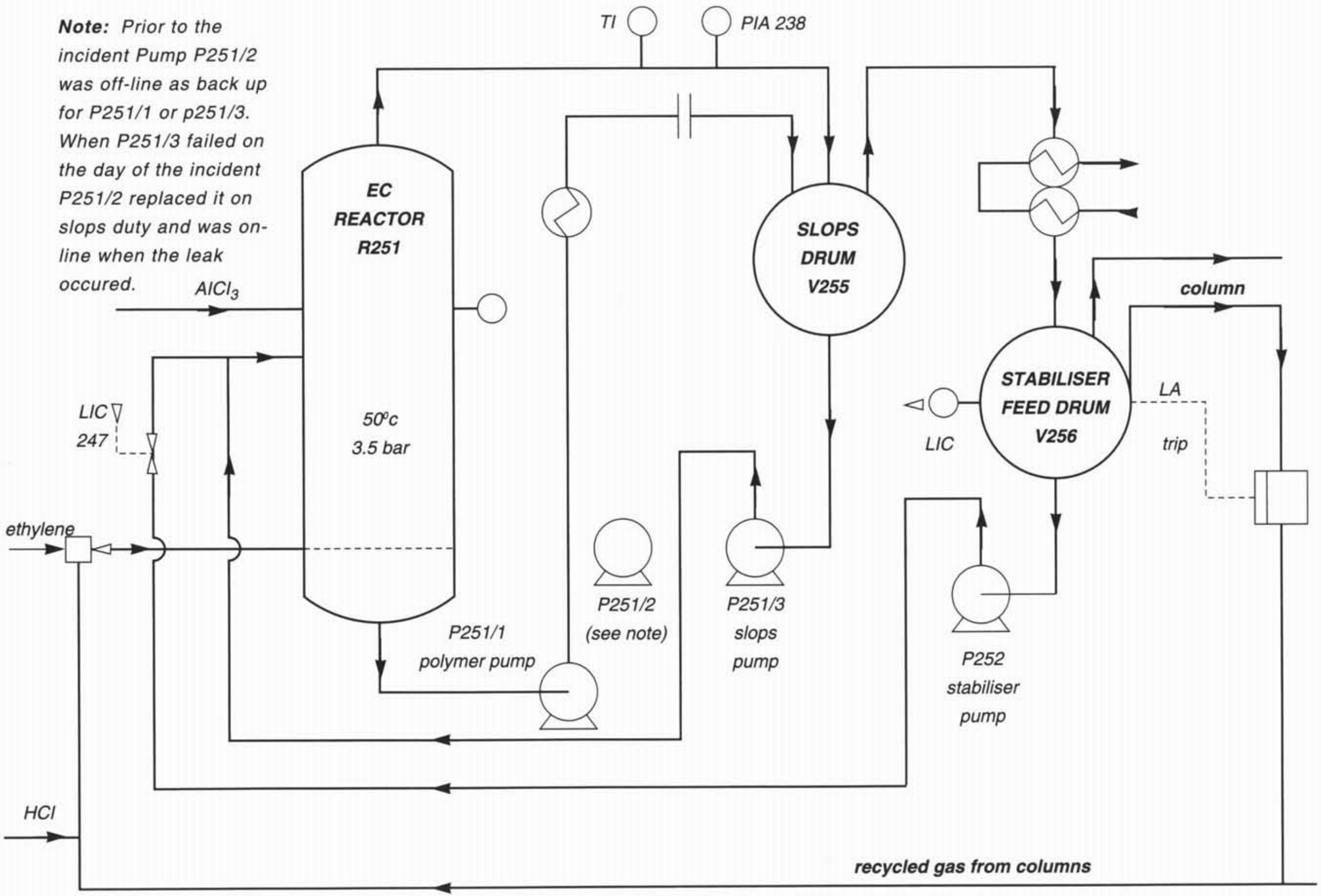


Figure 3: Simplified process flow diagram of EC process

protection against fire engulfment. It was introduced as a result of the assessment carried out as part of the preparation of the company's safety report (see paragraph 79).

The ethyl chloride process

16 Ethyl chloride was manufactured by the liquid phase reaction between ethylene and hydrogen chloride (HCl) in the presence of ethyl chloride and catalysed by aluminium chloride. The HCl was produced on a demand basis for the EC production plant by burning hydrogen in chlorine in an adjacent plant. It was filtered and compressed then fed to the EC reactor. A simplified flow diagram of the EC process is shown in Figure 3.

17 The ethyl chloride reactor known as R251 was a tall cylindrical vertical vessel, of about $78m^3$ capacity. It operated at 3.1 barg and about 50°C. Normal maximum working inventory was about 22 tonnes. Gaseous ethylene was imported by pipework at about 15 barg and injected with the HCl into the bottom of the reactor. The reaction was mildly exothermic and the heat of the reaction would cause some of the ethyl chloride to boil off. This was condensed, part taken off as product, and the rest returned to the reactor to provide cooling. Unreacted ethylene and HCl was compressed and also recycled to the reactor.

18 The product taken off the top of the reactor passed to the horizontal slops drum, of about 30 tonnes capacity. Here liquid in the vapour stream was collected for return to the reactor by one of two pumps which could be used for this duty, known as P251/2 and P251/3. The slops drum normal working inventory was small as the liquid was continually taken off. The vapour leaving the slops drum was condensed and this liquid collected in a second horizontal vessel, the stabiliser feed drum, of capacity about 11 tonnes with a normal maximum working inventory of 7 tonnes. This fed the crude ethyl chloride to two distillation columns in series en route to final storage spheres. There was also a liquid return line from the stabiliser feed drum to the reactor so the product could be recirculated when necessary, for example if the product was not to manufacturing specification.

19 The slops and stabiliser feed drums were positioned next to each other on a steel gantry at a height of approximately 3 metres above ground level (Figure 4), about 6 metres from the reactor. Underneath the two vessels was an area enclosed on three sides by a brick wall of height 0.6 metres sloping to the same evaporation area as the reactor. The evaporation area was immediately adjacent to these vessels at ground level. A by-product of the process was a polymer oil made up of heavier hydrocarbon components than ethyl chloride. This was removed as waste from the bottom of the reactor by a third pump, P251/1.

__Figure 4__ Photograph of slops and stabiliser feed drums (seen from the east)

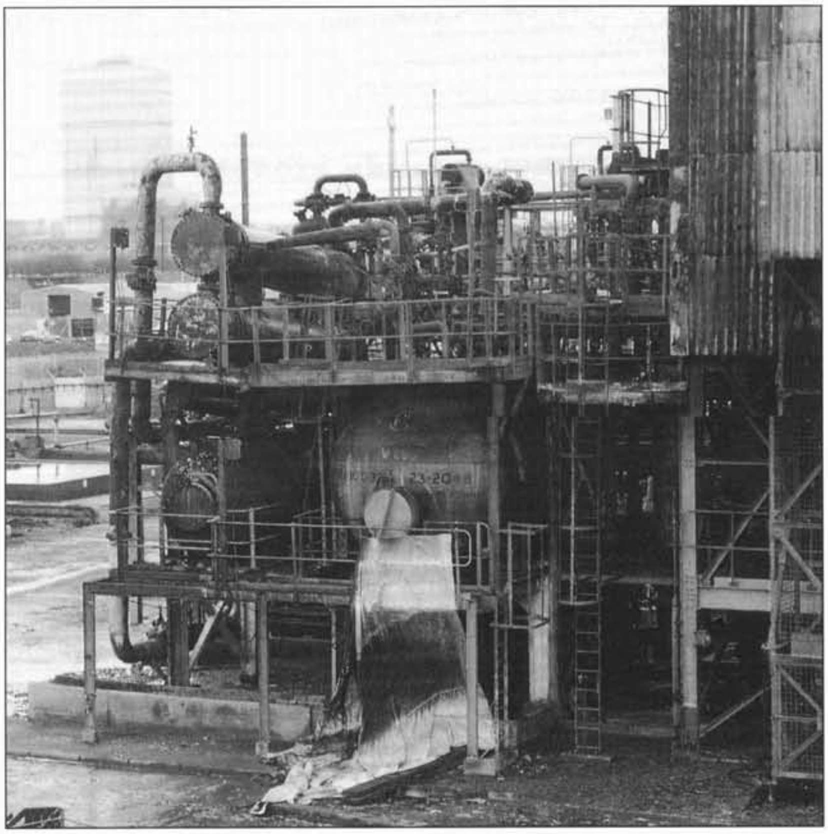
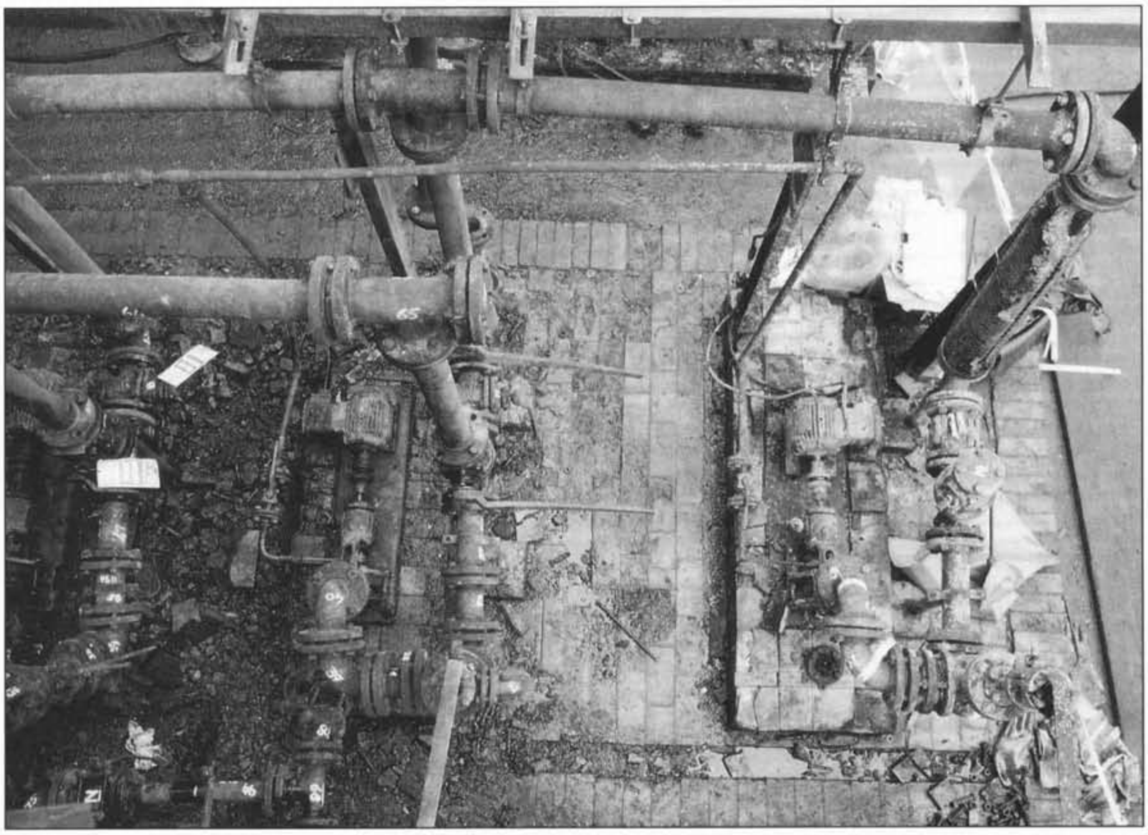


Figure 5 (below)
View from above showing remains of P251 pumps



Pumps, pipework and valves

20 All three pumps, P251/1, P251/2 and P251/3, were positioned alongside each other at ground level close to the base of the ethyl chloride reactor. They were outside the brick bund wall surrounding the reactor but on the tiled plant floor area which sloped gradually towards the evaporation area. All were of the centrifugal type manufactured with a silica filled epoxy resin casing to resist attack from the corrosive process fluid and powered by individual electric motors.

21 P251/1, as described above, was dedicated to removing polymer oil, deactivated catalyst and residual ethyl chloride from the bottom of the reactor. P251/3 was dedicated to returning liquid from the slops drum back to the reactor. P251/2 could be used for either duty.

22 The pumps were connected to pipework by proprietary flexible connections (bellows) made of a polymer, PTFE. These were fitted at both the suction and discharge ports of the pumps, essentially to protect the resin pump casings from mechanical shock loading in the event of slight movement of the rigid pipework system.

23 All the interconnecting pipework in the ethyl chloride plant was of flanged steel sections lined with PTFE, again to protect against internal corrosion. The whole plant area was congested due to the complicated pipework design and access to internal areas required considerable manoeuvring over and around plant and pipework.

24 Manual isolation valves were fitted to the pipework at the three main EC process vessels, namely the reactor, the slops drum and the stabiliser feed drum and were as follows:

(a) two manual isolation valves were fitted near the base of the reactor. One was directly underneath the reactor in a skirt surrounding it and accessible through a permanent opening. The second was fitted in the pipe between the reactor and the P251 pumps manifold (Figure 5). These valves were both about 1 metre above ground level and required access over the reactor bund wall to reach them;

(b) another manual isolation valve was provided adjacent to the reactor on the liquid return line from the slops drum and stabiliser feed drum. This was at a height of approximately 5 metres;

(c) the outlet pipework on the underside of the slops drum was fitted with a manual isolation valve at a height over 2 metres above ground level. This was difficult to operate from ground level; and

(d) a manual isolation valve was provided on the liquid outlet of the stabiliser feed drum, also about 2 metres above ground.

Chemical hazards

25 The crude EC reactor liquor was approximately 90-95% ethyl chloride, up to 2% hydrogen chloride, 0.5-2% polymer oil and 0.1-1.5% aluminium chloride. The main hazard was ethyl chloride although hydrogen chloride is a toxic and corrosive substance and readily forms hydrochloric acid mist on contact with moisture in the air. Ethyl chloride presented primarily a flammable risk.

26 Although it has a boiling point which is close to normal ambient temperature (12.27°C) ethyl chloride is generally handled as a liquefied flammable gas when in liquid form but may exhibit the characteristics of either a liquefied flammable gas or a highly flammable liquid, depending on ambient temperature.

27 Ethyl chloride burns to produce toxic fumes from combustion products. A pool fire as well as producing high thermal radiation will mainly produce toxic fumes of HCl with carbon dioxide, water and under certain conditions, trace quantities of phosgene. HCl has an occupational exposure standard (OES 15 min STEL)* of 5 ppm. If HCl is limited to less than the OES, there is not thought to be a significant risk from exposure to phosgene, although this is a subject of current research.

28 A pool of ethyl chloride would be formed by a sudden release of liquid from plant or equipment. A proportion of the initial release would be emitted as a flash vapour. Thereafter evaporation from the pool formed would maintain a flammable vapour cloud which could subsequently ignite. The lower explosive limit (LEL)* for ethyl chloride is 3.6% by volume.

29 In the event of a pressurised vessel containing ethyl chloride being exposed to fire for an extended period there is a possibility of a boiling liquid expanding vapour explosion (BLEVE)* following rupture. A BLEVE would result in a fireball with consequent radiation and over-pressure blast effects and flying debris.

30 The occupational exposure standard for inhalation of ethyl chloride (OES 8 hour TWA)* is 1000 ppm. The immediately dangerous to life and health (IDLH*) value is 20 000 ppm. It has a low acute toxicity, the principal effect being anaesthesia at high concentrations in air. However, prolonged exposure to high concentrations can result in respiratory and cardiac arrest.

31 The environmental effects of ethyl chloride are generally low. If spilled on land it will evaporate rapidly. Again, due to its high volatility and ready evaporation, ethyl chloride spillage into water is not a long term problem. There may be some short term ecological damage to vegetation and water courses if it is not removed promptly.

*See Glossary of terms, page 46

THE INCIDENT AND THE EMERGENCY RESPONSE

The release

32 At about 8.00 pm on 1 February 1994 alarm warning lights were noticed on the control panel in the control room of the EC plant. One alarm related to a fault on the "slops" pump, P251/3. The other alarm indicated a high level of liquid in the slops drum which was a process operating concern rather than an immediate safety concern. The process operator went out to the plant to investigate the faulty pump and found that it had stopped altogether. He isolated it and switched over to the spare pump, P251/2, and waited to see that it ran satisfactorily. The process supervisor checked these actions. They subsequently returned to the control room. At 8.20 two flammable detectors operated and the flammable gas alarm was sounded for the EC plant.

33 When the process supervisor, who was in the control room, opened the control room door he saw a large gas cloud estimated to be 10-15 m high, almost enveloping the plant and sounded the local gas alarm at 8.22. The cloud had a white, wispy steam effect which he initially thought was HCl. He went out to investigate and saw liquid around the evaporation area close to the plant, which smelt and looked like EC reactor solution. He therefore followed the pre-arranged emergency procedures and telephoned the company time office, which then became the emergency headquarters (EHQ) on-site, at 8.26. The Works Fire Tender arrived at 8.31 and was set up as Forward Control Point. The supervisor could also hear rushing liquid and saw that the cloud was moving off-site, so at 8.36 he initiated the off-site emergency plan by telephoning the EHQ again and calling 'Cloudburst', the agreed code-word for major incidents involving a chemical release. A message was relayed to county emergency services in accordance with the agreed procedure identifying an ethyl chloride emergency. As part of the emergency plan the supervisor's role was then to act as technical controller, the main role being to direct any emergency action at the scene prior to the Fire Brigade arriving, check the progress of any remedial action and act as a communication link with EHQ and others during the incident. Two teams of operators donned breathing apparatus and the second team identified the source of the release near to the base of the reactor. One of the operators felt liquid hitting him on the legs up to the waist.

34 The off-site alarms (sirens) were activated and the emergency services called. The Police logged the 999 call at 8.39 and Cheshire Fire Brigade Control logged the completion of the call from the Police at 8.41. In accordance with Major Accident and Cloudburst procedures, the full Cheshire County off-site emergency plan was initiated and the Emergency Services Reinforcement Base (ESRB*), and the District Off-Site Emergency Centre (DOSEC*) were set up. At the site, staff gathered in pre-arranged safe refuges.

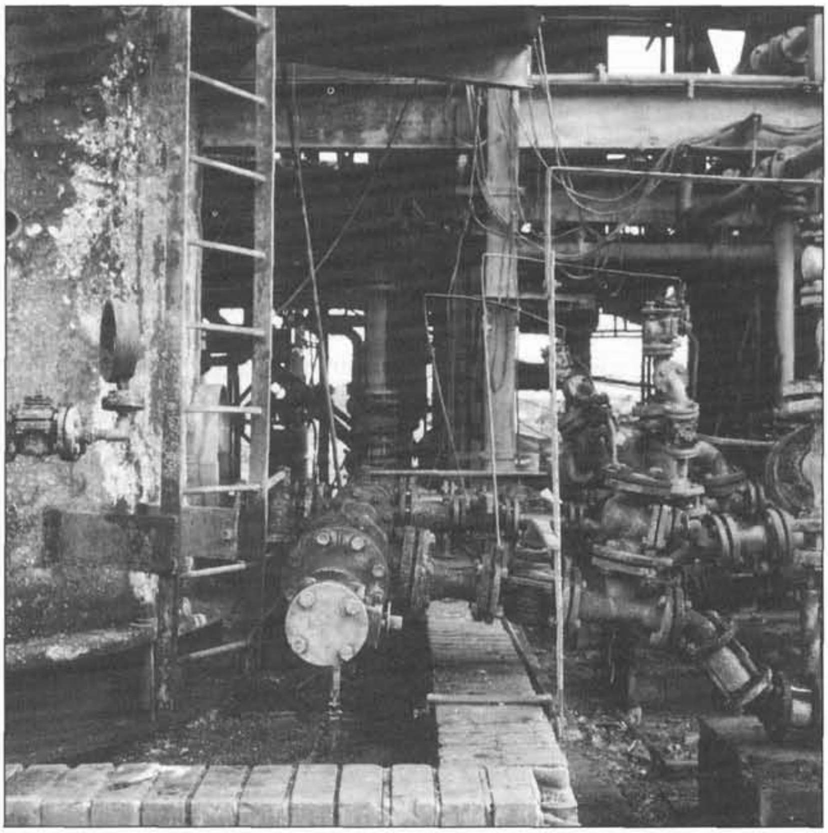
35 Three fire appliances were despatched to the site, provided with the necessary

* See Glossary of terms, page 46

protective equipment for the crews to deal with a toxic incident, arriving at the plant at 8.47 pm. Hazard information was exchanged between the fire officer and the technical controller and the attention of the fire officer was drawn to the need for isolation and dispersion of HCl in the cloud. As a result, the fire fighters set up monitors (water cannons) to put up a curtain of water droplets to control the cloud of HCl which is very soluble in water, and assisted with isolation of the leak.

36 Two fire fighters, guided by an Octel employee, then entered the cloud in an attempt to isolate the plant and stop the flow. The fire fighters were dressed in chemical protection suits and the Octel employee in a PVC suit and all wore breathing apparatus. One of the fire fighters closed the reactor outlet valve to the pump manifold at the base of the reactor (Figure 6). A second team of fire fighters went in to close the discharge valves of the polymer pumps P251/1 and slops pump P251/2 guided by the same Octel employee and succeeded. There was no time to close any further valves before the air supply in their breathing apparatus ran out. The fire fighter who closed the valves had to be led out of the cloud because his face mask was completely opaque as a result of external corrosion. He reported that he was facing P251/3 and that he was hit in the chest by liquid as he was closing the valve on P251/2. These actions did not stop the leak and a pool of liquid could clearly be seen. At this stage consideration was given to isolating the outlet valve at the base of the slops

Figure 6 *Photograph of Reactor R251 outlet valve to P251 pump manifold at base of reactor*



drum and the slops inlet valve halfway up the reactor. Because of their height, as well as the cloud, they were difficult to reach. During these attempts, the Fire Brigade maintained the water curtain.

37 Between 9.10 and 9.15 pm the first Octel managers arrived on-site. By about 9.25 pm one of these went to assist the plant supervisor, who was still acting as technical controller. He advised that the sprays be repositioned down wind of the pool to suppress the cloud and to avoid spraying onto the pool of liquid which would increase evaporation of ethyl chloride. It was also agreed that fire fighting foam should be laid on the exposed pool to inhibit vapour release. Around 9.50 pm, they started to lay down a blanket of foam. During the period between the arrival of the first three appliances and the laying down of the blanket a further five fire appliances were requested to attend the site to provide additional fire fighters with breathing apparatus and protective clothing.

The fire

38 At 10.08 pm flammable vapours of ethyl chloride ignited and flashed back to the pump area by the side of the reactor. The seat of the fire was described as coming from the base of the reactor area at a height of about 1 m above ground. This was a flame in the direction of the refrigerator units and towards the HCl compressor (Figure 1). It was described as spreading out like a fan and directed towards the tiled area on the floor of the plant.

39 The fire burned fiercely at the base of the reactor and spread to other parts of the plant, as flanges in the PTFE lined pipework started to fail. At this stage of the incident the Fire Brigade increased the appliances in attendance to 12 and mobilised their operational bulk stocks of foam but withdrew from the immediate scene because of the perceived explosion risk at the slops and stabiliser feed drums. The three large vessels were believed to contain quantities of the reactants and concern centred on the potential for an explosion should the vessels rupture. There were a number of flange fires and the top of the stabiliser feed drum in particular was being heated by a jet flame. This was one of the vessels with an intumescent cladding designed to withstand fire engulfment for at least two hours. At about 11.00 pm, as a precaution, a partial shutdown of the factory was started to allow Octel personnel to move to a safer location at the western extremity of the site. At the same time, two neighbouring factory sites to the east were advised to take similar action.

40 Also at 11.00 pm a major foam attack was organised to fight the fire at the slops and stabiliser feed drums as it was decided the cladding on these vessels allowed a sufficient safety margin to attack these vessels and that this was safer than allowing the fire to burn uncontrolled. To support this, increased transfer of foam was needed requiring a further 10 pumping appliances. Also supporting were Octel and Shell foam tenders using their roof mounted monitors which were very effective in attacking the fire on top of the vessels.

41 At 11.23 pm the possibility of complete evacuation of the EC plant area including the emergency crews was considered. The vessels had now been subject to the fire for 1 hour and 15 minutes and it was decided that evacuation might need to start within 30 minutes, taking into account the minimum 2 hour protection provided by the intumescent coating. A precautionary "30 minutes to evacuation" warning was put out and the local authorities' reception centre was alerted.

42 However, it was clear that the major foam attack had been successful in reducing the fire and consequent risk of explosion at the EC plant and withdrawal was no longer considered. The foam attack progressively reduced the fire to two main areas, the base of the reactor and the tops of the horizontal vessels. By about 1.00 am on 2 February the fire was being contained in these two main areas and control was being achieved. Once the brigade were satisfied that it was controlling the fire, the evacuation warning was cancelled and the alarm sirens were switched off.

43 The fire was allowed to burn on a reduced scale and was finally declared extinguished at 8.34 am on 2 February. Process liquids continued to leak from the damaged plant in small quantities until 12.20 pm.

ON-SITE DAMAGE AND INJURIES

44 One Octel employee and 17 firemen received treatment during the night of the incident. The employee who had been struck and contaminated by process liquids became ill and was detained in hospital overnight. His subsequent absence from work for more than three days was formally notified to HSE under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR). Two firemen were taken to hospital but not detained. No-one was seriously injured. The ethyl chloride plant was very extensively damaged and, on completion of HSE's on-site investigation, was demolished. A new plant has been built at an estimated cost of £6.1 million and was commissioned in January 1995. Other plants on the site were not damaged. Production of chlorine continued at a reduced level. Ethyl chloride was imported by road, rail and sea to make up for the loss of its production. The company estimate the costs of transport and of the disruption to the process may be several times the rebuild cost.

OFF-SITE IMPACT

45 During the night of the incident, a team of Octel employees toured residential areas downwind of the site but detected no significant concentrations of hydrogen chloride fumes. Merseyside Emergency Planning Services carried out hydrogen chloride measurements and recorded very low concentrations (0.14

parts per million in air) in a road on the industrial estate about 800 m south east of the site boundary.

46 During the incident, the adjacent roadways, Oil Sites Road and Bridges Road, were closed, as well as the nearby M53 motorway, junctions 9 and 10. A roadworks gang on the M53 was evacuated and there was also partial evacuation of two local factory sites, Zeneca and the north side of Shell UK Ltd.

47 According to measurements taken by Octel at the site Emergency HQ, the wind direction at the start of the incident was 270° ie directly from the west, and although there were fluctuations the centre of these remained at 270° until about 1.15 am, when there was a 20° swing to the south. After this time there were major fluctuations to the south and back to the west up till 8.30 am. Wind speeds were up to 24 mph at the start of the fire, but dropped to between 8-18 mph at 10.45 pm and dropping further to between 5-12 mph until 5.15 am, dropping below that after that time. Octel estimate that 5 tonnes of ethyl chloride was lost prior to ignition. 1.5% of this was HCl, the main toxic hazard. Calculations completed by HSE's Major Hazards Assessment Unit showed that the concentration of HCl would fall to the Occupational Exposure Limit (see Glossary) within 60-110 m downwind of the source. Following ignition, the main toxic hazard is again HCl. At peaks of wind speed recorded the concentrations would fall to the OEL within 300 m, but at the lower wind speeds recorded this distance is reduced to only 50 m, in other words barely beyond the site boundary. Nevertheless, the fumes at lower concentrations are acrid and unpleasant. Estimations of the intensity of the fire indicate that there were no significant phosgene fumes created.

48 There were a small number of complaints of ill health. Some of those working at the adjacent Shell refinery displayed symptoms consistent with exposure to HCl and there was one formal notification of ill health to HSE under RIDDOR to an employee of a catering company operating on the site. The local authority was not aware of any further instances of members of the public being affected. A medical officer attended the incident and made contact with local hospitals.

49 As regards environmental impact, 225 000 litres of foam and large quantities of fire water run off were discharged into the nearby watercourse, known as the South Boundary Ditch. The pollution load was not of concern to the National Rivers Authority (NRA), who were in attendance from 10.00 pm, because of the existing condition of the water course. NRA also concluded that the South Boundary Ditch discharged into the River Gowy at such a low rate that any contamination was diluted out. Visual checks by the NRA since the incident have shown no lasting effects. HSE is not aware of any damage to the Site of Scientific Interest located in the Mersey Estuary.

HSE INVESTIGATION

50 The HSE night duty officer was informed of the incident at about 11.30 pm on 1 February by the Cheshire County Emergency Planning Officer. The Area Director (Merseyside and Cheshire) was contacted immediately and after further briefing, from which the scale of release and fire became apparent, he activated the area's major incident plan.

51 The Area Director arrived at the ESRB at Ellesmere Port at 7.30 am on 2 February and was briefed by the officer in charge. He arrived at the scene of the fire at about 8.15 am and received an initial briefing from the company on the emergency, which was still in progress. Additional inspectors from the area office, accompanied by specialist inspectors, arrived later that morning. However, detailed examination of the site of the fire could not begin until the morning of 3 February when the fire fighting foam had been cleared and hosing down of the plant and the area around it had been completed.

52 A multi-disciplinary HSE team was set up to carry forward the investigation, led by the head of Field Operations Division's Special Hazards Unit†. The team included inspectors from the Merseyside and Cheshire Area Office, specialist inspectors in chemical, mechanical, electrical and process safety engineering from the North West Field Consultant Group and experts in fire, explosion, engineering and metallurgy from the Research and Laboratory Services Division (RLSD)* in Buxton and Sheffield. Later in the investigation additional specialist help was provided by the Major Hazards Assessment Unit† in HSE's Technology and Health Sciences Division**.

53 On the 3 February a statutory notice was served on the company under Section 22 of the Health and Safety at Work etc Act 1974 (HSW Act) prohibiting the company from restarting production of ethyl chloride until it had demonstrated to HSE that "the major accident hazards had been identified and that appropriate precautions had been taken to limit the consequences to persons and the environment". The following day a further notice was served on the company under Section 20(2)(e) of the HSW Act requiring that the ethyl chloride plant be left undisturbed.

54 There were three main strands to the investigation:

(a) to establish why the leak and subsequent fire occurred;

(b) to determine how the emergency was handled in relation to the pre-prepared on-site and off-site emergency plans and whether the plans were sufficient; and

(c) to investigate the management systems in place at Associated Octel.

* Now HSL (The Health and Safety Laboratory)
† Now part of a newly formed Division (Chemicals and Hazardous Installations Division)
** Now Directorate of Science and Technology

55 During the course of the investigation members of the HSE team:

(a) carried out detailed examinations and took photographic records at the site of the ethyl chloride plant;

(b) took possession of a large number of items of plant and equipment for further detailed examination at HSE's research laboratories. This included the three pumps (P251/1-P251/3), associated pipework and items of electrical equipment. Each component was individually numbered and photographed on-site before dismantling (see Figure 5). Large items such as process vessels were set safely aside at the Octel site for further examination. The scientific and technical investigations were made more difficult because the fire had caused such extensive damage to the plant and a number of items which could reasonably have been expected to yield more precise information as to the cause of the leak had been consumed. The technical investigations on-site and forensic examinations and tests at RLSD continued for many weeks;

(c) interviewed witnesses;

(d) examined documents relevant to the plant and to the company's management systems, in particular the maintenance and plant change systems, procedures and records; and

(e) interviewed or consulted a large number of people involved in, or affected by the emergency response. These included the Cheshire Fire Brigade, Cheshire Constabulary, and representatives of local councils and of local residents associations.

56 The company, its employees and their Trade Union representatives provided full co-operation throughout the HSE investigation. Thirty-seven written statements were taken. The company set up its own internal investigation at an early stage. The leader of the HSE team had a series of meetings with Octel management, with Trade Union representatives and with the leader of the company investigation to exchange information as to progress and action proposed. The company provided a video of the incident taken by one of its site security cameras.

57 It is estimated that the investigation took 300 staff days at a cost of £126 000 in staff time alone.

FINDINGS

Source of release

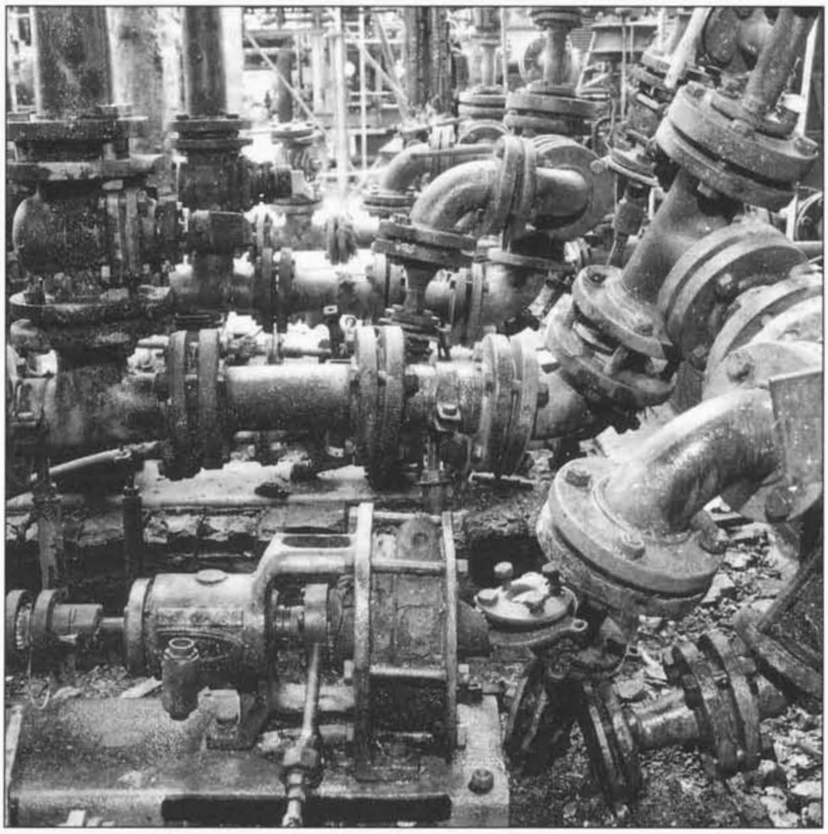
58 As so much of the EC plant was extensively damaged in the fire, investigators initially had to establish the source of the release by building up a picture from eye witness reports. Even this was difficult because the vision of operators and fire fighters at the scene had become severely restricted by the cloud and deposits on the masks of their breathing apparatus. The gas cloud had appeared thickest around the base of the EC reactor and Octel staff had soon identified the leak was at ground level in the P251 pump area. The pipework in this area was complex and congested and there were a number of flange connections which were all potential leak sources (Figure 7).

59 Evidence from witnesses including those that closed valves and who were struck by the liquid release allowed investigators to conclude that:

(a) the release was from the P251/2 line or possibly from the isolation valves for P251/3;

(b) liquid was flowing from the discharge side of the pumps to feed the release;

Figure 7 *Photograph of 251 pump area showing complex pipework and multiple flange connections*



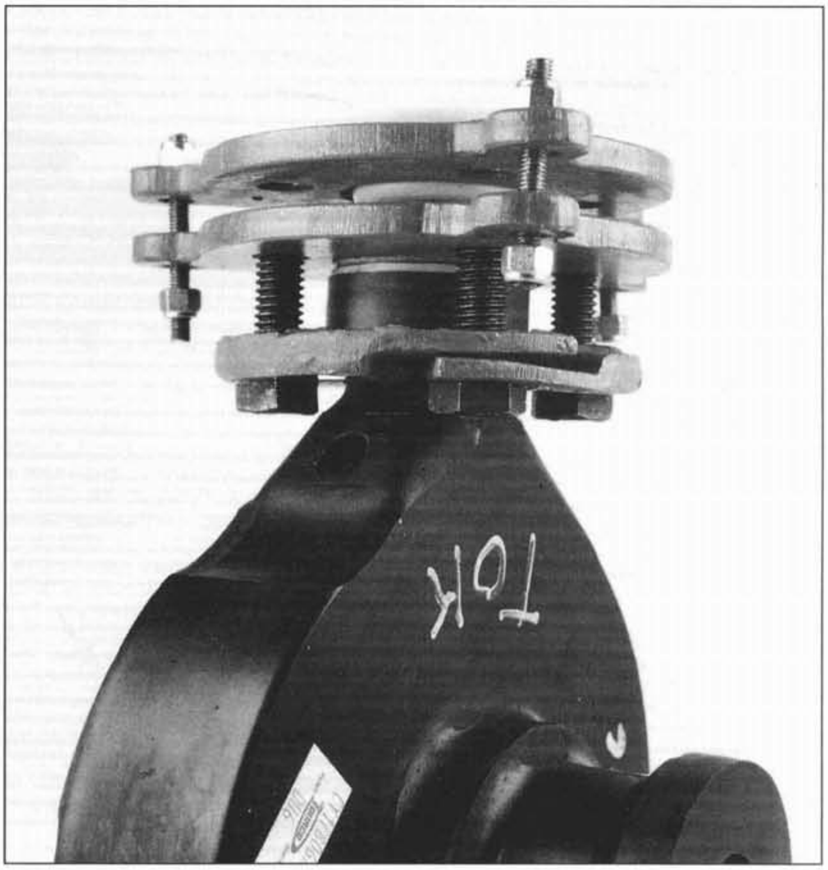
(c) this was a sudden large release which is characteristic of a catastrophic failure of a joint assembly rather than a gasket or seal failure; and

(d) the horizontal release pattern described was more typical of a leak source from a horizontal joint.

60 Scientific examination of the P251 pumps and pipework by RLSD revealed that a split flange on the discharge port of pump P251/2 was severely corroded and in a worse condition than either the flange for the suction port of the same pump or other split flanges on adjacent pumps. This flange had been used to secure the flexible joint to the discharge port of the pump. The two halves of the split flange overlapped. The overlapping sections were half the thickness of that of the main sections of the flange. In some areas of the overlapping sections, the flange material had been completely corroded away. All of the bolt holes appeared to have been enlarged by corrosion and were found to be approximately 19 mm in diameter, whereas the major thread diameter of the bolts was between 10 and 10.5 mm.

61 The original casings of the pump itself were made from silica-filled epoxy resin and these, together with the bellows, had been consumed in the fire. RLSD constructed a 'replica' of the original pump casings, bellows and flange assemblies from new components supplied by Octel or the manufacturers (Figure 8).

Figure 8 *Photograph of replica pump casing, bellows and flange assembly*



62 When the original split flange was mounted on the discharge port of the new pump casing the extent of the corrosion became evident. The wasting of the flange was such that its bore was almost equal to the diameter of the discharge port (Figure 9). The evidence suggested that:

(a) any movement of the flange halves allowed by the securing bolts in the corroded bolt holes would have allowed the flange to slip along the port of the pump;

(b) there was a high risk of a significant leak occurring without the split discharge flange completely disengaging from pump P251/2; and

(c) such a leak would be through an annular gap between the flange and bellows faces, ie in a horizontal plane.

This theory was supported by eye witness descriptions of the liquid release pattern. The jet flame at the start of the fire, which was described as spreading out like a fan, is also consistent with such an annular release.

63 A complicating factor was that during the incident the flange would have been subject to corrosion from escaping HCl, the rate of corrosion possibly being increased by the raised temperature. It was therefore difficult to establish the

__Figure 9__ Photograph of corroded split flange from P251 with 50 mm brass cylinder to simulate pump discharge pot

extent of corrosion before the incident. However, RLSD conducted some corrosion tests and from the results of these formed the opinion that the difference in the degree of corrosion between the discharge split flange on P251/2 and those on the other pumps could not be wholly accounted for by these effects and that the flange had been in a seriously corroded condition before the incident.

64 The scientific examinations also revealed other faults concerning P251/2:

(a) the pump to motor drive coupling was misaligned by approximately 3 mm. Such a misalignment could have induced unnecessary vibrations;

(b) the method of clamping down the P251/2 motor appeared to be improvised, as the clamping bolts were not passed through the correct holes but were clamped down onto short bridging pieces; and

(c) the pump design was such that the two halves of the pump casing were clamped together using steel casing clamps and six 120 mm bolts and nuts. However, the clamping plate on P251/2 had been fitted upside down and as a result some fixing bolts were misaligned.

These faults would have increased the risk of failure of the pump and its attachments.

65 The flexible joints consisted of two steel flanges with a small PTFE bellows between (Figure 8). No fragments of the original PTFE bellows were found. Each joint was approximately 3 cm long, the whole joint being specified as suitable for a working pressure of approximately 100 psig at 100°C. This was well within the normal operating conditions of the plant. However, joints are a relatively weak part of the system and liable to failure if subject to mechanical stresses outside design parameters. A high standard of inspection and maintenance is demanded when they are used.

66 The investigation team concluded that the release occurred at a point between fixed pipework and the discharge port of pump P251/2 as a consequence of either (a) a corroded securing flange on the pump working loose; or (b) the failure of a PTFE bellows. On the basis of their evidence and on the balance of probabilities, HSE formed the view that (a) was the cause of the release.

Maintenance of plant

67 The EC plant was shut down for 7 to 10 days every 6 months. This allowed work such as scheduled inspections and plant modifications by company personnel to be carried out, together with any statutory examinations by insurance company surveyors. In other respects the company's maintenance strategy for the P251 pumps, pipework and associated equipment was reactive.

For example:

(a) although new pipework systems were designed and tested in accordance with an Octel Code of Practice, this did not cover in-service examination and inspection;

(b) when significant corrosion was found, advice was sought on a case-by-case basis from the company's inspection department and/or material scientist;

(c) there was no routine visual inspection, such inspection was confined to other items of plant requiring periodic statutory or other examination as the opportunity arose;

(d) maintenance was on a breakdown basis. No formal written records of repairs or replacement were kept although diary entries were kept by the plant *maintenance engineer; and*

(e) there had been no identification of critical items of plant, such as the PTFE bellows, failure of which might cause a serious incident. Because of the lack of records it would have been difficult to draw up a well-informed inspection or replacement schedule had such a strategy been initiated.

68 The HSE investigation team found no evidence to suggest that the chlorination plant maintenance section and others involved in maintenance work at the plant were doing anything other than following company policy. Such a reactive rather than planned maintenance policy falls a long way short of the standards expected by HSE at a major hazards installation.

69 Apart from the items referred to in paragraph 64 which related to P251/2 in particular, other items were also identified which raised questions about the standards of maintenance at the EC plant:

(a) one half of the split discharge flange on pump P251/1 had been installed upside down;

(b) in one case, five gaskets had been used to pack a flange. This significantly reduced the integrity of the joint;

(c) the motor and pump shafts of P251/1 were also axially misaligned, although not to the extent found on P251/2.

Maintenance prior to the incident

70 Pump P251/2 had been taken out of duty on 21 January 1994. As was customary, the pump was disconnected leaving the flexible joints attached to the pump. It was removed to the maintenance workshop, dismantled and a new mechanical seal,

shaft and coupling fitted. Fitters were not expected to examine the bellows or split flanges. The pump was refitted the following day without any reported problems.

Source of ignition

71 There was strong eye witness evidence that the ignition occurred at an electrical control panel, connected to a 110 v supply, for an HCl compressor adjacent to the EC process plant. This was one of two compressors used to supply HCl to the EC reactor from the HCl burner units. A flash was seen at the control box while foam was being laid down in the vicinity and the flash spread across to the EC plant which was rapidly engulfed in flames.

72 The compressor was inoperative as its piston had been removed, nevertheless electrical supply was available at the panel at the time of the incident. This panel was at the location marked in Figure 1. On the control panel, there were a number of items of electrical equipment, each of which were designed to an appropriate explosion proof standard.

73 There can be no conclusive evidence of the precise source of ignition. Examination at RLSD showed that four items taken from the control panel were damaged by the fire. Examination of an emergency stop switch did suggest a possible fault with the blanking off plug at the bottom of the box. The plug may not have been correctly fitted or it may not have been the correct type. Either of these deficiencies could have allowed water or foam to enter the box which would then have caused tracking and arcing between the terminals and led to an external ignition of the vapour.

Events during the day and in the control room

74 From evidence given by witnesses and by analysing the pen charts in the control room, the following sequence of events emerge.

6.00 am	new EC plant shift starts
approx 9.00 am	the original pump returning liquid from the slops drum stops, although this was not identified at the time
	as a result the liquid level in the reactor starts to fall and levels in the slops drum rise
approx 10.30 am	the operator is concerned about the fall of liquid level in the reactor and stops drawing off ethyl chloride from the stabiliser feed drum but still maintains the input of reactants into the reactor the net result is that liquid in the EC plant is accumulating

3.30 pm	an operator in the same control room operating an adjacent plant notices the alarm light is displaying the high level alarm for the slops drum. The EC operator is engaged and he forgot to query this with him later
6.00 pm	new EC plant shift starts
7.50 pm	shift supervisor notices a steady white light for the slops drum high level alarm and queries it. He also notices the alarm lights on the panel for the slops pump. As a result, the operator investigates, confirms pump 251/3 has stopped and switches to pump 251/2
approx 8.15 pm	EC release occurs
8.20 pm	flammable gas alarms sound

75 The events clearly show that operators had not identified that an important pump had been stopped for about 11 hours when it was identified by the shift supervisor on his "rounds". One operator had misinterpreted data at 10.30 am and as a result there was about twice the normal inventory of 30-40 tonnes in the EC plant at the time of the release. It is emphasised that these actions of themselves, although inadequate, were not critical to the safety of the plant but, because of the subsequent events, did add to the "fuel" in the plant which would have been significant in the event of a tank rupture.

76 A detailed examination of the alarm system in the control room, particularly the slops drum and slops high level alarm, was made by HSE's electrical inspectors. The high level alarm was set to operate at about 10 tonnes and operated an audible alarm and a flashing white light on a wall display panel above the control panel. The audible alarm can be stopped by pressing an accept button, at which stage the flashing white light should become steady.

77 Investigators were unable to identify anyone who would admit to accepting the high level alarm. Subsequent tests by HSE electrical inspectors have shown that the panel alarms worked as designed. However, these tests also showed that when the slops pump (P251/3) was stopped, there was no audible alarm as expected, but panel alarm lights lit up. A new control panel for the EC plant had been installed in mid-1993. There was a proposal to install such an alarm audible for pump P251/3 stopping but this idea had been abandoned because the design of the panel did not appear to readily allow for it. No records were kept either of the original design of the control panel or of the attempted modifications and, as a result, the decisions made would not have been subject to formal management control which is expected of any such changes with significant safety implications.

Company risk assessment of the EC plant

78 The EC plant was constructed in 1972 and was designed and constructed to standards current at that time. A review of the design took place in the mid-1970s when mild steel pipework interconnecting the principal process vessels was found to be corroding rapidly. This was replaced initially by glass-lined, and later by PTFE-lined, pipework.

79 In 1984, in response to the new CIMAH major hazards legislation (see Appendix 2, paragraph 3) then about to come into force, Octel's Hazards Evaluation Department conducted a major hazard survey of the plant. The survey was restricted to checking compliance with the relevant codes of practice and assessing the frequencies of worst events. The study reviewed HSE published guidance for liquefied petroleum gas (LPG)[1], which is similar in properties to EC; an ICI/ROSPA Engineering Code 2 on liquefied flammable gas storage and handling as well as BS59083 concerned with fire precautions in chemical plant. The most important recommendations of the company survey related to the design of diversion walls to divert spillages away from the vessels to a safe area, provision of cooling water to storage vessels, the provision of remotely operated valves for the liquid lines from the EC main storage vessels and the provision of fire protection for the EC process vessels. Other important improvements included uprating and replacing the relief vent system, installation of dry hydrant mains, purchase of a mobile foam cannon and installation of new instrumentation including flammable gas detectors.

80 Thus, although the survey was limited to a comparison of the plant with recommended standards, it did identify problems related to the largest inventories of EC in storage and where there were likely to be failures, eg tanker connections/disconnections. An extensive action plan was drawn up and formed part of the company's safety report which was submitted to HSE in July 1989 (see Appendix 2, paragraph 5). Progress was recorded in an update in 1992. Virtually all outstanding work was completed prior to the incident, including the provision of fire protection on the three largest process vessels, some two years before the incident.

81 The weakness of the survey carried out by the company was that it did not comprise a risk assessment which comprehensively reviewed the design and operation of the plant. The potential for a major release in the liquid return lines and pumps from the slops tank and stabiliser drum to the reactor had not been identified in the survey nor in the subsequent safety report. Although the hazards of EC and HCl were well-known, the risks concerning this part of the plant were identified as being relatively minor. As a direct result, insufficient attention was paid to a range of design and operational safety features which either would have reduced or avoided the risk of such a release in the first place or would have mitigated against its consequences. These included:

(a) the provision of remotely operated shut off valves (ROSOVs) to enable rapid isolation of inventories in the principal process vessels in the event of a release; and

(b) a higher standard of routine maintenance and inspection of plant to prevent leaks and to ensure that any minor leaks which did occur were identified and remedied quickly;

(c) the provision of drainage facilities adequate to cope with a major liquid release from the reactor recycle system.

Other aspects of the EC plant operation had been reviewed since 1984, such as the design of the relief vent system, but the decision to undertake these was not based on a structured programme.

The on-site and off-site emergency plans

82 The Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH) require Octel to provide an on-site emergency plan and to provide information to the public on what to do in the event of an emergency. Local authorities are also required by CIMAH to prepare an off-site emergency plan. The detailed requirements of CIMAH and other legal provisions are given in Appendix 2.

83 HSE's responsibilities in relation to the planning and provision of emergency response is limited to enforcement of CIMAH Regulations 10-12 and comments here are confined accordingly. The generally excellent emergency response to this incident and such issues as the training of fire fighters are matters for the Home Office and fall outside the scope of this report.

84 Octel had prepared an on-site emergency plan, last revised in November 1991, which set out comprehensive procedures to be adopted in the event of incidents involving chemical liquid spillage, fire or toxic gas release. The plan was developed and applied to the whole site for each of the works. Specific responsibilities of individuals were identified and training given by the separate works. HSE made no adverse comment on the plan in its assessment and inspection work under CIMAH.

85 The company had met the public information requirements of CIMAH. A leaflet detailing the nature of the hazards and the action to be taken in the event of an emergency had been sent to all householders within the public information zone in January 1992. This zone, designated by HSE, covered an area of 1.5 kilometres distance from the site boundary. A company representative had visited large organisations in the public information zone and provided the local authority environmental health department with information for distribution to smaller undertakings. The information concentrated on chlorine release as the main off-site risk which forms the basis of the off-site emergency plan. A re-

issue of an updated public information document was imminent at the time of the incident.

86 An off-site plan had been prepared by the County Emergency Planning Officer (CEPO) who is responsible for such plans to Cheshire County Council. The plan was revised in August 1991 and updated in May 1993 when new digital maps were added. For the most part, this plan was considered to be adequate, but in meetings with the Cheshire Emergency Planning Department during 1993, inspectors of the local HSE area office had discussed a number of reservations about the plan as follows:

(a) the written emergency arrangements specified were not sufficiently site specific and in this respect did not fully comply with the advice given by HSE in HS(G)25;

(b) the arrangements were primarily directed toward the eventuality of an incident involving chlorine and the associated toxic hazards. Although HSE recognised these were the principal hazards liable to affect people off-site, insufficient attention was directed toward the risk of fire and explosion deriving from the storage and use of liquefied flammable gas. This was of significance since such plans should form the basis for training fire fighters who may attend the site in an emergency; and

(c) an adequate means had not been identified by which the Fire Brigade could obtain rapid retrieval of information about the site and its hazards in the event of an incident.

87 These reservations about the off-site plan had been drawn to the attention of those responsible at Cheshire County Council in writing by HSE. Although these matters had not been concluded when the incident occurred, the full extent of these changes are to be included in all Cheshire off-site plans by the CEPO.

How the emergency was handled in relation to the emergency plans

88 For the most part the emergency was handled in accordance with the on-site and off-site emergency plans. However, the investigation revealed a number of deficiencies either in the plans themselves or in the way they were put into effect.

On-site

89 HSE's investigation and post-incident reappraisal of the plan revealed that the training given to staff on emergency procedures was thorough and detailed but concentrated on responses which were more appropriate to toxic rather than flammable risk. There had been numerous emergency exercises involving

people working on the EC plant but these had mainly focused on chlorine releases because of the risk from adjacent plant on-site. For example, in the year he had been in post the supervisor had never taken part in an exercise involving a flammable gas release. These inadequacies in training may explain the following actions taken during the incident:

(a) personnel entered a flammable gas cloud at great risk to themselves in circumstances when they should not have done so;

(b) where used, only personal protective equipment suitable for toxic risks was worn; and

(c) inadequate information was given to the fire fighters (see paragraph 86 above).

90 About an hour and three-quarters elapsed between the start of the release and the ignition of vapours causing the fire. Initial information given by the company technical controller to the Fire Brigade was interpreted as confirming that this should be handled primarily as a toxic incident and action was taken accordingly (paragraph 35). In fact the main risk was of fire. This should have been recognised immediately because it was the flammable gas alarms that first signalled a release. The plant supervisor who was acting in the capacity as technical controller was the sole company representative at this stage and was under great pressure in the ensuing emergency. It was not until the first Octel manager arrived at the scene at about 9.25 pm that advice was given both to avoid playing jets of water on the pool of liquid and to lay down a blanket of foam so as to suppress the release of flammable vapours. The laying of foam began at 9.50 pm. Whether the fire could have been prevented had foam been laid at an earlier stage in the incident is a matter for conjecture. A very large quantity of liquefied flammable gas had been released and there was a very high risk of a source of ignition eventually being found.

91 A factor which may also have contributed to the initial confusion over the emphasis to be placed on the flammable versus the toxic risks was the inadequate support for the technical controller at the start of the incident. This partly arose because of delays in key Octel managers arriving at the site. The duty manager required to be called from home, had taken off his pager and did not respond until after 9.30 pm, although other managers were successfully called in. At least one other manager who was called as part of the back-up Octel management team was initially prevented by the Police from going on-site as part of their instructions for restricting access.

92 The on-site plan was also found to be deficient in that there were inadequate procedures for isolating the electrical equipment on and around the plant quickly and safely. Some items of equipment were not isolated until the following day. Electrical equipment on the plant was designed to be to an "explosion proof"

standard but predictable damage in the event of a prolonged incident necessitates such isolation. Plant lighting in the area was left on during the incident.

Off-site

93 For the most part the emergency was handled in accordance with the off-site emergency plan. However, a number of problems and deficiencies were identified as follows:

(a) Company representatives gave inadequate and ambiguous information about the nature of the hazards and the appropriate response when the Fire Brigade first arrived (see paragraph 90) which was not checked by the Brigade despite clear information being available;

(b) the off-site plan was deficient in that it was primarily directed toward toxic hazards and it had been criticised by HSE in this respect prior to the incident (paragraph 86);

(c) the Fire Brigade did not have its own means of rapidly retrieving enough information about the multi-risk complex chemical plant at the Octel site, its hazards and the way in which the incident might develop. At the time, basic chemical information was available to the fire fighters but this was not easy to interpret nor apply to the specific circumstances prevailing on-site in order to determine the most appropriate response. An example of information held by the Fire Brigade that could be misleading in these circumstances was the HAZCHEM code for ethyl chloride which is '2WE'. The HAZCHEM code is legally required to be marked on road tankers and other vehicles which carry dangerous substances to give information to the emergency services on immediately arriving at an incident. The first two digits relate to the type of nozzle attachment and fire fighting medium to be used, ie water fog in this case and that full protective clothing should be worn and the substance contained. The 'E' suffix signifies 'consider evacuation' which is likely to be an entirely appropriate action for the area around a road accident but is unlikely to be the correct course of action for a fixed installation where employees and local residents will usually be safer to stay indoors and away from windows. Of course, any decision on evacuation of an area around a fixed installation will be reached taking into account all the circumstances that prevail and the information available.

(d) the residential population within the public information zone was aware of the possibility of an incident at the site and generally followed the advice given. However, the population outside the public information zone was at best only aware of information from the radio and television and had no details on which to make judgements about what to do, even though they were not at risk. Difficulties were encountered in getting information to these residents. The off-site plan did not cover such a contingency explicitly nor is it required to do so under Regulation 11 of CIMAH which sets a minimum requirement. This raises questions for those involved in planning and provision of emergency response as to how such information needs can be met. It is open to local authorities to inform over a wider area by local agreement. Steps in this direction have already been taken by the Chief Officer of Cheshire Fire Brigade (see paragraph 137);

(e) Communication arrangements provided for a major emergency response were not entirely effective on the night:

- The ESRB was based at Ellesmere Port Fire Station, where it was found that the telephone lines, faxes etc provided were overloaded.

- The telephone landline between DOSEC and ESRB was not initially brought into operation.

- As a result, the Police Emergency HQ found it difficult to communicate with appropriate officials at the ESRB and could not directly contact DOSEC. The off-site plan requires Police and Fire Liaison Officers to be at the DOSEC, which was done. They provided radio contact and liaised with the Senior Fire Officer there.

- A direct consequence of this was that DOSEC was not approached to give advice and support to the extent envisaged in the emergency plan. For example, at one stage, in response to repeated requests from residents (including a disabled person), the Police took the decision to make preparations to evacuate Meadow Lane, without prior reference to DOSEC;

(f) the three keyholders to the DOSEC room at Ellesmere Port Municipal Offices were unavailable at the start of the incident and there was a resultant delay in gaining access; and

(g) the Police had not been given a list of key Octel managers who should be allowed on to the site to assist in handling the emergency. This resulted in some delays.

Local concerns

94 There is an unusually high concentration of large chemical plants around the Mersey Estuary. Over the last three years, there have been several incidents which have aroused the concern of the general public about the hazards and the adequacy of the control measures. The off-site toxic hazards have been of particular concern. On the night of the incident the emergency services were swamped with telephone enquiries from anxious residents. Immediately after the

incident Ellesmere Port and Neston Borough Council alone received 40-50 contacts from the general public. Several local residents also telephoned or wrote to HSE's area office to voice their concerns. A number of representatives of local councils and residents associations also made their views known to HSE either in meetings or by means of correspondence.

95 The principal issues raised which have not been dealt with elsewhere in this report were as follows:

(a) some people upwind of the incident did not hear the sirens and thought they should have done when they subsequently learned about the incident. Some residents in Ellesmere Port had, however, heard loud hailers on a vehicle touring the area;

(b) others who lived some distance downwind of the site, for example at Ince and Elton, did not hear the Octel siren and thought that the siren at the nearby Shell refinery should have been sounded to alert them too. Nevertheless, some were alerted by loud hailers on a fire engine touring the area;

(c) a number of residents who did not come within the 1.5 km public information zone thought that they should also have received prior information about the Octel site; and

(d) there was concern, articulated in numerous press reports, that the plant was "20 minutes to Doomsday". This concern derived from the fact that the intumescent cladding on the process vessels had been designed to provide a minimum two hour protection from fire engulfment and that at a point in the emergency when the vessels had been subject to the fire for about one and a quarter hours, the Fire Brigade put out a precautionary "30 minutes to evacuation" warning to the fire fighters.

Sirens

96 The sirens were sounded in accordance with the emergency plans. In practice, the reason residents upwind of the site did not hear them was because of the wind direction and for this very reason they were never at risk. The siren local to Ince and Elton was only to be used to signal an incident at the Shell refinery and had it been sounded would arguably have added to the confusion and concern. However, this does raise the question, for those involved in planning and provision of emergency response, of what is the most effective means of (a) alerting the public who may be at risk to an emergency; and (b) providing others who are concerned, though in fact not at risk, with information and reassurance.

Public information

97 The company information leaflet had been distributed in accordance with requirements designated under CIMAH Regulation 12. However, given public concern in an area of high concentration of chemical plants, the question remains of what information, if any, should be provided to people outside the public information zone and in what form - see paragraph 93(d).

"20 Minutes to Doomsday"

98 Calculations show that the very worst event as a result of fire was not a vapour cloud explosion but a Boiling Liquid Expanding Vapour Explosion (BLEVE)*. The size of a fireball from a BLEVE will depend, among other matters, on the amount of flammable material available. This is not precisely known but it is estimated as a worst case that the slops drum contained about 30 tonnes of ethyl chloride. Using this figure, the fireball radius would extend to a distance of 65 m from the vessel, which would just reach the south boundary at one point. Within this radius it is expected that the effects would be fatal. The effects diminish beyond the fireball radius but there is an approximately 1% chance of being killed at 140 m from the centre of the fireball.

99 In practice, there were a number of contingency measures provided at the process vessels to prevent explosion. HSE technical examinations showed that bursting discs and pressure relief valves operated effectively by relieving pressure and venting flammable vapours to a safe place. The reactor, slops tank and stabiliser feed drum were each coated with an intumescent passive fire protection (PFP) material. Intumescent PFP materials work by reacting to form an expanded char when exposed to high temperatures which acts as a thermal insulation. Examination by RLSD showed that the intumescent coating of the reactor and slops tank had successfully withstood the effects of the fire (see Figure 10) and that the metal of the vessels was unlikely to have been exposed to temperatures above 300°C. The stabiliser feed drum showed extensive charring of the intumescent coating. In some areas the retaining mesh was visible, with about 1-2 mm of material (assumed to be primer) beneath it.

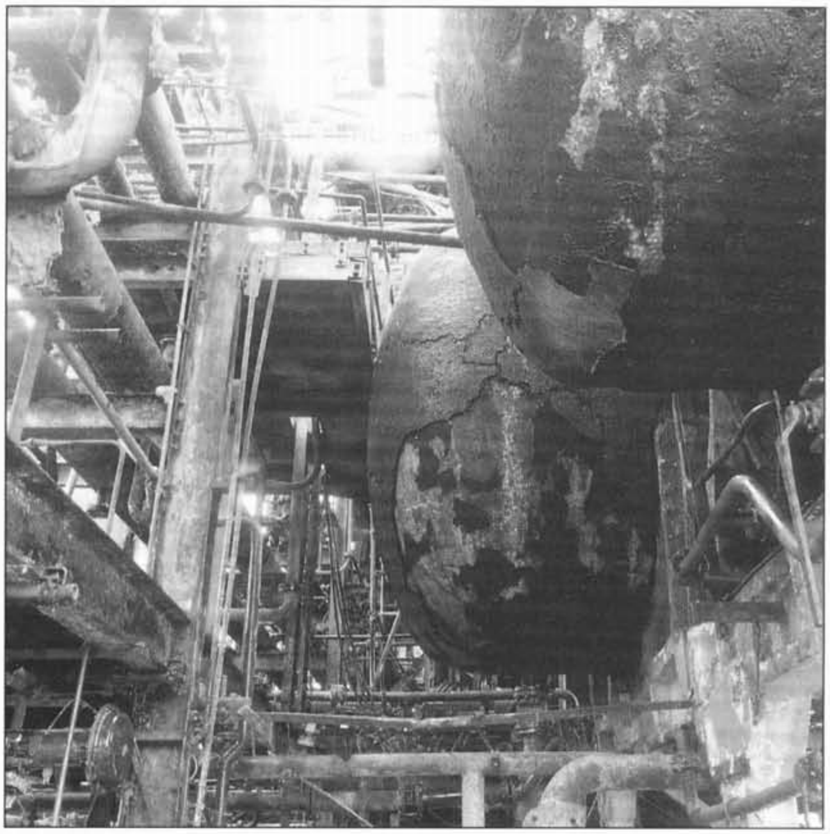
100 As intended, the combined effect of these mitigation methods did successfully provide the Fire Brigade with the necessary time to bring the fire under control and thus avert the risk of a BLEVE of any one of the vessels. On the evidence of HSE's findings the press reports of "20 minutes to Doomsday" did in fact prove to be an exaggeration. This incident does, however, serve to underline the importance of mitigatory provisions at major hazard chemical plants. Clearly, the Fire Brigade response was entirely appropriate in the circumstances at the time.

Call for public enquiry

101 There were many calls for a public enquiry into the incident. The local MP,

*See Glossary of terms, page 46

Figure 10 *View of slops drum (foreground) and stabiliser feed drum (seen from the west)*



Andrew Miller, pressed the then Employment Minister, Mr Michael Forsyth, on this issue in an adjournment debate in the House of Commons on 11 February 1994. Mr Miller later presented a petition for a public enquiry from his constituents. A number of local councils wrote formally to HSE to add their support. The then Secretary of State for Employment, Mr David Hunt, visited the Octel site on 25 February and confirmed that the findings of the HSE investigation would be made public.

MANAGEMENT AND SAFETY SYSTEMS

Management structure

102 The Ellesmere Port site is the company's administrative centre and therefore accommodates all management functions such as marketing, business development, finance and manufacturing under the control of the company managing director (Figure 11). The director of manufacturing, reporting to the managing director, heads production at Ellesmere Port and at the company's bromine plant at Amlwch in North Wales.

103 Production at Ellesmere Port is organised in two managerial groups known as Lead Alkyls Group comprising the lead plant, the tetraethyl lead and tetramethyl

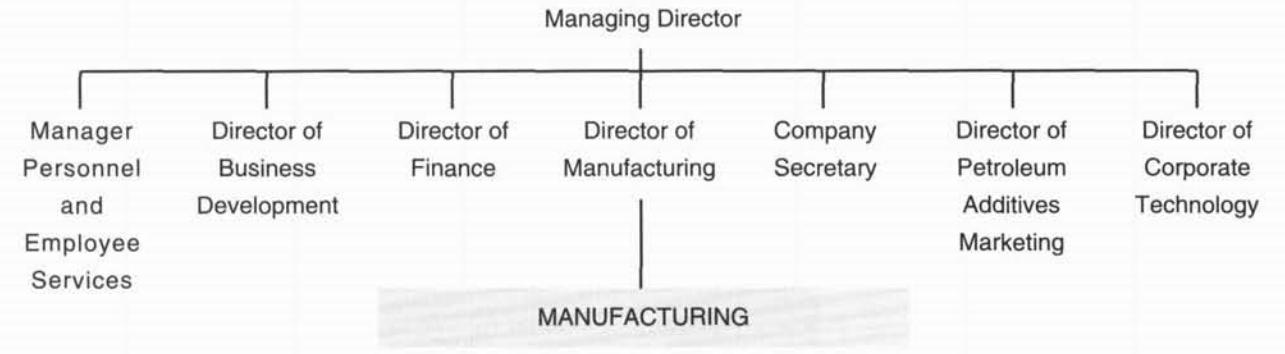


Figure 11(a) *The Associated Octel Company Ltd - Senior Management*

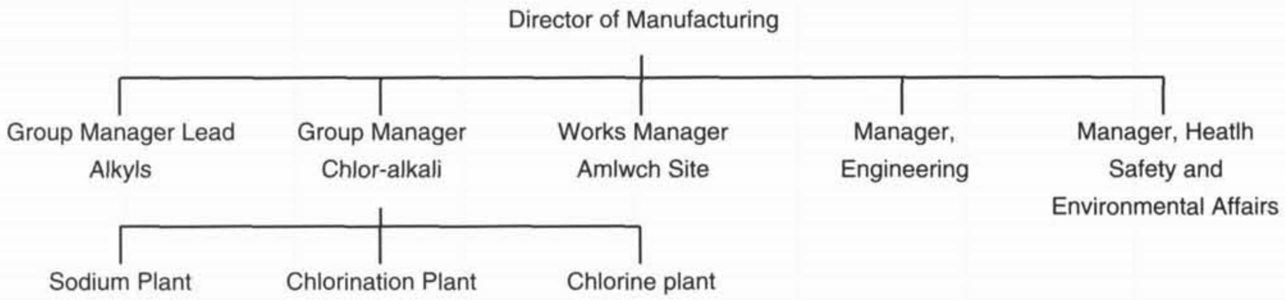


Figure 11(b) *The Associated Octel Company Ltd - Manufacturing Management*

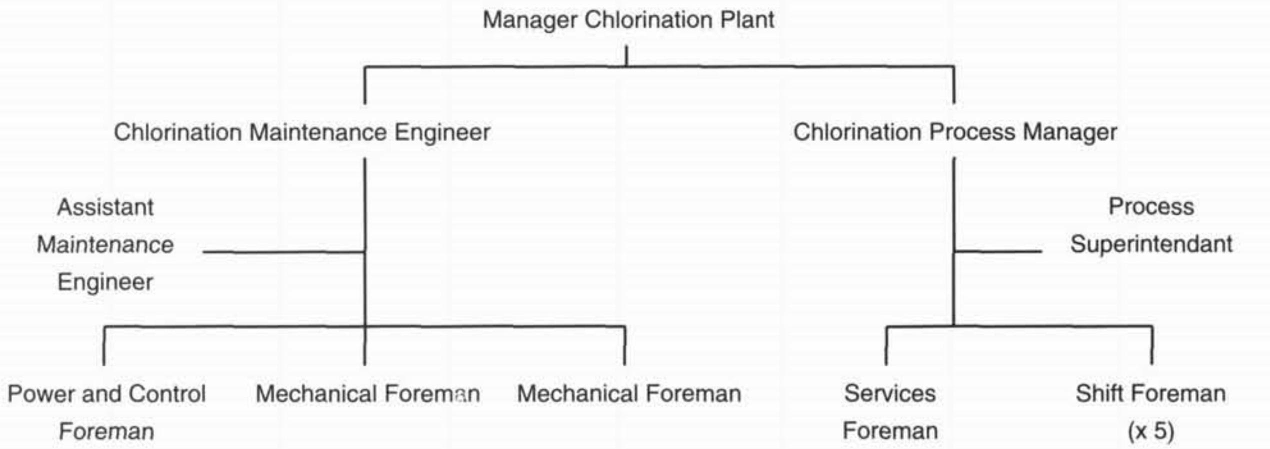


Figure 11(c) *The Associated Octel Company Ltd - Chlorination Plant Management (chlorination = chlorine liquefaction and ethyl chloride plants)* lead plants and the compound blending plant, and Chlor-Alkali Group comprising the chlorine, sodium and chlorination plants. Each group is led by a manager. There is also an Engineering Group, which is a service group and separate from the production groups. This group has a number of functions including responsibility for arranging the inspection of Octel plant (mainly pressure vessels) throughout the company and keeping the records of examination. Pipelines, in general, are the responsibility of the maintenance engineers for the various process plants. There was no specific guidance given by the company on the standard of inspection and maintenance.

104 The sodium and chlorination plants are each run by a separate plant manager. Chlorination plant comprises the chlorine liquefaction and ethyl chloride plants (Figure 11).

Management of EC plant

105 The manager of the chlorination plant was responsible for both process and maintenance matters on the chlorine liquefaction and ethyl chloride plants.

106 A maintenance engineer reporting to the chlorination plant manager was responsible for maintenance in the EC plant. This responsibility covered mechanical and power and control systems and he also identified any civil work required. He had an assistant engineer and a maintenance supervisor who was responsible to the maintenance engineer for all mechanical maintenance on the chlorination plant. It was his team that dealt with plant maintenance and any necessary breakdown maintenance required during the day, as well as organising the work of the six-monthly shut down on the EC plant.

107 On the process side, support was given by a process manager. A shift supervisor on each of five shifts was responsible for the EC plant and two other adjacent plants, involving seven operators in total. The EC plant was controlled by two shift operators from the control room. The main duties of one (EC1 duty) was to run the HCl burners and compressors, the other duty (EC2) was to run the EC reactor and associated plant used to separate and draw off pure EC. Outside daytime hours there was no other process management staff on site.

Health and safety management

108 The company's health and safety policy statement assigns ultimate responsibility for health, safety and environmental matters to the managing director, with responsibility for the Ellesmere Port site delegated to the manufacturing director. It states that individual departmental managers have line responsibility for the health and safety of their respective employees.

109 This general policy is implemented by procedures laid down in the Company Health and Safety Manual, the individual departments providing further details in

departmental versions of this document. There was such a manual for the Chlor-Alkali Group of which the EC plant was part.

110 In 1984 company management had commissioned a report to assess the risks on-site relating to the major hazard plant (see paragraph 79) and the company instituted £2 million of improvements. The chlorination plant management held six-monthly meetings to review progress. There were no other arrangements for reviewing the adequacy of controls for the hazards on the plant except that linked to the Major Hazard Survey.

111 In 1991 the company adopted the ILCI International Safety Rating System (ISRS), a systematic proprietary health and safety audit system. It is around the 21 management topics in ISRS that Associated Octel has based its safety management systems. The aim was to achieve improvements in safety management by setting stepped targets to be achieved on an annual basis. As a result, many of the safety management systems in the company are or have recently been undergoing development or revision. The company audits itself periodically in accordance with ISRS by way of monitoring its health and safety performance and as a result had set its managers a number of targets to meet the pre-set level of performance. The company acknowledge that much work is still required to achieve a good level of performance of safety management in accordance with the ISRS system.

112 The company has a Health, Safety and Environmental Affairs Department, the stated role of which is to provide support throughout the company on all health, safety and environmental matters.

113 The manager of the Health, Safety and Environmental Affairs Department reports to the manufacturing director. He has reporting to him a safety officer, a medical officer and a hazards and environmental adviser. Each of these also has staff reporting to them. Additionally, each works area has a full-time safety officer reporting to production management.

114 It also operates site-wide a system known as STOP (Safety Training and Observation Programme) designed to promote identification of unsafe acts and practices.

115 The current safety management arrangements described above were all instigated around 1991 when it was identified that the company's lost time accident record was poor; its accident frequency rate for 1990 was more than double the Chemical Industries' Association average. It was also realised at that time that current safety control methods were outdated. In 1990 the first prosecution by HSE in the company's history also acted as a stimulus for safety management change.

HSE AND THE ASSOCIATED OCTEL COMPANY LIMITED

116 HSE had previously prosecuted The Associated Octel Company Ltd at the Ellesmere Port site on two occasions. In August 1990 a charge was brought against the company under Section 2 of the HSW Act for failure to provide a safe system of work for the movement of some heavy equipment in the lead plant. The company pleaded guilty and was fined £1000 at Ellesmere Port Magistrates Court. On the second occasion, in March 1993 at Chester Crown Court, the Company was convicted of a breach of the HSW Act, Section 3 and fined £25 000 with £60 000 costs. The offence related to a failure to control the activities of contractors at work in a vessel on the chlorine plant. An appeal by the company against conviction was heard in June 1994. The appeal was dismissed but permission to appeal to the House of Lords on a point of law was granted.

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

(a) to conduct planned preventive inspection with particular emphasis on those parts of the site subject to CIMAH (Appendix 2);

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

(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 in the management of health and safety.

118 For example, in 1990 the HSE Area Director met the company's managing director to discuss the company's accident record. Subsequently the company adopted the ISRS audit system (see paragraph 111). More recently, HSE's contacts were primarily concerned with assessment of the company's written safety report submitted as required by the CIMAH Regulations. Consistent with HSE operational policy, certain topics and parts of the site were selected for visits to sample the veracity of the safety report. The topics and areas selected in respect of the EC plant included the electrical control systems and instrumentation at the HCl burners, the instrumentation and trips on the EC plant, the safety of the electrical distribution system to the sodium and chlorination plants (see paragraph 13b) as a whole and the pressure relief valves and bursting discs on the EC process vessels. These visits were paid in October 1992 by area inspectors and specialists in process safety and electrical engineering. HSE's assessment procedure was completed when a letter with comments was sent to Octel in October 1993.

119 The last visit to the EC plant was on 10 June 1993 as part of a preventive

inspection specifically targeted at the company's permit to work system. The last visit to the site as a whole was in December 1993. Visits were also made to investigate accidents, incidents and dangerous occurrences. The last visit to the EC plant for these purposes was paid on 23 February 1992. As a result of these visits, formal and informal advice was given concerning improvements to plant, systems of work and to the emergency plans.

120 HSE had planned a major safety management audit at the company for the 1994/95 work year on the basis that this was a multi-risk major hazard installation; there was some HSE concern about safety management systems and because of recent accident and incident history, including a release of liquid EC from the plant scrubbing systems in November 1993.

CONCLUSIONS AND LESSONS TO BE LEARNED

121 There are a number of lessons to be learned from this incident which are of general relevance to the chemical industry and to those involved with the planning and provision of emergency response. Most of these lessons are not new but they should provide an additional stimulus to the industry to critically review their own risk assessments and safety management systems.

122 It is for the record that potentially the consequences of this incident could have been much more severe, certainly in terms of on-site damage and injuries to company personnel and members of the emergency services, had it not been for a number of safety measures and emergency procedures successfully coming into effect. Key factors were:

(a) 'Cloudburst' was called promptly and the emergency services were on the scene within minutes. The water curtain they quickly put up helped prevent the cloud drifting off-site;

(b) fire-resistant 'intumescent' cladding had previously been applied to the principal process vessels and proved effective in protecting them from the effect of an intense fire;

(c) other safety devices provided on the process vessels, eg pressure relief valves and bursting discs, operated effectively;

(d) the action and bravery of the fire fighters and of company personnel first in seeking to identify and isolate the leak in difficult and dangerous circumstances and then in controlling the fire; and

(e) the use of Octel and Shell mobile foam cannons which were able to disperse foam jets over fires on plant at high level.

These provisions and actions prevented rupture of the process vessels and a subsequent BLEVE.

123 The immediate technical cause of the incident was the failure of a pipework component leading to a major release of process liquids (paragraph 66). However, the underlying cause was a failure on the part of the company to identify the risk of a major release in this part of the EC plant. Experience of running the plant over the last 22 years and the pattern of breakdown maintenance, albeit not formally recorded, had suggested a risk of minor leaks rather than a single major breach of containment. Undue reliance was placed on this and although a major hazard review was conducted by the company in 1984 this did not place sufficient emphasis on a fundamental assessment of inherent risks in the design of the EC plant (paragraph 81). Moreover, the most significant major hazard on the site as a whole arose from the storage and use of chlorine and the company directed a lot of its attention towards the identification and management of toxic hazards. As a direct result of the failure to conduct a fundamental assessment of the inherent risk, insufficient attention was paid to a range of safety precautions which would have reduced or avoided the risk of a major release or mitigated its effects (see paragraph 81 onwards). None of these safety precautions were new to the company. Fundamental risk assessment would have provided a trigger for their implementation at a plant designed over 20 years ago.

Lesson 1: Risk assessment should be seen as a dynamic process. There should be periodic reviews of chemical plants which should include:

(a) a reassessment of the risks of existing plant in the light of current knowledge and the effects of any new plant; and following from this

(b) a review of the existing design and safety provisions at the plant and the practicable measures in the light of current knowledge, to avoid or mitigate the identified risks; and

(c) a consideration of the risk assessment approach to ensure that the best and most appropriate techniques are being used, taking into account current thinking.

Lesson 2: Companies with a range of major accident scenarios should not focus unduly on those hazards which present the most serious accident scenarios but should also give due attention to other significant hazards on site.

124 The initial release occurred at a point between fixed pipework and the discharge port of a pump recycling ethyl chloride to the reactor, as a result of either (a) a corroded securing flange on the pump working loose (paragraph 62) or (b) the failure of a PTFE bellows connecting the pump discharge to the pipe (paragraph 65).

125 There was no formal system of routine visual inspection of these and other components in this part of the EC plant (paragraph 67). Maintenance of these components was on a breakdown basis and no written records of the frequency of component failure or replacement were kept. Other factors such as the misalignment of a motor drive coupling and misalignment of bolts on the flange (paragraph 64) were also a consequence of poor installation and maintenance and increased the risk of failure of the pump, its flanges and joints. If an adequate system of planned maintenance had been in place the risk of this incident occurring would have been greatly reduced.

Lesson 3: Adequate records should be kept of routine maintenance and replacement work in order to build up a local history of plant performance and reliability on which future protocols for inspection, maintenance or replacement can be based.

Lesson 4: The consequences of a failure of any component of plant and equipment should be a primary factor, as well as its reliability, in determining the necessary inspection, examination and maintenance protocols.

126 The incident escalated rapidly because it proved impossible to stop the initial release. The design of the drainage facilities at the plant (soakaways, evaporation areas and bund walls) were inadequate to cope with such a release. The manually operated valves, which could have isolated the inventories in the three principal process vessels, were very difficult to access in the emergency amid complex pipework and because of their location. Plant operators and fire fighters were put at risk by exposure to leaking reactants. Their difficulties were compounded by poor visibility as their face masks clouded over and by exposure to jets of liquid (paragraph 36). In spite of their brave actions, it proved impossible to close all the valves.

127 These problems could have been prevented and the inventories rapidly isolated if remotely operated shut off valves (ROSOVs) had been installed. The company had installed ROSOVs at other parts of the site, for example at the large EC storage spheres.

Lesson 5: As part of their comprehensive risk assessments, companies in control of chemical process plant at major hazards sites should critically review the provision of remotely operated shut off valves (ROSOVs) at both storage and process vessels in which significant inventories of dangerous substances are held.

Lesson 6: HSE, in conjunction with other interested parties, should develop and publish additional guidance on the provision of ROSOVs and other methods of mitigating risks on process plant.

128 A number of mitigatory measures, including prior provision of intumescent fire

protection cladding to the principal process vessels, proved to be of particular value in averting an escalation of the incident to a BLEVE (paragraph 99).

Lesson 7: HSE, in conjunction with the industry, should consider what guidance, if any, should be published on the provision of passive fire protection on vessels.

129 In the hours leading up to the release, process data indicating pump P251/3 had stopped appeared to be misinterpreted by process operators. Subsequently plant alarm signals were overlooked. Even if appropriate corrective action had been taken at this stage, the incident would still have occurred (the release occurred when the replacement pump P251/2 was switched on). However, the net result of the operators losing track of the process dynamics was that a much larger inventory of process liquids than normal had built up in the EC plant, mainly in the slops drum (paragraph 75). This contributed to the scale and duration of the release and subsequent fire. The earlier misinterpretation of data also meant that the company was not in a position to give reliable information to the Fire Brigade when they arrived about the EC plant inventories. Clearly, misinterpretation or misunderstanding of process alarms and data, especially at major hazards installations, could have disastrous effects.

Lesson 8: The competence of process operators should be assessed after initial training and when first put to work on plant and subsequently on a routine basis. The frequency of assessment should be determined at the completion of training and by a number of factors, eg the complexity of task, technical content and in particular the risks associated with the process.

130 A contributory factor in one of the alarms being overlooked was that only a visual alarm and no audible alarm existed to signify pump 251/3 had stopped. Even the visual alarm was confusing. There was no record of the type of alarms which should have been provided for this pump. There was evidence that the alarms may have been altered since the new control panel had been installed (paragraph 76).

Lesson 9: The configuration of electrical control panels should be recorded for each function and any change should be subject to a formal plant change procedure, assessed by a competent person.

131 About an hour and three-quarters elapsed between the start of the release and the ignition of vapours causing the fire. There was ambiguous information about the nature of the hazards and the appropriate response when the brigade first arrived. The end result was that initial action taken was more consistent with a toxic incident but actions to reduce the risk of fire were not taken as quickly as they could have been (paragraph 90). Factors which may have contributed to the initial confusion included: shortcomings in company training and emergency exercises which concentrated on the toxic risks (paragraph 89), deficiencies in

the off-site plan which was primarily directed toward toxic risks (paragraph 86), and lack of support for the technical controller at the time he most needed it (paragraph 91).

132 The incident emphasised the difficulties faced by Fire Brigades when attending multi-risk, major hazard sites. The fire fighters did not have means of rapidly retrieving comprehensive enough information about the site, its hazards, the way in which the incident might develop and, most importantly, the best means of response.

Lesson 10: Emergency planning and training procedures relating to major hazard sites should encompass all the main types of major accident scenarios and employers in providing training should ensure necessary attention is given to smaller but significant risks.

Lesson 11: All those involved with planning for and the provision of emergency response should agree the information they may need to assist their response and the means of accessing that information quickly. This information will be required for each of the major accident hazards identified at each of the CIMAH top tier sites.

133 Notwithstanding the conclusions at paragraphs 131 and 132, the incident was, for the most part, handled in accordance with the written emergency plans and as a result the public were not put at risk. However, some problems and deficiencies identified during the HSE investigation have been discussed in the findings (see paragraph 88 onwards). These details may be of value to those involved in the planning and provision of emergency response.

134 A number of questions about the adequacy of the on-site and off-site emergency plans have been raised by local authorities and general public in the vicinity of the Octel site. These are considered in the findings (paragraphs 94-97) and represent real concerns which need to be acted upon or allayed.

Lesson 12: In the light of this report HSE should review the guidance in HS(G)25 so that it addresses such issues as:

(a) the information needs of Fire Brigades;

(b) the level of detail to be incorporated in CIMAH off-site emergency plans by local authorities;

(c) any special arrangements in areas of high concentration of chemical plants.

(d) the means of alerting the public to an emergency and the subsequent provision of advice both to people at risk and to others with anxieties or concerns;

(e) provision of information to the public beyond the public information zone by companies and local authorities; and

(f) planned isolation of electrical equipment on complex chemical plant.

Lesson 13: Companies and local authorities should consider the provision, prior to and during an incident, of information to the public beyond the public information zone designated under CIMAH so as to allay the anxieties and concerns of those who, while not at risk, may hear the alarm siren.

Action by the company

135 The EC plant, which forms an essential part of the company's operations on-site has been rebuilt and was recommissioned during January 1995. The three main process vessels involved in the fire have been replaced and their replacements protected with improved insulation cladding, according to the supplier's specifications. There have been a number of detailed design changes to the plant which afford improved safety of the plant:

(a) relocation of the reactor (15 m SE) to ensure adequate separation from other process plant and to avoid liquid spillages running beneath adjacent plant;

(b) relocation and provision of a larger run-off lagoon away from the plant;

(c) vessel connections below the liquid level have been reduced to the minimum and remotely operated shut off valves fitted to isolate the pipe connection below liquid level at the three main vessels;

(d) the original three P251 pumps have been replaced by four pumps (ie two each dedicated to polymer and slops duties) and as a result pipework runs considerably simplified;

(e) the above pumps have been fitted with Hastalloy (a metal alloy) casing instead of a resin casing. As a result bellows are no longer required;

(f) the cladding for the structural steel has been extended to include the overhead assembly. This assembly collapsed during the incident but did not contribute significantly to this incident;

(g) a level indicator (radar type) has been installed in the slops drum to provide improved information to the operator; and

(h) additional flammable gas detectors have been fitted on the plant in view of their effectiveness in this incident.

136 Although the plant design is to a high standard, it is crucial that the plant is operated and maintained to a similar standard. There has been a strong emphasis on ensuring systems for management of safety on site are to the necessary standard. As a result, Octel have invested a lot of time and effort in the following:

(a) arrangements for ensuring health and safety on site more clearly defined in the company safety policy and implemented through annual safety plans.

(b) more effort to achieve commitment from employees to health and safety by appointment of 'safety operators'. Their main roles are to achieve good communications between employees and management and to be involved in routine safety auditing with management.

(c) improved arrangements for managing maintenance building on initiatives being taken before the incident, the main elements of which are:

- creation of a register, listing full details of all plant equipment;
- assessment of criticality for each item of equipment, based on availability requirement, hazard, reliability, cost of downtime etc;
- determination, of the type of maintenance based on criticality to be applied to each plant item, ie predictive (by condition monitoring), preventive (by regular inspection) or breakdown (for low criticality, low cost items);
- development of maintenance procedures for all significant maintenance jobs, based on skill, hazard and criticality of equipment;
- development of plant histories, based on criticality, leading to a formalised approach to improvement in plant performance and availability;
- development of maintenance planning, recording and reporting systems and procedures;
- development of corporate management information systems to support maintenance management; and
- development of improvement programmes for engineering standards of safety, design and technical assessment, including existing systems such as change control.

As a result of all these actions the company was advised in December 1994 that the Prohibition Notice issued by HSE on 3 February 1994 prohibiting the manufacture of ethyl chloride on site was complied with.

Action by the Cheshire Fire Authority

137 The Cheshire Fire Authority's previous concerns about the handling of industrial major hazard emergencies were reinforced by this incident. These concerns centred on the provision of information, firstly to the public and secondly for those involved in handling the emergency. The Chief Fire Officer has taken the following actions:

(a) lessons learned from the incident have been discussed at a liaison panel providing an opportunity for the Fire Service to discuss initiatives with members of the Cheshire chemical industry and others involved in the planning and provision of the emergency response;

(b) having reviewed the policy of evacuation or shelter for the local population, the Fire Brigade has produced a leaflet and video promoting a shelter policy and explaining the action to be taken in the event of a major accident. The video is for use in schools and the leaflet is being distributed to all residents within North Cheshire and to those near similar major hazards elsewhere in Cheshire;

(c) introduced a new electronic mailing facility which will allow the Fire Brigade to quickly update local TV and radio stations, who have agreed to broadcast the shelter message and other information during an emergency;

(d) secured agreement to use the Cheshire County Council "information point" system, which is a staffed 24-hour telephone contact point, as an emergency "hotline" which will allow callers to obtain the latest information personally;

(e) following successful trials, there are plans for electronic mailing to link the emergency services, DOSEC and the site operator;

(f) run trials involving a lap-top computer in the cab of the fire fighting vehicles, on methods of storing and quickly retrieving hazard information for fire fighters. More detailed technical information is required for complex major hazard sites and Cheshire Fire Brigade have initiated a research programme into what can be provided. Currently available expert management and hazard information systems have already been reviewed and new systems may be developed;

(g) given consideration to introducing a "tiered" Brigade response to industrial incidents to encourage site operators to call the Fire Brigade more readily. The tiers suggested are:

(i) incidents occurring on-site with no potential to go off-site;

(ii) incidents with the potential to go off-site but without major risk of harm to the public; and

(iii) incidents which are likely to go off-site with potential to harm the public.

There are both advantages and disadvantages which are to be carefully weighed before implementation;

(h) reviewed the current site warning arrangements and is encouraging the use of sirens throughout Cheshire to a standard specification to avoid confusion by the public

(i) begun to review, with a number of agencies, Cheshire Fire Brigade's overall response to environmental risk incidents and will shortly enter a joint partnership with the National Rivers Authority for dealing with waterborne pollutants; and

(j) he has commissioned the Defence Research Agency to create an operationally viable robotic vehicle for use in major incidents.

REFERENCES AND FURTHER READING

1 *HSE The storage of LPG at fixed installations* HS(G)34
HSE Books 1987 ISBN 0 11 883908 X

2 ICI/ROSPA *Code of Practice for liquefied flammable gases storage and handling* ROSPA Engineering Codes and Regulations1970

3 BS 5908 *Code of Practice for Fire Precautions in the Chemical and Allied industries* Obtainable from British Standards Institute

4 HSE *A guide to the Control of Industrial Major Accident Hazards Regulations 1984* HS(R)21 (Rev) HSE Books 1990 ISBN 0 11 885579 4

5 HSE *The Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH): further guidance on emergency plans* HS(G)25 HSE Books 1985 ISBN 0 11 883831 8

GLOSSARY OF TERMS

1 Boiling Liquid Expanding Vapour Explosion (BLEVE)

Used to describe the sudden rupture of a vessel system containing liquefied flammable gas under pressure due to flame impingement. The pressure burst and the flashing of the liquid to vapour creates a blast wave and potential missile damage and immediate ignition of the expanding fuel-air mixture leads to intense combustion leading to a fire ball. This is to be distinguished from a so-called 'vapour cloud explosion' which has a larger explosive effect and may occur following release of large quantities of flammable vapours. Such an explosion requires tonnes of flammable material, obstacles such as chemical plant and a degree of confinement to create the necessary flammable mixture as well as a source of ignition.

2 District Off-Site Emergency Centre (DOSEC)

This has an important role in the CIMAH off-site emergency plan. It is designated accommodation providing facilities to enable the Chief Executive of Ellesmere Port to co-ordinate activities to provide effective off-site responses other than those concerning the operational actions of the Emergency Services.

3 Emergency Services Reinforcement Base (ESRB)

Designated accommodation manned by the Police, Fire and Ambulance Services at a convenient and safe point to the incident from which a rapid response can be directed. It is an essential element of the Cheshire CIMAH emergency response.

4 Immediately Dangerous to Life and Health (IDLH)

The maximum exposure concentration from which a person could escape within 30 minutes without any irreversible health effects.

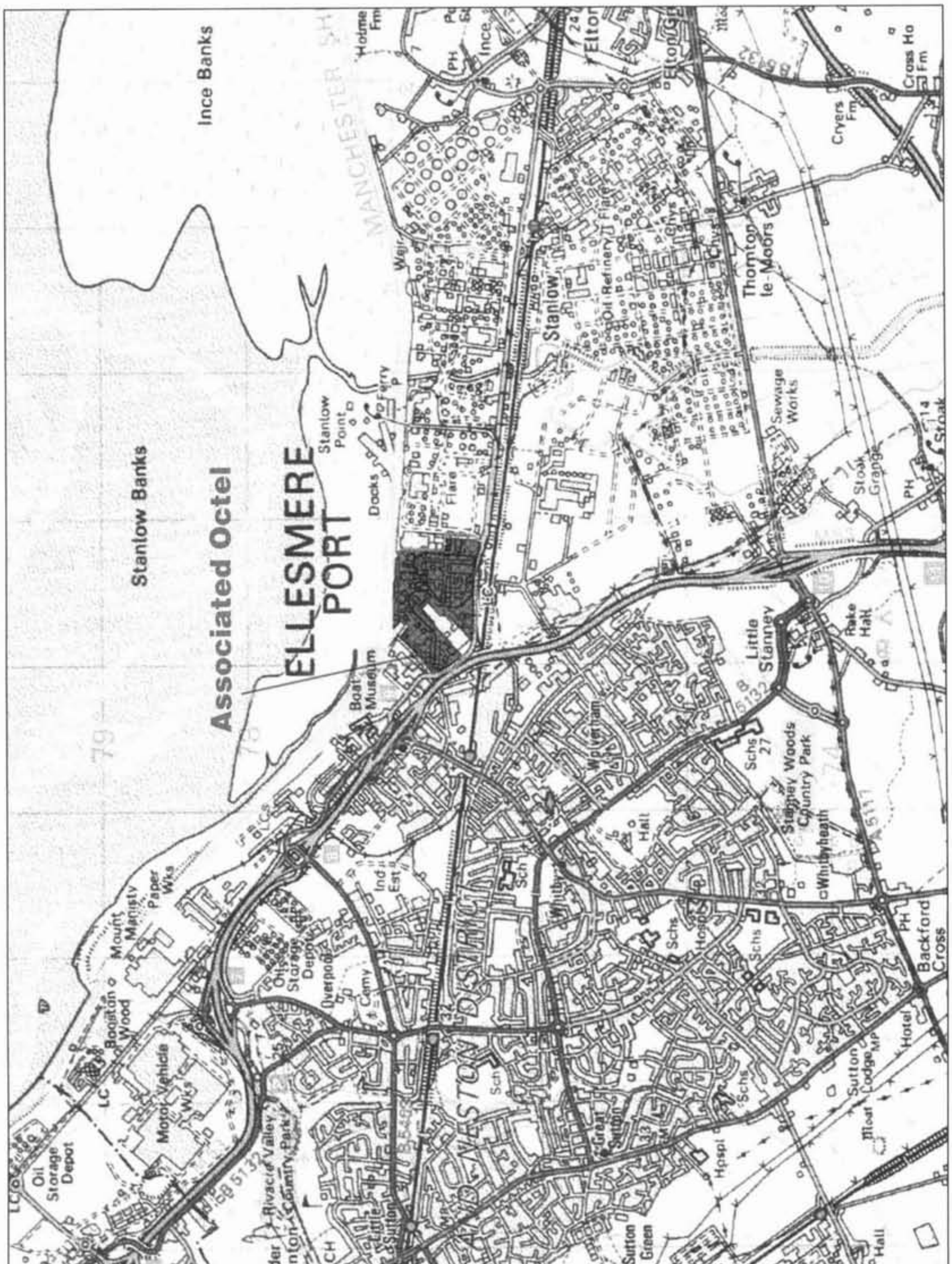
5 Lower Explosibility Limit (LEL)

The threshold at which a substance will form a flammable mixture with air. A source of ignition is still required to cause a fire. At higher concentrations there will be a maximum explosibility limit, above which the concentration will be too rich in fuel to ignite.

6 Occupational Exposure Limit (OEL)

There are two types of occupational exposure limit defined in the Control of Substances Hazardous to Health (COSHH) Regulations which are set to protect the health of persons at work. Occupational exposure standards (OESs) are set at levels at which there is no indication of risk to health. For Maximum Exposure Limits (MELs) a residual risk may exist and the level set takes socio-economic factors into account. Two levels may be set for an OES, time weighted average over an 8 hour period (ie TWA 8 hour) and a short term exposure limit (STEL) of 15 minutes.

APPENDIX 1 MAP OF THE OCTEL SITE AND IMMEDIATE SURROUNDINGS



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APPENDIX 2 HEALTH AND SAFETY LEGISLATION

1 The Associated Octel Company Limited is subject to the application of the Health and Safety at Work etc Act 1974, the Factories Act 1961 and various regulations made under these Acts. HSE is the enforcing authority for health and safety legislation at the premises.

Of particular relevance to the incident is the following legislation:

Health and Safety at Work etc Act 1974 (HSWA)

2 HSWA imposes general duties on employers towards employees and others, including members of the public off-site, to ensure that they are protected from the risks arising from their activities.

The Control of Industrial Major Accident Hazard Regulations 1984 (CIMAH)

3 The CIMAH Regulations apply to the Associated Octel site and are designed to prevent or mitigate the effects of major accidents to both people and the environment. The requirements operate at two levels or tiers.

The lower tier requirements are to:

(a) report major accidents to HSE; and

(b) where required to do so, demonstrate to HSE that the plant is being operated safely.

The top tier requirements, which apply to Associated Octel in addition to the above, are to:

(a) submit a safety report to HSE which identifies the nature and use of dangerous substances at the site, identifies how major accidents could possibly occur and describes the arrangements in place to prevent, control or mitigate them;

(b) prepare an on-site emergency plan; and

(c) provide information to the public about the major hazards on-site and their dangers and what to do in the event of an emergency.

Local authorities are also required by CIMAH to prepare an off-site emergency plan.

4 The top tier requirement applied to The Associated Octel Company Limited by

virtue of the quantities stored or handled of several dangerous substances, namely chlorine, ethyl chloride, methyl chloride, tetraethyl lead, tetramethyl lead, dibromoethane and motor fuel anti-knock compounds.

5 The company had submitted to HSE a five volume safety report in July 1989, and this was updated in August 1992. An additional supplementary volume dealing with off-loading of ethyl chloride from ships was submitted in October 1992. The extent to which the other top tier requirements were met is discussed in paragraphs 75-81.

The Notification of Installations Handling Hazardous Substances Regulations 1982 (NIHHS)

6 These regulations pre-date CIMAH and require notification by companies of hazardous quantities of specified substances above certain thresholds. The quantities thus notified are used to consider the suitability of land use planning proposals within a set distance around the plant known as the consultation distance, in the case of Associated Octel this is 1.5 km.

7 When developments are proposed within the consultation distance, the local planning authority consults HSE for an opinion on the risk which would be presented to people at the 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.

8 The consultation distance is also used by HSE to set the area in which a top tier major hazard site should provide information to the public (see Appendix 2, paragraph 3). This is referred to as the public information zone.

The Planning (Hazardous Substances) Regulations 1992

9 These came into force on 1 June 1992 and placed further controls on hazardous developments. They are administered by the Hazardous Substance Authority (HSA), usually the local planning authority. If a company wishes to handle specified quantities of certain substances, it must apply to the HSA for consent to do this, whether or not planning permission is also required. Transitional arrangements during the introduction of these regulations meant a company could claim automatic consent for double the quantities of substances kept and notified before 1 June 1992, which Octel did.

The Fire Certificate (Special Premises) Regulations 1976

10 These regulations make HSE responsible for fire certification concerning means of escape and other general fire precautions such as fire fighting equipment at premises such as Associated Octel, handling substantial quantities of specified hazardous materials. The company's current fire certificate was issued on 6

February 1991. This legislation does not cover process fire precautions such as provision of passive fire protection, soakaway pits etc.

The Management of Health and Safety at Work Regulations 1992

11 These set out broad general duties applying to almost all work activities in the country and can be seen as making explicit what is required of employers under the more general duties of the HSW Act. Two particular requirements are under Regulation 3 to carry out a risk assessment and under Regulation 4 to set up arrangements for managing of the health and safety measures in place.

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