

Case Study - The Fire at Hickson & Welch Ltd, Castleford, UK

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Hickson & Welch is a medium sized, fine chemical manufacturer based in the North of England. It is subject to the UK CIMAH regulations (the Seveso directive). In September 1992, during the cleaning of a still base, the material inside decomposed violently and a flame erupted from the open manway of the vessel. The flame destroyed a control room before striking the site's four story office block. Tragically, five employees lost their lives.

The paper describes how the Company set about tackling the many issues arising from the accident, including the investigation to establish its cause and steps to prevent recurrence. Some general conclusions are drawn and the programme implemented by the company to achieve improved safety standards is also discussed.

1.0 Introduction

1.1 The fire at Hickson & Welch Ltd in September 1992, which killed 5 people, was one of the most significant incidents for the chemical industry in the UK in the early 1990s. It occurred 3 months after a major fire at another large chemical site in the same county. The earlier fire neither killed nor seriously injured anyone but did produce significant off-site environmental effects. Conversely, the off-site effects of the Hickson & Welch Ltd fire were minimal though the effects on-site were very serious. The proximity of the two events raised the profile of major hazard sites and public awareness of their potential for major accidents.

1.2 The accident has had a profound effect on the Company and its employees. The Company has publicly expressed its sorrow at what happened and continues to do so.

1.3 The incident was thoroughly investigated by the Company and the Health and Safety Executive (HSE). HSE have published a report of the incident which contains a number of lessons for the chemical industry. The Company had already responded to the lessons by the time the report was published.

1.4 This paper deals with the incident from the Company's point of view. It considers the background to the events; the events themselves; the investigation of the incident, both internal and external; the effects on the surrounding population; and the actions taken since the incident to prevent recurrence.

2.0 Background

2.1 Hickson & Welch Ltd is a medium sized chemical company in an industrial area of Northern England. The Company had its origins in 1915, making explosives for munitions by the nitration of aromatic compounds. It is located on the outskirts of Castleford with a major river, the Aire, running through the site and an active canal forming the northern boundary. The site has grown over the years and is now 70 hectares. By virtue of the quantity and nature of the chemicals on site, the site is subject to the Control of Major Industrial Accident Hazards (CIMAH) regulations.

2.2 Hickson & Welch Ltd is one of the world's largest manufacturers of nitrotoluenes and produces aromatic organic intermediates, predominantly based on nitrotoluenes, for the general chemical market. The Company also manufactures chemicals under contract for specific customers. The latter chemicals are also predominantly but by no means exclusively, based on the chemistry of aromatic compounds. By far the biggest tonnage of products handled are nitrotoluenes, produced by continuous nitration and purified by distillation and crystallization.

2.3 Most of the basic unit processes of organic chemical manufacture are undertaken, including nitration, hydrogenation, amination, chlorination, phosgenation, alkylation, sulphonation and condensation. The site has a number of modern, computer controlled plant together with manually operated plant fitted with a variety of pneumatic and electronic control systems and instrumentation. Most processes are done by batch operation with a few semi-continuous processes and a number of continuous distillation operations. Nitrotoluene is produced by a continuous nitration process.

3.0 The Event

3.1 At about 13.20 on 21 September 1992 a jet of flame erupted from the open manway on the end of a still base vessel (60 still base) from which residue was being manually removed. The flame first struck a timber framed building, about 22 metres from the vessel. The building contained offices, mess facilities and the control equipment for plant in the area. The flame cut a 6m wide swathe through the building and pushed a control panel weighing 1040kg onto its side and out of the building. Two of the five occupants of the control building died immediately. Two more died later in hospital as a result of their injuries.

3.2 The flame then struck the main, four storey office block some 55 metres from the vessel. At the point of impact windows in the building shattered, brickwork spalled and window frames melted. A number of offices were set alight. At the time there were 63 people in the building. One employee was overcome by smoke on the second floor and died later in hospital. A plan of the area around 60 still base is shown as figure 1.

3.3 The jet of flame was estimated by eye-witnesses to have lasted for approximately 1 minute, though the fires it caused burned for some time afterwards. The fires were extinguished by the Company's emergency team and by the West Yorkshire Fire Service who (with the police) were on site within 5 minutes.

4.0 The Plant and Processes involved in the Event

4.1 The Castleford site has the capacity to produce (roundly) 30,000 tonnes of nitrotoluenes per year. They have been produced on the site for many years, initially by batch processes. In 1962 continuous processes were introduced for the nitration of toluene and the separation of the isomers. Toluene is nitrated by a cascade process using a mixture of 96% nitric and 80% sulphuric acids. The product is a mixture of mononitrotoluenes (MNT), together with un-nitrated toluene, and small amounts of dinitrotoluene (DNT) and nitroresols. (Both mono- and di-nitroresols are present, they are referred to together as nitroresols.) The organic and aqueous layers produced by the process are separated in centrifuges. The organic layer is washed with water to remove acid and then processed to produce the final products, orthonitrotoluene (ONT), paranitrotoluene (PNT) and metanitrotoluene (mNT), together with waste streams rich in DNT and nitroresols.

4.2 Nitroresols are highly coloured and their presence, even at low concentration, leads to discoloured product. For many years they were removed from the organic products by washing with dilute sodium hydroxide solution, to extract them as their sodium salts. Until 1988, the waste stream from this processing was, after further treatment, discharged direct to the river - with the full knowledge of the water authority - as it could not be dealt with by the on-site effluent plant. The further treatment was carried out with great care as nitroresols are toxic and can be absorbed through the skin leading to a possible occupational health hazard. The resultant nitrotoluenes were thoroughly washed to ensure that no traces of

sodium hydroxide passed to the distillation stage. The presence of sodium hydroxide in a still at elevated temperatures is known to create significant instability.

4.3 For these environmental, health and safety reasons the process was changed in 1988 to remove the alkaline washing stage, leaving subsequent purification stages to produce the final products. The nitrocresols now pass through the purification stages into the final waste stream.

4.4 The separation of the organic stream from the nitration plant into the pure isomers is done by a series of fractional distillation and crystallization steps. These steps are summarised in (figure 2), omitting any recirculation or repetition, and produce essentially pure products for sale or as a feedstock for use on site. The crystallization and distillation steps are standard unit processes.

4.5 The liquid stream leaving the last crystallizer is essentially free of ONT and consists of about two thirds other nitrotoluene isomers and one third higher boiling substances including DNT and nitrocresols. There are over 500 tonnes of material a year in this stream, the majority of which is potentially usable product. Recovery of usable material has clear environmental benefits and prior to the incident it was routinely distilled in 60 still base.

5.0 60 still base

5.1 60 still base was an insulated, horizontal, carbon steel vessel fitted with three steam batteries. It served as the base vessel for the batch distillation of the mixture of nitro compounds described above. It was supported some 2.9m above the ground and was 7.9m long by 2.7m in diameter with dished ends, giving it a capacity of 45 m³. The steam batteries entered at one end, two side by side about 400mm above the bottom of the vessel, the other between and below them, about 200mm above the vessel bottom. The batteries extended about two thirds of the way along the vessel. At the other end of the vessel the dished end was fitted with a manway, about 400mm in diameter. The off-take line was fitted into the base of the manway mounting and the vessel was sloped gently, by about 70mm, towards this end. An isometric drawing is included as figure 3 and figure 4 shows the principal connections to the vessels.

5.2 The principal connections to the vessel were: the charging line, towards the front of the vessel; the off-take line; the vapour line to the condensers on top of the vessel; and the steam supply to the batteries. The vessel was fitted with a single thermometer pocket, towards the front of the vessel and in front of the batteries. It reached down to a level between the three batteries. There was also a relief vent. The vessel was designed to operate under full vacuum and the relief vent consisted of a simple flap covering a 250mm opening on the top of the vessel. The relief vent was designed to open at a low positive pressure, being held in position by the vacuum in the system. The vent was also routinely opened by the operators to take samples for thermal analysis and to dip the vessel to check the level of the liquid and residue layers.

5.3 As can be seen from figure 4, 60 still base could be fed from a number of storages. These storages could be used for other isomer streams as production demanded and so were occasionally required to be cleaned out. The final residue from 60 still base was pumped to a dedicated storage, 193 store, from where it was taken off site for final disposal.

6.0 Operation of 60 still base

6.1 60 still base was a batch still. The normal mode of operation was for the nominally empty still base (judged by viewing into the vessel) to be charged with 45 - 50 tonnes of material, filling it to within about 500 mm of the top of the vessel. The material was then sampled by filling four 250ml glass jars with material and submitting them for testing (discussed below in section 8). If the tests were satisfactory the distillation was carried out, under vacuum, controlling the amount taken off the still so that there was always at least 50% of volatiles (under the conditions of the distillation) present in 60 still base. This process removed about 70% of the contents of the still. The temperature of the material in the still base would

normally be 135°C to 140°C. The still base was operated so that the temperature of the material inside never exceeded 155°C.

6.2 When the permitted amount of volatiles had been taken off, the still was cooled under vacuum. Once cool, the vacuum was broken and the remaining residue re-sampled and tested. A second, smaller charge of fresh material would be added to bring the contents back to the same level as before, about 500mm from the top of the still. The contents would again be sampled and submitted for testing. If the tests were satisfactory the distillation would proceed as before, again to an end point where there were at least 50% of volatiles (under the conditions of the distillation) present. The final residue was then sampled and tested, whilst the residue was pumped away to 193 store, to ensure that the material was safe for final disposal.

7.0 The Safety of the Separation Process

7.1 The crystallization steps in the processing stream are low risk because the temperatures are low (less than about 100°C) and the chance of runaway are similarly low. However any process which involves heating any nitrotoluene, pure or impure, to a high temperature (more than about 100°C on a plant scale) is potentially hazardous. The Company has considerable technical knowledge in this area, gained from laboratory simulations and from plant experience. There are a number of significant, fundamental points which, whilst not surprising, are worth summarising:

1. All nitrotoluenes are liable to thermal runaway on prolonged storage, on a plant scale, at elevated temperatures. These temperatures can be reached with the steam supplies typically available on a chemical plant. (Most nitrotoluenes are, of course, liquids at normal temperatures and stored at ambient temperature.);
2. The most unstable components in a nitrotoluene distillation will be concentrated in the less volatile residue;
3. The presence of mineral acid in nitrotoluene, especially at elevated temperatures during distillation, will tend to increase the quantity of non-volatile residue formed, though this residue will not be significantly more unstable than the residue formed without acid present;
4. The presence of strong alkali (sodium hydroxide) even in quite small amounts will make the residue much less stable and hence more liable to thermal runaway.

7.2 The residue and any contaminants are concentrated in the still base of a batch still. The material in the still base is held at a high temperature for the whole length of the distillation, the temperature often rising towards the end of the process. In a continuous still the residence time is much lower and while there is considerable concentration of the residue it should not have the opportunity to collect in the still base. For these reasons, continuous stills are to be preferred for nitro distillation. 60 still was the only batch still in the nitrotoluenes system but was operated at a lower absolute pressure and hence lower temperature than the continuous stills.

7.3 An operating still is an isothermal system with a capacity to absorb (and dissipate) very large amounts of heat. The essential basis of safe operation for all stills containing a thermally sensitive substance like a nitrotoluene, is the maintenance of a sufficient quantity of boiling, volatile material in the heated section so that any temperature rise will be prevented even if some exothermic decomposition is taking place. The testing regime must ensure that any potential exothermic activity is well within the capacity of the still to absorb it and the operating regime must ensure that boil-up in the still is maintained by the presence of volatiles and the maintenance of the required vacuum.

8.0 The testing regime

8.1 Because of the thermal sensitivity of nitrotoluenes a testing regime for the material about to be distilled in a batch still has been in place for a number of years. In the case of 60 still, the still base itself was sampled to test the actual material charged, on a batch by batch basis.

8.2 The tests are designed so that they use readily available equipment and can be carried out by technical staff on a routine basis. The sample from the plant is distilled down in a high vacuum, rotary (thin film) evaporator, using the lowest temperature possible to remove the volatiles. Because of the better vacuum achievable in the laboratory the distillation temperature is typically 20°C to 40°C lower than the temperature which will be used on the plant. The concentration of the non-volatile residue is calculated and 2gm samples of the residue are then tested for their thermal stability.

8.3 To test for thermal stability, the 2gm samples are placed in short glass test tubes and the test tubes are then placed in a heated metal block held at a constant temperature. The temperature of the sample is monitored over several hours by using a thermocouple linked to a chart recorder. The sample temperature is compared to an inert reference sample (graphite) in the same block and any significant (>0.5°C) exothermic activity is readily apparent.

8.4 The test temperatures are chosen by reference to the plant's normal operating temperatures and to the maximum allowable temperatures. This should represent the maximum temperature the material can be exposed to on the plant. To allow for the differences in heat flow between the 2gm samples used for testing and the tens of tonnes which are present in a still, a "scale factor" of 10°C for every order of magnitude change in the size is used. The temperatures normally used for samples from 60 still base were 200°C and 225°C.

8.5 On average samples from 60 still base tested in this way showed a 3°C exotherm. If no exotherms were found or if they were judged to be acceptable (<5°C) the distillation was allowed to go ahead. However the amount of volatile material distilled off was controlled so that the material left in 60 still base was always 50% volatile material under the conditions of operation of the still. The amount allowed to be distilled off was set by the concentration of non-volatiles material found by the laboratory tests.

8.6 Duplicate samples of the material in 60 still base were taken and tested in two separate laboratories. If the test results did not agree the sampling and testing routine was repeated. Only when clearance was given by the tests did distillation take place. Using this testing regime, many thousands of tonnes of material were distilled in 60 still base over a 30 year period without incident.

9.0 The residue content of the vessel

9.1 In most reports of this event, no matter how short, reference is made to the fact that the still had not been cleaned out for 30 years. As has been pointed out in para 6.2 above the residue in the still was removed after every second batch. This had happened for many years without any build up of residue being noted. The residue in the still base was generally a free flowing, moderately mobile liquid at the temperature at which it was discharged (50°C to 100°C). It could be pumped away to storage without difficulty and then removed in tankers for off-site controlled incineration.

9.2 The evidence of any build up of residue in 60 still base over a period of time is not conclusive and there had been no need to clean out the still during the preceding years of operation. Although the HSE report refers to evidence of a build up of residue over a period of months, some witnesses suggested the still was essentially clear of residue only a few days before the accident.

9.3 The Company has done calculations of the known flows through 60 still base in the month before the incident. These suggest that up to 6 distillations before the final distillation, the quantity of residue remaining in the still base from batch to batch was about 1m³. This should be compared to the vessel volume of 45m³. Evenly distributed, it would have a depth of about 100mm, well below the lower battery which was about 200mm above the bottom of the vessel.

9.4 The actual involatile residue content of 60 still base at the time of the incident was considerably greater than this. It is known to have covered the bottom battery and its volume has been estimated at 3.5m³

with a depth of about 350mm at the sampling point which is at the high end of the vessel.

10.0 Operation of 60 still base immediately before the event

10.1 The quantity of residue in the system had started to rise to higher levels than normal (as described above). This was subsequently found to be due to higher levels of acidity in the product from the nitration process. In turn, this was caused by restrictions in the water flow to the washing section of the nitration, due to a build up of "hardness" in the associated pipelines. This hardness had arisen from the incoming, external water supply.

10.2 Two of the storages (162 and 163) which could feed 60 still base were required for other duties. As much of their contents as possible were pumped out using the normal pipework. However the connections were some 300mm above the base of the storages and something over 4 tonnes of material remained in each. This material was only suitable for disposal. The method of removal employed was to suck it into 60 still base using the vacuum in the vessel after a distillation had been completed but before the residue from the distillation was pumped away for disposal. This was a non-routine procedure completely outside documented procedures. Considerable difficulty was experienced in removing this material from 60 still base, in strong contrast to the usual operating experience. It took 24 hours to get the still to the point where the operators could say it was "liquid empty".

10.3 Another two distillations were carried out in the normal way. The test results on the samples were within the normal range and the distillations proceeded without any difficulties being noted. After the distillations were completed about 26 tonnes of material were left in the still. This was, within normal operating limits, the amount expected from the tests which had been carried out. It should be remembered that the distillation was stopped when the concentration of non-volatile residue reached about 50% of the material left in the still.

10.4 For a second time, great difficulty was experienced in pumping the residue out of the still base. After 10 hours pumping 350mm of residue, some 3.8 tonnes, was left in the vessel. Further efforts to remove this material were made over the following 12 hours but the material blocked the transfer lines. Some was removed but in the end the attempt to remove the material by pumping was abandoned and it was decided to remove the remaining residue mechanically.

11.0 The removal of the residues

11.1 The residue was to be removed by raking it out and, since it had cooled in the two days since the distillation had been completed, it was decided to warm it up to a maximum of 80°C. by putting steam on the batteries. At about 9.30 am steam was put onto the bottom battery and a pressure of 3 to 5 barg was noted as the condensate cleared. The controls were adjusted to give a pressure of 5.3 barg, corresponding to a saturated steam temperature of about 160°C.

11.2 A scaffolding was erected at the low end of the vessel and the manway was removed, with a skip being placed under the manway so that the residue could be raked into it. A metal rake was used to scrape the material out of the open end but the rake was not long enough to reach to the back of the vessel. At about 12.40 the steam pressure was noted to have risen to 8 bar, equivalent to a saturated steam temperature of 177°C. The temperature of the contents of the still base was measured by a thermocouple which was registering 48°C at this time. The thermocouple was properly located for normal operations but it was subsequently established that the position of the thermocouple could not indicate the true temperature of the residue.

11.3 At 13.00 the steam supply was shut off and by 13.15 most of the material which could be reached with the rake being used had been removed. At about 13.20 the jet of flame erupted from the still.

12.0 The Internal Investigation

12.1 An investigating team, led by the technical director, was established immediately and started work as soon as it was safe to do so. In total 90 samples were taken from the storages which fed 60 still base; from the store which held the residue after distillation; from the lines and pumps used to feed to and from 60 still base; from the material remaining in 60 still base and from the material scraped out of the vessel into the skip. Also, 9 recent duplicate samples taken but not required to be used in testing, were available for analysis. All the documents which could be recovered were gathered together but a number were destroyed in the control building. Witness statements were gathered by senior staff and the position of the witnesses at the time of the incident logged.

12.2 Once samples were gathered testing of the samples commenced and this work was notable for its intensity. Company staff voluntarily worked extremely long hours to get the tests done. The results showed that:

1. The material remaining in 60 still base and the material in the skip showed minimal thermal activity;
2. The material in the stores which had fed and which were ready to feed material to 60 still base showed the expected levels of thermal activity.
3. The material sucked from 162 store showed the expected levels of thermal activity.
4. The material in the body of 193 store, used to collect the final residue prior to disposal, showed the expected levels of thermal activity at the normal test temperature.
5. At higher temperatures, 15°C to 25°C above normal (ie up to 250°C), the samples from 2, 3 and 4, showed large exotherms of over 100°C.
6. The material in 163 store showed greater thermal activity than normal, with exotherms of over 250°C being recorded at the normal test temperature (225°C).
7. The presence or absence of air in the system made no significant difference to the exotherms detected.

12.3 Samples of the materials from 162 and 163 stores and from the final residue store, 193, were submitted for ARC testing to Columbia Scientific. The conclusions from the ARC testing were the same as those drawn above, reinforcing the suitability of the simpler tests to determine the level of thermal activity.

12.4 A detailed examination of the steam supply system was made. Nominally, the system supplied steam at 7 barg with a relief valve set at 7 barg. This would be equivalent to a saturated steam temperature of 177°C, though with the available superheat the temperature could have been up to 188°C. In fact the relief valve was found to operate at 9 barg which would have raised the available temperature further.

13.0 The External Investigation

13.1 The external investigation was carried out by HSE under section 14(2) of the Health and Safety at Work Act 1974. This section of the act, under which the Health and Safety Commission instructs HSE to investigate and to make a formal public report, was invoked because of the nature of the event and the public concern which surrounded it.

13.2 The police were initially involved in the investigation, taking statements and organizing witnesses. During the investigation, they prepared a file for the Crown Prosecution service who considered whether criminal proceedings, outside the scope of the Health and Safety at Work Act 1974, should be brought. Following the inquest, the Company was informed that no such charges would be brought. Given the technical nature of the investigation and the nature of the events, HSE took the lead liaising with the Police, the Coroner's office and the Crown Prosecution Service as appropriate.

13.3 The investigation involved very large amounts of HSE resources, both inspectors and technical staff being heavily involved. The day after the event 18 HSE staff: specialist inspectors; scientists; and

factory inspectors; were present on the site. In the days and weeks which followed other staff, including specialists in Process Safety and Control Systems from HSE's headquarters in Bootle, became involved. The whole investigation took 270 staff days of HSE's resources.

13.4 The external investigation had three outcomes: the Coroner's inquest; the prosecution of the Company in the Crown Court and the publication of the HSE report.

13.5 The Coroner's inquest was held in Wakefield Coroner's Court from 8 - 10 March 1993. The verdict in all five cases was accidental death.

13.6 HSE have indicated in their report (paragraph 71, page 23) that they considered a number of charges, including charges against named individuals. They chose to take a prosecution against the Company, regarding the incident as "due to cumulative management failures and omissions which represented corporate failure." The Company was charged under section 2(1) of the Health and Safety at Work Act 1974 and the case was heard in Leeds Crown Court on 30 July 1993. The Company pleaded guilty and was fined £250,000 with HSE being awarded £150,000 costs. The Company's own costs were considerable and not confined to the court case and inquest.

13.7 The findings of the HSE investigation have been published in their report. Their technical findings did not differ significantly from the Company's own conclusions though the emphasis they placed was different. Their laboratory investigations came to the same conclusions as the Company about the nature of the material in the still base at the time of the fire and its potential for exothermic runaway.

14.0 The Fires in the Control Building and the Office Block

14.1 The control building was of timber framed on permanent brick foundations. It was destroyed in a matter of seconds by the jet of flame from 60 still base which is estimated to have had a temperature of in excess of 2300°C. The building complied with the relevant standards for its occupancy. It had four final exit doors: two emergency fire exit doors and two for normal use. The fire exit doors were outward opening though the two doors normally used were inward opening.

14.2 The office block was a brick built, four storey structure. It contained a considerable number of offices, some individual and some open plan. The building had a fire certificate issued by HSE under the Fire Certificates (Special Premises) Regulations 1976. The building was separated along its length by a corridor which was specified as a "protected route" (that is: a route which is constructed to be fire resisting and which is therefore protected against fire elsewhere in the building) in the fire certificate. Fire badly affected offices on the side of the building struck by the jet of flame but did not penetrate the central corridor.

14.3 However, the integrity of the corridor had been breached during the installation of services after construction. These breaches were concealed behind suspended ceilings and they allowed smoke to penetrate across the building into the room where an office worker was fatally affected by it.

14.4 Since the incident the UK Chemical Industries Association has been working on new guidance for on-site control and office buildings. Hickson & Welch Ltd has had a senior engineer as a member of the working party to share our experience with other chemical companies. The Company has altered all its site buildings to make all doors, wherever practicable, outward opening. When the seriousness of the breaches in the fire resisting structure in the office block became clear, the Company publicised the problem as widely as it could. It drew other companies' attention to this problem which could lie concealed behind suspended ceilings in many other buildings which have been fitted with new services, such as computer networks.

15.0 The Effects on the surrounding population

15.1 The physical effects of the fire off-site were small. There was no significant off-site pollution.

the only off-site effects coming from the smoke from the burning office buildings. The fire in 60 still base was essentially over in about 1 minute. The other fires which continued to burn were brought under control quite quickly. Fire water was readily available and the fire water run off was contained on site, before discharge via the on-site effluent treatment plant. None reached the river Aire untreated.

15.2 Hickson & Welch Ltd have a long history of involvement in the local community. The Company and the local authority co-operated over many years to consolidate the site the Company now occupies and to provide only appropriate development around the periphery. The Company has sponsored and supported many local charities, sports, arts and educational organizations. The highest profile sponsorship in Castleford itself is that of the town's Rugby League Team, the ground being opposite one of the two entrances to the site.

15.3 Since 1986 the Company has had a Community Liaison Committee, involving Company directors, senior managers and union officials meeting with local representatives. The representatives come from the community around the site, from local schools and businesses, from the local authority and the emergency services. It meets two to four times each year to discuss the Company's performance, including its safety and environmental performance; to give local people a chance to tell the Company about their concerns; and to discuss matters of mutual interest.

15.4 At the time of the incident the Company consulted with the Liaison Committee and wrote letters to 2500 premises around the site. A telephone help and information line was established, open 7 days a week, with Company staff answering enquiries from the public. A community market research exercise was carried out to gauge levels of concern and was followed up later to detect any changes in attitude. The Company held several open days to ensure the population around the factory understood the operations being carried on. A staff counselling service was set up and an independent memorial trust fund established to which the Company contributed.

15.5 The effects of these involvements in the local community was considerable at the time of and since the incident. There was, of course, great concern in the local community at the terrible accident. However there was also a sense of a shared tragedy and a willingness to support both those bereaved and those who were working at the plant. There were few calls for the plant to be closed down and there was a willingness to support the Company at a time of great distress. This has recently been manifested in a letter sent - quite independently of the Company - to the local press. It came from a number of prominent local people, mainly members of the liaison committee. It expressed support for the Company and called on the press to stop reporting every news story from the site with a reference back to the accident in 1992.

15.6 Clearly such support must be earned and it is the Company's intention to live up to the support which the local community have given.

16.0 Changes since the incident

16.1 As would be expected, an incident such as this has been followed by many changes. A number of these were in train before the incident, others would have happened with or without it. However they are significant in the way the Company has responded to the events of September 1992.

16.2 The Company had many meetings with HSE in the period after the incident and received a great deal of guidance from HSE. By the time the HSE report was published the Company was able to say that it had responded to all the lessons the report sets out. For example:

The Company had surveyed all the buildings on-site to ensure that any breaches in fire resistance had been sealed and had surveyed all buildings to check on their means of escape. Subsequently the Company and HSE have been working together to revise the site's Fire Certificate.

The Company installed a computerized roll call system and re-reviewed its emergency

procedures with the emergency services. The revised procedures have been rehearsed in exercises both on and off site.

The Company had instituted a "non-routine job permit", which includes a hazard assessment, to control jobs for which there are no pre-existing written procedures.

All of the site's operating procedures had been reviewed and a system put in place to ensure that they are regularly updated.

16.3 60 still base was removed from the site after the incident investigation was over. The material previously distilled in 60 still base is now disposed of, off-site, by controlled incineration.

16.4 The destroyed control building has been replaced by a new, purpose designed control centre which is designed to cope with the most severe, credible accident which could occur on site. The Company is developing a programme to strengthen or re-site other control buildings. The side of the office block facing onto the plant has been re-built, again designed to be proof against the most severe, credible accident. The Company's medium term plan is to re-locate laboratories, currently inside the plant, into this building.

16.5 The safety of all the stills on site has been reviewed by an expert team, with a number being subject to HAZOP in depth. The HAZOP results have been used to define the Company's standards for the instrumentation required on stills, for operation and safety. HAZAN has been used to prioritize the work and all stills are now at or above acceptable levels of instrumentation. In parallel with this work, a survey of all actual and potential steam temperatures was carried out urgently and where appropriate control and operational changes were made.

16.6 The range of safety testing techniques available in the technical departments has been considerably enhanced with the purchase of reaction calorimetry and DSC equipment. Any proposed process is reviewed before it goes into plant scale operation and there is a programme to review all the Company's existing processes over a three year period, with staff dedicated to this. The priority of the programme was set by senior managers by consideration of the known chemistry of the processes. The service is available to and is being used by other companies in the Hickson International group.

16.7 The Company's safety performance has changed dramatically in the past three years. The accident frequency had been improving over a 15 year period but 1992 did see a step backwards. By 1994 the Company had improved its Reportable Lost Time Accident (RLTA) frequency rate by a factor of over 10, from 3.2 per 100,000 hours worked in 1992 to 0.29 in 1994. This is less than 50% of the RLTA frequency rate HSE quotes for the chemical industry as a whole.

16.8 This change has been achieved by employees at all levels working together to change the attitudes to safety on the site. The Company uses the International Safety Rating System (ISRS) to manage safety and involve staff. There has been a commitment to safety from Board level downwards, with safety performance being reported at all levels on a regular basis. Safety briefings, highlighting the Company's safety performance and focussing on a particular safety topic, are given to staff on a monthly basis. Managerial changes have been made, including a strengthening of both Technical and Safety departments to ensure that appropriate advice is available. ISRS also involves regular external audits and the Company achieved level 5 at the end of 1994, putting it in the top 50% of the companies audited.

16.9 In parallel with this the Company's environmental performance has been changing. Some £13 million is being spent on environmental improvements and this has had a significant impact on the Company's discharges to air and water. As noted above, no significant off site pollution was caused by the incident but further protective measures have been taken, for example a 350mm high kerb is being constructed along the river bank to prevent fire water (or other pollutants) entering the river Aire.

16.10 The Hickson & Welch Ltd performance in this area was made public in mid-1994 by the publication of a site Health, Safety and Environment Report, making the Company one of the first medium

sized chemical company in the UK to take such a step. The report explains the Company's commitments to best practice and sets out the Company's performance over the last four years. The Company is committed to publishing annual updates to the report.

16.11 Finally, at Hickson International level, a Responsible Care Supervisory Board has been set up under the chairmanship of Dr Keith Humphries, the immediate past president of the UK CIA. The Hickson Group are believed to be the first UK chemical organization to set up such a board. The board is composed of directors of group companies with direct responsibility for safety performance. It oversees the implementation of and advises on Health, Safety and Environmental performance across the group and reports directly to the main board.

17.0 Conclusion

17.1 There is no doubt as to the essential causes of the fire. A thick tar-like residue containing a considerable concentration of nitrotoluene and other unstable nitro-aromatics was heated by steam which would have had a temperature sufficient to initiate a runaway exothermic decomposition (>160°C). Because of the solid nature of the material, only slow heat transfer would have taken place, leaving the material next to the battery at the steam temperature. All nitrotoluenes are potentially unstable at this temperature on the scale of 60 still base and once the decomposition had started the temperature would have risen exponentially. The decomposition spread very rapidly through the whole mass, some 2 - 3 tonnes, and ejected a jet of flame through the two openings in the vessel.

17.2 There are a number of other factors which contributed to this principal cause. However, the critical step was to heat the material in the still base with steam and without either adequate heat transfer or a suitable heat sink. Once the steam was turned on, thermal decomposition of the material became possible, then - as the temperature rose - probable, then inevitable.

17.3 The effect of superheating on the possible temperature of steam heated equipment is also worthy of comment. Generally, in a system absorbing significant quantities of heat, the equation of steam pressure with saturated steam temperature is likely to be correct. This will be true in an operating still where the material in the base is boiling and absorbing significant quantities of heat. The steam will be condensing rapidly and the maximum temperature will be that predicted by the steam pressure.

17.4 If the system is not absorbing large quantities of heat these assumptions fall down. In a vessel containing a material with low thermal conductivity, heat will not be transferred away from the steam coils or jacket and the steam may not be condensing. In his case significant amounts of superheat may be available in a system which is operating quite correctly. The maximum possible temperature will be higher and this higher temperature needs to be allowed for.

17.5 The other processing problems identified or suggested - the position of the thermocouple, the fact that the residue had not been tested, the type of rake used, the length of time the still had operated without clean out - are subsidiary to these main points. Of course, that is not to say that lessons cannot or should not be drawn from them.

Acknowledgements

I must acknowledge the work of the investigating team whose work I have drawn on for this paper. I am grateful to HMSO and HSE for permission to reproduce diagrams from their report.

Reference: "The fire at Hickson & Welch Ltd" ISBN 0-7176-0702-X, HSE Books, 1994

In memoriam:

Sara Atkinson, Neil Gafney, John Hopson, George Potter and David Wilby.

Figure 1: Plan of area around 60 still base showing path of flame

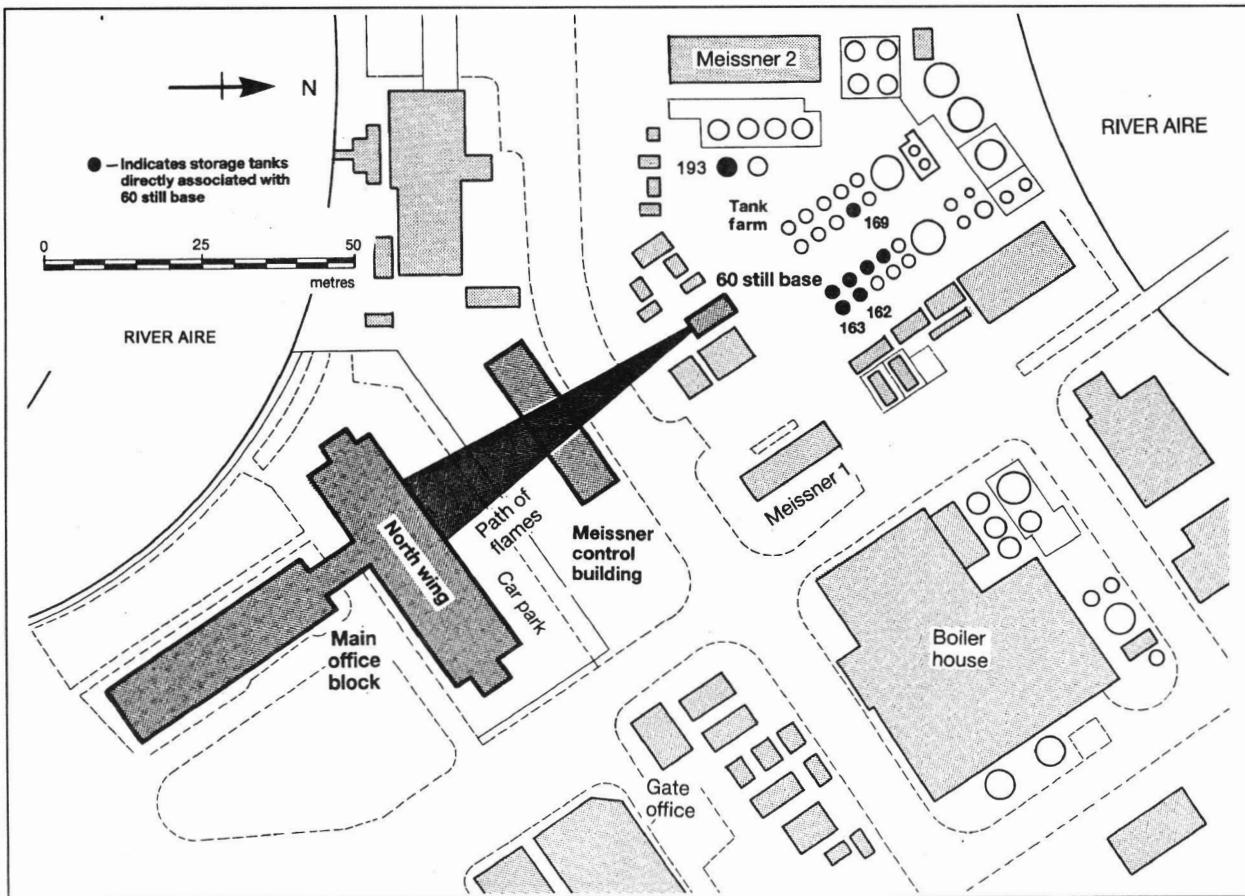
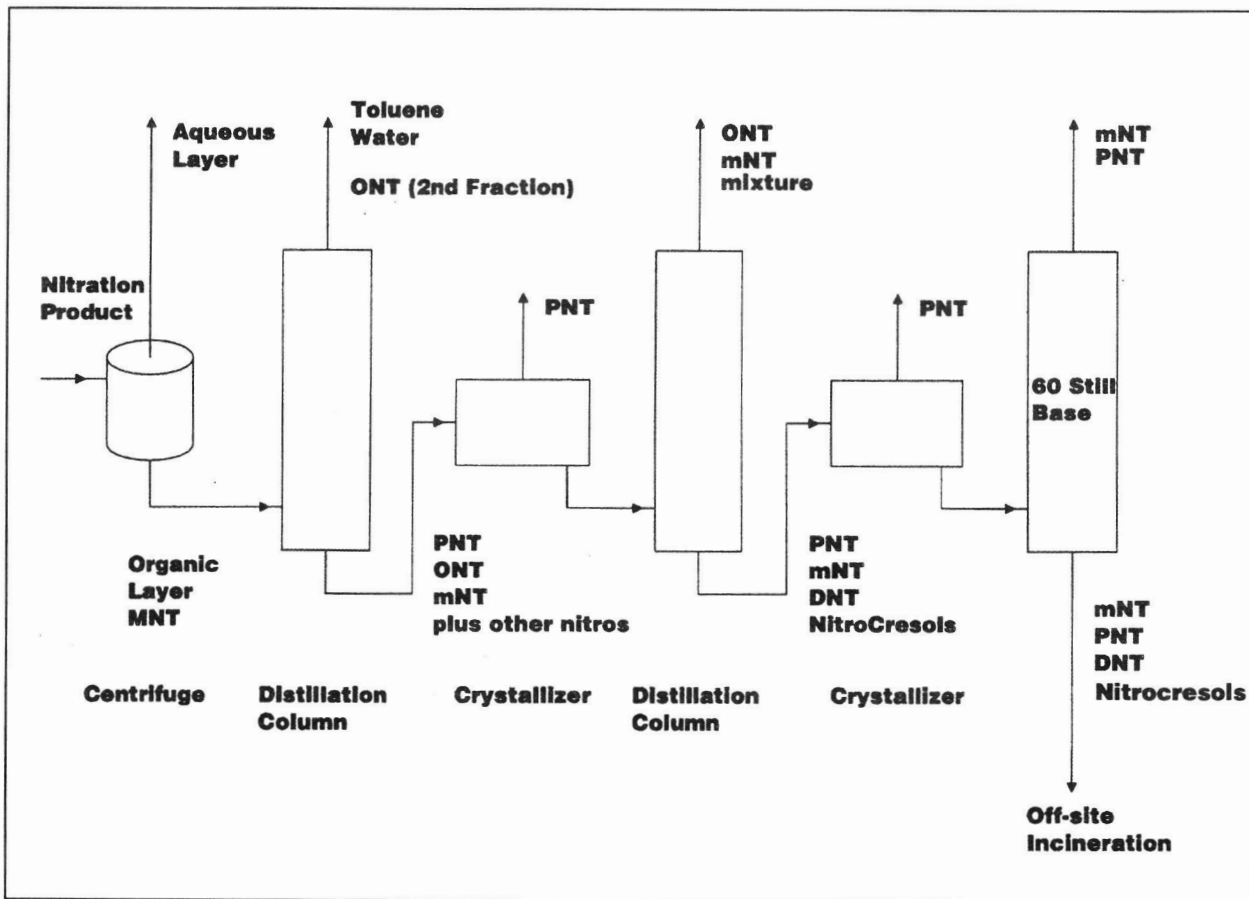


Figure 2:

Nitrotoluene separation system



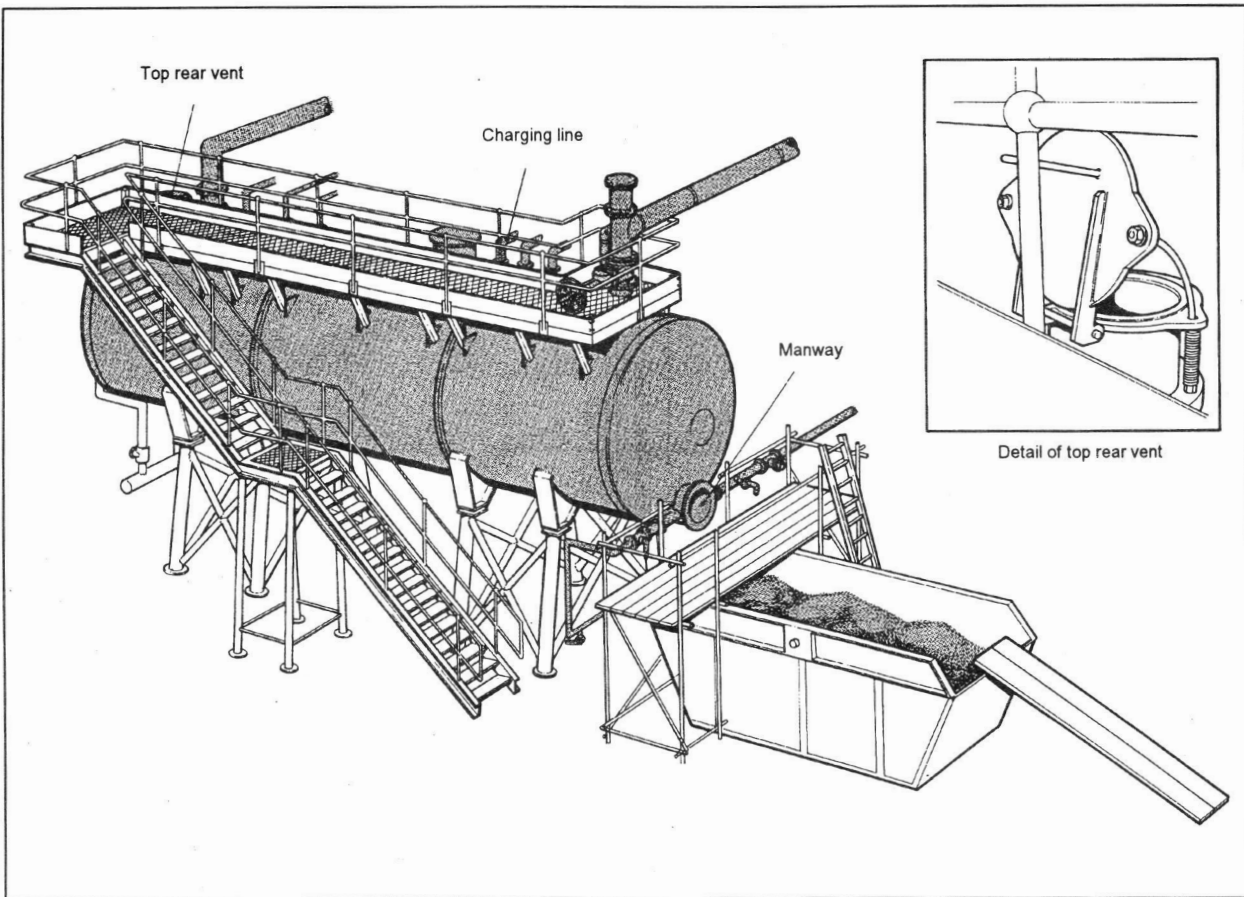


Figure 3:

60 still base

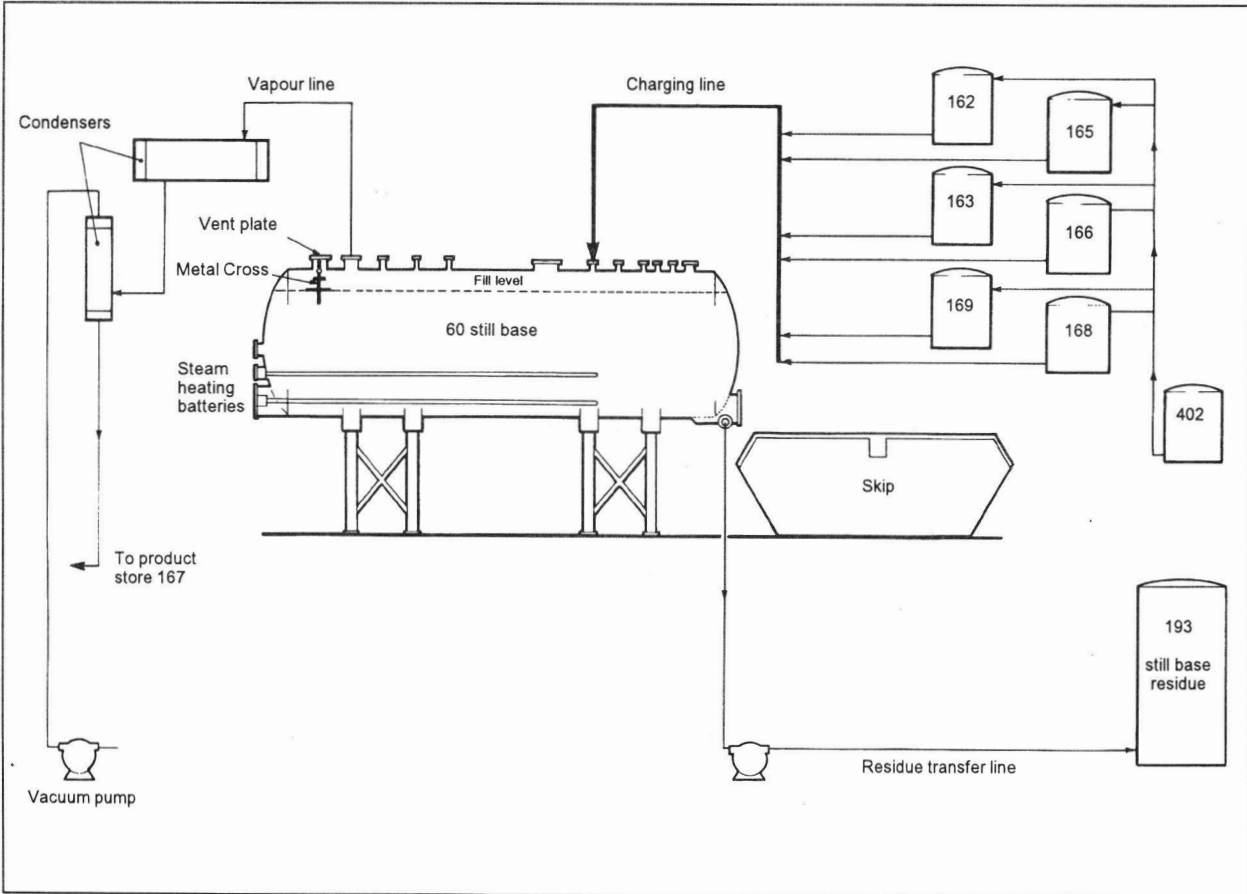


Figure 4: Schematic diagram of 60 still base and associated plant