Lessons learnt from some accidents which resulted in discharges to regulated waters

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Introduction

In his introduction to "An Engineers View of Human Error" (ref 1) Trevor Kletz advises us to

> Accept people as we find them and to try to remove opportunities for error by changing the work situation – that is, the plant or equipment design or the method of working

This paper recounts three more incidents which validates that principle.

All the incidents described in this paper were at establishments subject to the Control of Major Accident Hazards Regulations 1999 (COMAH)[Note 1] at the time of the incident. They were all Higher[Note 2] Tier Establishments. COMAH is regulated by the Competent Authority (CA), which in England comprises the Health and Safety Executive and the Environment Agency acting jointly. The incidents came to the Authors attention as he was investigating them as a member of the CA investigation teams. The opinions expressed in the paper are however entirely the author's own.

It will come as no surprise that there were multiple Root Causes of each incident – had any of these not been present, it is unlikely that the incident would have occurred, at least in the way it happened. None of these had a single "main cause" but human error is a common theme.

It is inevitable that a proportion of material will escape into the environment as a result of any complete loss of containment event. For protection of people, the environment and business the top priority is to avoid loss of containment. People and the Environment can be further protected by secondary or tertiary containment. This is normally only supplied to mitigate the impact of liquid releases, it cannot be provided in some cases and it is not provided in all cases where it should be. Even if it has been provided, it can fail.

A stock tank dewatering operation goes wrong

The Incident itself

The incident first became apparent on a Tuesday following a long Bank Holiday. It had actually started the Thursday before. Water accumulates at the base of the type of the floating roof stock tank involved in this incident, which from time to time has to be removed (dewatering). The incident occurred following a Tank "dewatering" operation. The operation was undertaken by a "Stand-by" man who was on a temporary contract to the operator. He believed he shut the valve at the end of the operation but it became apparent later that he had not. A picture of the valve involved is shown as Figure 1(note this is the valve as reconfigured after the incident, - the second, smaller valve was fitted after the incident).

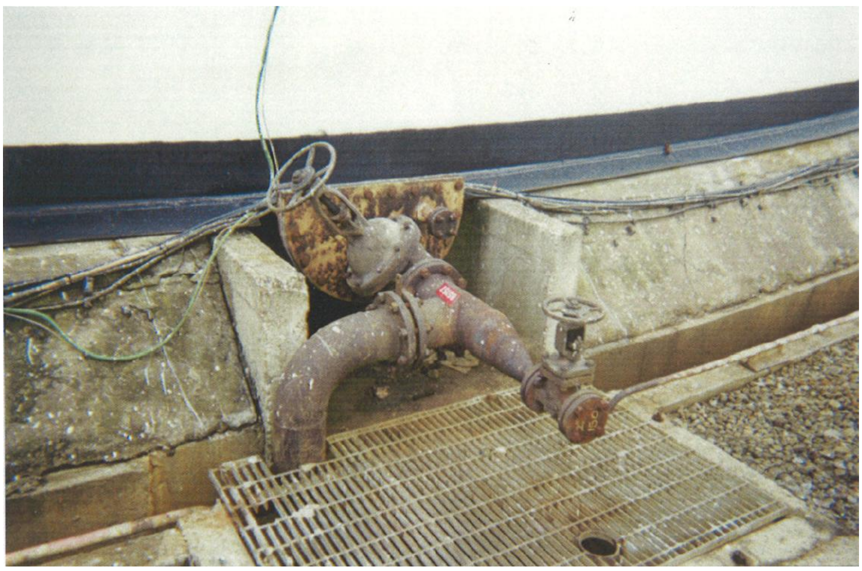


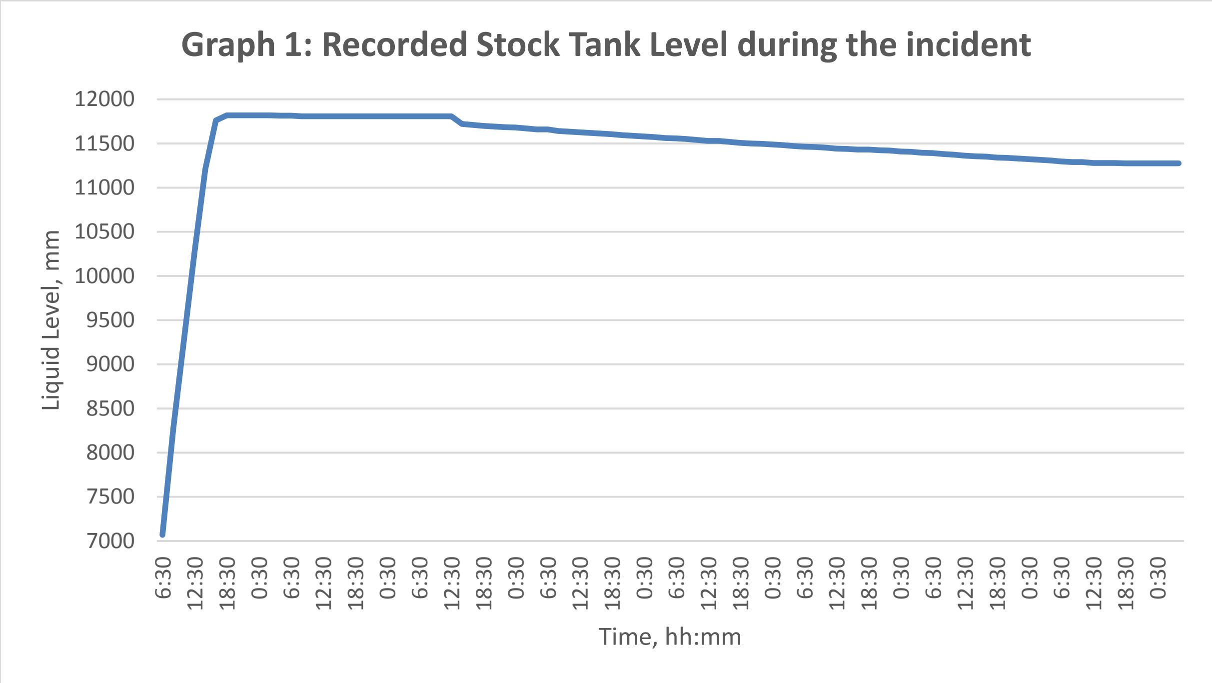
Figure 1 - The Dewatering Valves as reconfigured following the event

The product from the dewatering valve should have run down into a sump in the tank's "bund" and then along an underground drain to the outside of the "bund" and, via a "penstock" valve into the site drainage system. Because it was so stiff, the "Stand-by" man had been unable to open the penstock valve. He carried on with the dewatering operation regardless and did not observe any build-up of water from the dewatering operation in the bund. It was later determined that the penstock valve had indeed been stuck shut and the underground drainage system was fractured which meant that any liquid that left the tank drained straight into the ground.

Notes: 1 SI 1999 No 743 The Control of Major Accident Hazard Regulations 1999, which were in force at the time of these incidents, have been replaced with SI 2015 No. 483 The Control of Major Accident Hazards Regulations 2015

2 "Higher" tier establishments are now known as "Upper" tier establishments

It was standard practice for production technicians in the control room to record the levels of all the stock tanks in use that they were responsible for on a log sheet every two hours. They had 9 stock tanks in use at the time of the incident. The levels that were recorded for the Stock Tank involved in the incident are shown Graph 1 below.



The operating records were reviewed daily by the "process records" team who usually worked normal days. Normally the process records for all operations after 06:30 hrs on the Thursday would not be looked at until the following Tuesday but in this incident they were actually reviewed by a skeleton process records team on the Monday. On discovery of the discrepancy, the process records team immediately reported the stock loss to the production team. They went out promptly to "investigate" the loss. They attended the pumps and believed they had found a passing valve on the pump suction side of the tank. This would have meant that instead of only taking product from the duty tank, they were also taking it from the tanks showing the level discrepancy. The shift team reported that they had found and resolved the problem.

The shift team had not resolved the problem, and the tank carried on discharging its contents at a rate of between 3 and 4 t/h. Up until this point the liquid that was being discharged from the tank had been primarily water. Sometime overnight, as much water as possible had been drained out of the tank and the tank started discharging its contents, a 50/50 mixture Benzene and other hydrocarbons. This was first detected the following morning by a ship that had just left the adjoining jetty. It moored up on the other side of the river after a number of crew members complained of headaches and feeling sick. They were sent for hospital checks. The ship reported the incident to the harbour master. At about this time, an oil layer was noticed in the water by the Jetty that the ship was moored at. Following these reports, the harbour master initiated the port's oil spill plan. The crew members did not suffer any long term effects. Oil booms were deployed on the River within a couple of hours of the discharge being reported. The quantity of oil seeping out into the River in the Jetty area peaked after about three days and reduced slowly over the following three weeks. The total hydrocarbon loss was estimated as being between 120 and 180 t, of which about 20 t was captured by the initial attempts of capturing it physically.

The environmental consequences

The drainings from the stock tank leaked out of the underground drain into the ground beneath the bund. This is "made" ground made up historically from steel works slag, general waste and dredgings from the river. Between 100 and 140 t of organic material was released. It is evident that some of this material was retained in the ground and some found a fairly rapid leak path to the river, emerging by the jetty that the ship was berthed at.

The initial concern was the location of the release to the River. This was adjacent to an inter-tidal mudflat on the River which is a designated Site of Special Scientific Interest (SSSI) as it is a feeding ground for a number of rare water fowl, as shown in Figure 2

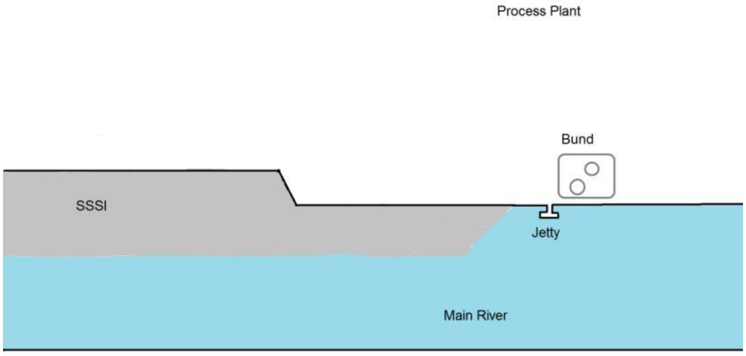


Figure 2 - Sketch of the Location of the Incident

Full ecological assessments of the SSSI was undertaken a month after the event and again four months later. Fortunately, the environmental impact was localised and short term. The investigations demonstrated that there was no impact on the adjacent mudflats.

It fairly rapidly became apparent that a significant amount of material had been retained in the ground adjacent to the tank and along the line between the fractures in the bund drain and the bank above the Jetty, because unacceptably high concentrations of Benzene were monitored in the air locally. As soon as was reasonably practicable following the incident, the company started to remediate the land using a soil vapour extraction system. This initially extracted significant amounts of material and was operated for more than six months before it could be demonstrated that as much material as could be reasonably extracted had been. Some 14 years after the event, elevated levels of benzene were still being detected in the groundwater close to the incident's location.

The root causes

There were four distinct causes as follows:

i) The tank dewatering valve was not fully closed after dewatering. Despite the standard set by HSG 176, only a single isolation valve had been provided for the dewatering operation. It should have been obvious to a competent process operator that the valve was passing. The standby man was not a process operator. He was a general worker normally used as a standby man for safety purposes, fork lift truck driving, general cleaning etc. For the previous couple of weeks prior to the incident, he had been used to dewater large stock tanks similar to the tank involved in this incident. Before commencing this work, he has received some informal training by a regular process operator comprising an explanation of the P&ID's and an introduction on how to use the process logging system to record the dewatering operation. On the first occasion he went out to actually dewater a stock tank he was accompanied by the process operator who had "trained" him. Subsequently, he had been left alone to do the job.

ii) The slip plate had not been refitted at the conclusion of the dewatering operation. The company reported that following the dewatering operation a slip plate should have been fitted on the dewatering valve as shown in Figure 1. This was the back-up system in the event of the valve failing or being defective or not being fully closed. Despite this there were no clear written procedures in place at the time of the incident on how dewatering operations should be carried out. It was also reported that the slip plate which should have been present prior to this dewatering operation starting was not in fact there. This indicates that it may have been normal practice to leave tanks in that condition

iii) It was planned to line and make the bunded area around the tanks impermeable. At the time of the incident this had not been done. The liquid released from the stock tank went straight into the ground underneath. The company suffered an incident two years previously which had led to consideration of a programme of work to make the bunds impermeable. The drainage system in the bund was known to be defective but no work of any kind had been done to minimise the risk that this presented.

iv) Despite the regular checks on the levels of the storage tank, the level dropped for three days without any corrective action being taken. Following an instruction to attend to it, the "corrective" action taken was ineffective. The Tank level was allowed to drop for a further 20 hours before the loss of containment became obvious.

Considering these failings, several common management system root causes are apparent in areas such as competency, design, operation, maintenance, and monitoring implementation of required process safety improvements. Such failings, if found today, would lead the CA to question the commitment of the senior management at the site to Process Safety Leadership values.

The consequences to the operator

It should be noted that the company was very cooperative with the regulating authorities following the incident. Despite this, the subsequent investigation was somewhat disruptive to normal operations, requiring key personnel to stop undertaking their normal duties to manage the recovery operation.

It became apparent during the early stages of the investigation that the operating procedures covering Stock Tank Dewatering were seriously deficient. An Enforcement Notice was issued requiring these procedures to be revised in line with relevant good practice. This Enforcement Notice was complied with very quickly.

The company stopped using contract "standby" men on all process related tasks immediately after the incident. They also bypassed the defective underground drainage system for dewatering operations and fitted the second isolation valve on the tank dewatering stream – the smaller of the two valves shown in Figure 1. Other operators have chosen to install self closing valves on stock tank dewatering duties, intended to ensure that the operator remains in place throughout the dewatering period since the valve works as a "hold to run" device. Other available risk reduction measures include bund sump leak detection systems.

As mentioned above, two ecological surveys of the adjacent SSSI were undertaken and a third survey of the invertebrates in the River bed close to the point of discharge. The active ground decontamination was operated for more than six months. Since then, groundwater contamination levels in several places close to the event have been monitored on a far higher frequency than would normally be required. All of these measures were paid for by the company.

The company completed the development of and implemented the project to line the five bunds in a similar position to the one involved in the incident adjacent to the River. In each bund the works involved:

- Constructing new drainage channels and a blind collection sump to deal with normal arisings including rainwater
- Laying an HDPE liner over the gravel area of the bund Sealing these to both new and existing concrete structures within the bund to provide a water tight seal to the base of the bund.
- Further enhancing the integrity of the containment system by applying a sealant paint to the concrete surfaces

Following the incident the company thoroughly reviewed its operator training system and operating instructions, starting with their structure. In the end, it took about 5 years to completely revise the structure and ended up with an externally accredited training system and set of associated operating procedures and instructions. Some of the main drivers for this development were the shortfalls uncovered in the incident investigation in the systems they had in place previously.

The Company was prosecuted for offences against the Environmental Protection Act 1990 and the Water Resources Act 1991. The company entered Guilty pleas at the first opportunity before the Court.

Liquid Export on to a ship is not stopped when necessary

The Incident itself

This incident happened after a ship had received a cargo of Aniline from a storage terminal while they were trying to stop the flow. Table 1 gives the time line for the event

Table 1 - Timeline of the Event

Time	Event
07:40	Ship asked loading to stop. Terminal attempted to comply
07:42	Nitrogen introduced to flexible hose to blow remaining product to ship
07:44 – 07:45	Terminal stops blowing nitrogen through jetty flex Aniline observed escaping from ship Terminal supervisor contacted.
07:46	Vessel starts preparing to route load to a spare tank
07:48	Vessel tank's hatch blows
07:49	Terminal Operators left jetty to muster at site office.
	Ship opens up route to the spare tank
07:56	Terminal site muster completed and Operators instructed to return to jetty 2.
08:00	On return to the jetty, terminal operators press the correct stop button and flow to ship stops.

When the ship asked the terminal to stop loading Aniline, the jetty operators responded by pressing a button that he believed would stop the pump and attempted to close the product isolation valve at the head of the jetty. The closed position was not the same orientation as the other valves on the jetty. Heavy rain was falling and the operator did not see the labelling on the valve. Therefore the valve remained open. The jetty operator then tried to blow the product remaining in the lines connecting the terminal with the ship with Nitrogen (7 bar supply pressure). A couple of minutes later, after the ship had said Aniline was still being received, the Terminal stopped blowing nitrogen through the flexible hose connecting the ship to the jetty and disconnected the nitrogen supply. Very quickly after that, Aniline was observed escaping through a pressure/vacuum valve on one of the ship's tanks. The vessel's crew then started to change the product route on board ship to route the incoming Aniline into a spare tank on board. They were not in time to prevent an overfill of the tank that was being filled. The tank's hatch blew off with a loud bang, spraying product over the ship, into the river and onto the Jetty. Figure 3 is a frame captured from the terminal's video surveillance system showing the burst.

At that stage, the terminal operators initiated the "Site Toxic Alarm" which meant that the jetty operators had to leave the jetty to go to their muster point so they could be accounted for. After the jetty operators left the jetty but before they returned, the ship had managed to reroute the Aniline into a spare tank on board the ship. On their way back to the jetty, the lead jetty operator pressed an alternative "Stop" button to stop the pumps. This action worked, and by the time that got back to the front of the jetty, the discharge to the ship had stopped. It should be noted

Figure 3 - The Aniline Burst

- On the previous evening, the Terminal's Shift Supervisor had agreed with the vessel to complete loading when the vessel told the terminal to stop, as opposed to the original agreement for the terminal to stop loading when they thought the correct amount of material had been loaded. The original agreement was recorded in the formal ship-shore checklist. The change was not recorded but both sides agreed following the incident that it had been made.
- The terminal was expecting to stop the loading operation just after the morning shift change. When loading, the jetty is manned by a lone jetty operator. When setting up an operation or stopping loading it is manned by two operators. Because they were expecting to stop loading soon, two jetty operators attended at shift change
- Of the two Operators on duty at the jetty at the time, one (Operator 1) was fully trained and had worked for the terminal for 7 months and the other (Operator 2) was training and was to work alongside his colleague under his supervision. Operator 1 had loaded Aniline "several" times previously.

- At the time of the incident, both operators were fully suited up in "Chemical" wet suits and it was raining quite heavily

The environmental consequences

There were difficulties in establishing both the quantity of material loaded on to the ship and the amount of material that was lost to the River. Most of the material that was lost was contained on board the ship in the "scuppers". Some of the material that was released in the "burst" – see figure 3 above – was lost to the River

The best estimate is that about 1 t of Aniline was released into the river but there is significant uncertainty in that figure. At 3.6 g/100 mL at 20 °C, Aniline is relatively soluble in water. It is very unlikely that the relatively small quantity discharged to the river will form a stable discrete layer – it will dissolve fairly quickly. Given the dilution and flow patterns of the estuarial system, it would be expected that any effects would be fairly local. No adverse environmental effects were reported associated with this incident.

The root causes

All of the following actions made a contribution to the event, or could have helped avoid it:

i) The operator opened, rather than closed Valve X6 when requested to stop transfer of product to the ship. The valve position should have been changed to make it line up with the other valves on this and the other site jetty.

ii) The operator failed to use the correct Pump Emergency stop button on the jetty.

iii) The ship did not have a route prepared to accept further flow in the event of the flow not being stopped on demand.

iv) The ship failed to isolate the flow from the shore once it had become apparent that the Terminal had not stopped the flow.

v) The ship failed to comply with a number of elements of the Actions specified to be taken by ship personnel in the event of an emergency on board, as specified in the Cargo Information Book. In particular, they failed to sound the ship's horn which would have given an immediate local effective warning that something was going wrong on board.

vi) The ability to stop a flow to the ship relied on locally operated manual valves as opposed to ROSOVs, a situation reliant on the presence of operators and the ability for them to work safely. The need for ROSOVs should be assed using HSG 244.

After the incident, the Terminal found the loading isolation Valve X6 was open. During the discharge, the valve had been gagged back to limit the loading rate to meet the ship's loading requirement. This use of an isolation valve for control purposes is not good practice. It is clear that the jetty operator had fully opened, rather than closed it, at 07:40. Immediately following the incident, management discovered that the telltale on the top of the valve had been installed incorrectly. It appears that about 12 to 18 months prior to the event, the valve was replaced after reports of the original valve passing liquid. It is thought that, when the valve was replaced, the gearbox was also replaced with a manufacturers standard design gearbox, which resulted in a gear box orientated incorrectly to the Terminal's standard, as shown in Figure 4. No records can be found relating to this work.

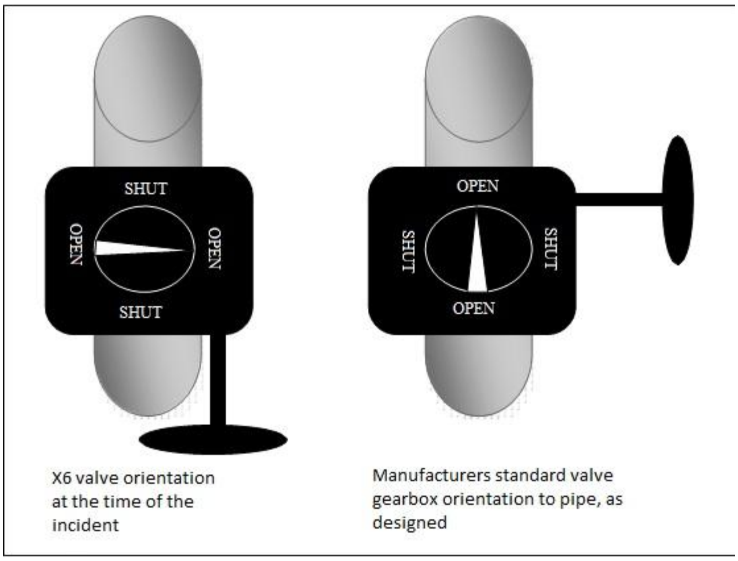


Figure 4 - Orientation of Valve X6

On all the other valves on the establishment the telltale on the top of the valve shows the open direction of the hole in the ball. In this case, the telltale was at right angles to the direction of flow – so was actually open when the telltale of every other jetty valve shows "closed" and is in fact closed. This anomaly had been previously recognised and the abnormal operation of the valve was clearly indicated on the valve body in yellow paint, as can be seen in the photographs attached as figure 5

The "Pump Room 2 Emergency stop button" that should have been activated at 07:40 is located adjacent to the (hand actuated) jetty isolation valve X6. It was intended as an emergency stop button but was normally used to stop the pumps. This use of emergency systems for normal control is not good practice. There were a number of "Pump Room 2 Emergency stop buttons" located in the Jetty area, including one of about 5 Emergency Shutdown stop buttons shutting down different sets of pumps at the entry to the jetty area. At the time of the incident, access to these was restricted by scaffolding. Subsequent to the incident, the operator has simplified the "Pump Emergency Stop" buttons on the establishment and now every "Pump Emergency Stop" button stops all pumps.

Figure 5 Picture of the Jetty Valve

Operation on board the ship was not investigated by either the Competent Authority or the Terminal. It was handed over to the Marine Accident Investigation Branch for investigation but it appears that they did not take it any further – neither party has received any feedback on the subject and there is no investigation report available on the Marine Accident Investigation Branch's website

The consequences to the operator

The Terminal had already been considering simplifying the jetty Emergency shutdown system so all stop buttons stop all jetty supply systems as part of the Work linked to a "Reduced manning on Jetty" project. They brought this part of the project forward following this incidentThe Terminal corrected the unhelpful orientation of the indication on Valve X6 following the incident.

The Terminal also completed a project to change out all the jetty valves from manual to ROSOV's.

The Terminal Operator has substantially reviewed it's in house operator training since the incident and replaced it with an externally accredited training programme.

The Competent Authority considered taking the company to court on a number of matters raised during the investigation but for a number of reasons decided not to take this forward.

A warehouse catches fire

The Incident itself

The operator had recently commenced a contract from an EU manufacturer for the storage and distribution of "Personnel Care Products" – not toxic to Humans. The material, typically a mix of deodorant Aerosols and other non COMAH products such as hair dye and shampoos and other liquid detergents. These were produced abroad and sent to UK as packaged final goods in pallets sealed in blister packs. They were stored in a single Warehouse allocated for highly flammable storage. As required, they were then shipped out to final customers. Smaller customers do not take whole pallets of single products, and for these customers the operator rearranged the blister packs onto multiple product pallets. Figure 6 is an aerial photograph centred on the establishment, taken before the fire

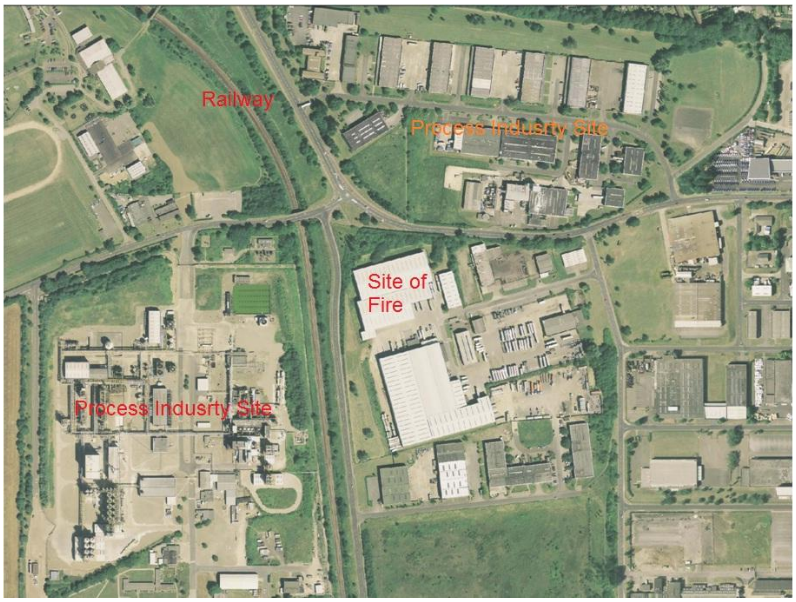


Figure 6 - A picture of the Establishment before the Fire

The establishment is the warehouse complex in the middle of the picture. The top one caught fire. It was Located in the middle of an industrial complex, with one other COMAH Upper Tier establishment and a chemical plant regulated under EPR in fairly close proximity. A passenger railway line runs immediately to the east of the site and the A is about 2 miles to the west of it.

The timeline of the fire starting is given in table 2

Time	Report
12:51	Lapping flames on one pallet observed Fire extinguisher applied
12:52	Fire Alarm sounded
12:53	Evacuation complete, First explosions heard in building
12:55	Security cameras obscured by smoke
13:01	Police had arrived
13:02	FRS started to arrive

The fire was well established by the time the Fire and Rescue Service (FRS) arrived – Figure 7 shows a photo of the fire taken at about 13:00 hrs by a member of the public and put up anonymously on the web.

The event took place at about mid-day on Friday, 05-Nov. The direct extent of the impact was up to 10 miles away at the peak of the fire, and the plume was seen from Newcastle to Teesside, about 50 miles. All the bonfires in the county planned for that Friday evening had to be cancelled because the County FRS were unable to provide cover.

Figure 7 - Photo of the fire

It is worth pointing out:

- Nobody was injured – The Operators Emergency plan was implemented properly.
- Once it became apparent how big the fire was, the FRS adopted a controlled burn approach to the warehouse on fire, cooling the adjacent warehouses. None of the other 8 warehouses on the establishment were significantly affected by the fire.
- The apparent extent suggested that this was a major incident. The off site Emergency Plan swung into operation as planned.
- Silver and Gold commands were both operating by 15:00 hrs and then disbanded in a timely manner. By about 17:00 hrs, the incident was contained and did not pose a threat of escalation. The warehouse inventory remained burning for several days. The escalated command structure was disbanded, with the caveat that they could be reconvened if necessary.
- Immediately following the incident, the co-operation between the regulatory authorities, the Police, the FRS and the Competent Authority (CA) was extremely good. The CA started work on the investigation over the weekend and first visited the site on the Monday morning, while the police were still establishimg that the fire had not been deliberately started. The CA went into the middle of the warehouse on Tuesday along with the FRS investigators and CSI while the FRS still had control of the scene – they were still damping down isolated spots.
- More details of this incident are given in Ref 1

The environmental consequences

The explosions during the first two to four hours on the site sent exhausted aerosol cans over an area which extended up to 500 m downwind of the establishment and 200 m upwind. A few of these initiated minor fires where they landed but fortunately they either went out of their own accord or were quickly put out.

Figure 8 - foaming on the River

During the early phases of the fire, firewater was applied to the warehouse itself and quantities of liquid detergent were picked up in the firewater runoff. This was discharged into the local River, causing extensive foaming along the 7 mile stretch until it meets a larger river. An example of this is shown as Figure 8. The receiving river itself was an “improving” River, slowly recovering from historical Industrial Pollution. It had been restocked with fish some 5 years previous to the incident and prior to the incident surveys indicated that these were doing well with the population increasing. There were initial reports of a few dead fish on the bank on the day of the incident, but nothing was found the following day when the banks were systematically inspected. A Fish Survey by the Environment Agency some months later confirmed that no lasting damage had been caused by the Incident.

Figure 9- Kerb round warehouse slab

The warehouse was not provided with kerbing at its base. This is standard practice for warehouses containing hazardous materials. During the fire, a lot of liquid was released and the FRS reported that it was 2+ ft deep in places. Immediately after the fire, it was obvious that liquids were seeping out of the fire from compromised packaging from the warehouse slab to ground. Following pressure by the Agency, the operator had a small kerb built round the whole periphery of the warehouse to limit liquid runoff and enable waste liquids to be collected as they became obvious. A small section of this is shown in Figure 9. It was fortunate that there was very little rainfall in the period between the fire and the time the operator had the site completely clean. However, during and immediately after the fire, there were some discharges of contaminated non-hazardous material to ground. The geology of the site indicated that there may have been some leakage paths to the underlying aquifer but monitoring of the groundwater for several years following the event had not shown any signs of contamination.

The root causes

Figure 10 - The Site after the Fire

The destruction (see Figure 10) was so severe that all the investigation teams agreed no forensic evidence could be obtained.

The root cause cannot be identified to evidential standards.

General principles to consider however in such a situation is that there is scope for the aerosols to be damaged or their integrity otherwise compromised resulting in a release of LPG. How likely this could be can be affected by various possible factors including how and where the aerosols are stacked (e.g. on or above ground level), the room for forklift trucks to manoeuvre in the aisles, whether loose aerosol cans are present such that they could be run over etc. Once the LPG is released possible sources of ignition to consider include electrical sources of ignition such as unprotected forklift trucks and other similar equipment used or brought into the warehouse.

The consequences of the initial fire were as expected. Once one aerosol has ignited, it had been modelled that the whole warehouse would catch fire in about six minutes. The modelling unfortunately proved remarkably accurate.

There were other factors that did not help mitigation of the event.

The company believed that there was an “Interceptor” which could have been of use in an Emergency on the main site drain. This never existed. Both Agency personnel on site and the FRS looked for it on site but found nothing. This was still causing confusion several hours after the start of the incident and probably delayed diversion of the drain downstream so allowing non trivial amounts of detergent into the River – hence the foam. Eventually the discharge was diverted, and at least some polluting material was prevented from entering the River.

The Emergency Services were aware of the hazardous substances in the warehouse. Most of these were aerosols, but all others were listed down to kg quantities. However, they were not aware of other materials stored in it. Most of these were liquid detergents, which actually caused the foaming problem. The Emergency Services were not aware of the detergent at the start of the event. Within a couple of hours of the start of the event, the operator was able to provide a complete inventory of the warehouse contents from their off site back-up computing system – their main office was on site and was not available during the fire. However, this inventory was of the trade names of the products. It took the operator the best part of a week to get adequate information from their customers on the chemical nature of the contents. Even then, the data was not sharp – mostly composition ranges. The reason given for this lack of precision was commercial confidentiality in what is essentially a “perceived effects” business.

The initial reports sent to the Environment Agency appeared to point at a chemical works producing Polyvinyl Chloride (PVC), next door to the establishment that was actually involved. This was probably due to a misunderstanding by a member of the public. The PVC plant imports VCM and stores it in bulk. The reports of black smoke could easily have been VCM burning. Clearly this is a very different set of hazards and far more sustained. Fortunately the PVC works was upwind of the warehouse and unaffected by the fire, apart from shutting down quickly.

The consequences to the operator

The warehouse and all the stock in it were destroyed by the fire. The company permanently lost that business and the company decided that it would withdraw from the business of storing flammable aerosols. They denotified under COMAH a few months after the fire.

There were a number of other financial and personnel consequences to the company

Because a definite root cause could not be determined, the Competent Authority did not take any enforcement action as a result of the incident.

The company accepted a formal caution from the Environment Agency for offences against the Water Resources Act.

Common Lessons

Operator's responsibility

Paragraph 5 (1) of the Control of Major Accident Hazards Regulations 2015 requires an operator to take all measures necessary to prevent major accidents and to limit their consequences for human health and the environment. This includes providing a working environment where the plant and equipment is fit for purpose and will not lead to errors. In the first example, fitting a second isolation valve as per recommended practice would probably have avoided the incident. In the second example, installing one valve which worked in the opposite direction from all the other similar valves on the establishment was likely to be misunderstood when the operator was working under pressure. In the third example, had the company had provided a suitable means of controlling water runoff from the warehouse and the site there would probably have been fewer environmental consequences. In the first two cases, the operator corrected matters essentially immediately after the incident. In the third case, the operator exited the business of handling high hazard materials.

Ongoing Toleration of minor deficiencies to Layers of Protection.

Operators write operating procedures and instructions to ensure that appropriate practice is adopted. However, procedures are valueless if the Operator does not have rigorous management system in place to ensure adherence to them. In the first example, there should have been a slip plate on the dewatering line before the dewatering operation commenced. It was missing then, and not replaced after the operation was completed. It was not even considered important enough to include a "temporary" working instruction written two years before into the formal operating procedure. In the second example, the operator knew that the valve had been fitted "wrongly" 18 months before the incident yet had not taken any steps to correct the matter. He was also using an isolation valve as a flow restriction valve. In the third example, the operator believed there was an "interceptor" which could have been used in an emergency on site. However, its absence shows that this was never sufficiently verified. Management sets the standards in any business and must be permanently vigilant going into adequate detail to ensure that the appropriate standards are complied with. This is particularly important when handling high hazard materials. It must come from the top and extend all the way down the management chain.

Estimation of loss to the Environment

All three cases exhibit the common problem of estimating the actual loss to the environment. In the first case, although the total loss to the environment of 100 – 160 t oils is reasonably precise, it has not been possible to estimate what fraction of it has been lost into the river and what fraction was initially retained on land – the estimates vary between 20 and 80% to each. In the second case, the estimate of loss comes from a calculated estimate of the total loss during the burst and analysis of the CCTV evidence to split the material between that retained on the ship, that retained on the jetty and that actually discharged into the River. In the third case, again the total loss is well characterised but it has not been possible to estimate how much material was burnt, how much was discharged to the River in contaminated firewater and how much seeped into the ground. From both a regulatory point of view and for managing remediation work, it is important to have a reasonable idea of how much material has been discharged to what environmental media. Managers, especially those responsible for environmental matters, should be aware of this during an incident and as far as is reasonably practicable monitor what has gone where.

When all else fails, unplanned discharges end up in the Environment whatever they are!

The essential feature of a loss of containment event is, in the end, material that should not be there ends up in the environment. Usually, far more material than was involved in the incident itself ends up as waste, contaminated with the material involved – and if that was a dangerous substance, the waste is normally made hazardous. That happened in all three events described here.

In the first event, there were releases to atmosphere, regulated waters and land. The company was monitoring atmospheric benzene levels in the bund and by the jetty for a couple of weeks after the incident. They had to activate the site toxic alarm again two days after it because the benzene levels had got so high as to be hazardous to human health again for a short period. Fortunately, there were no observations of any actual harm arising from these emissions. Significant quantities of oil contaminated water were collected from the spill onto the River. This contaminated water had to be treated. Fortunately, the site has an effluent treatment plant was acclimatised to treating the organics present on site and the effluent was treated satisfactorily there. The incident contaminated parts of the ground beneath the bund and when they came to refurbish the bund, they generated larger quantities of Hazardous waste than they otherwise would have done.

In the second event, the only significant release was to water. Unusually, it was not possible to recover any of the material and no waste was generated.

In the third event, there were releases to atmosphere, water and land. The releases to atmosphere took the form of spent aerosol cans and a thick black smoke. Following the incident, "pickers" picked up most of the cans so as well as the cans themselves the waste included gloves, other PPE and waste sacks. The particulates in the smoke did not seem to settle out locally and we do not know either the nature or the fate of them. Some of the liquid released during the incident ended up in the river and caused the foaming effect in it. Later on in the event, the discharge from the site to sewer was diverted to emergency tanks at the local sewage works leaving large volumes of contaminated water to be treated. The local sewage works could not cope with this so it had to be tankered away. More of the liquid escaped to ground. This probably biodegraded. A further portion of the liquid was removed from the warehouse slab towards the end of the fire and its immediate aftermath by gully sucker and tankered off site for treatment. However, most of the liquid still remained on the warehouse slab when they came to clean it away a short time after the fire. It was either in unburnt containers or being held up in the solid debris left after the fire. They needed to stabilise the free liquid with absorbent before it could be loaded onto trucks for further treatment. Although there were no toxic chemicals on the site at the time of the fire, the waste from the slab was classified as "Hazardous" because it contained potentially unstable full aerosol cans which were not destroyed in the fire itself.

References

1 Presentation "Fire and explosions at an aerosol warehouse", Graham Atkinson, HSL, available at http://www.nfpa.org/~/media/files/proceedings/atkinsonpresentation.pdf?la=en

Sources of Figures:

All Environment Agency except Figures 3, 4 and 5 with the permission of the operator involved.