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Report No 21

MIS-IDENTIFICATION OF CHEMICALS

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Report based on the work of the EPSC Safety Issues in Batch Production Contact Group

Any enquires about this report, or other EPSC matters, should be addressed to Mr Lee Allford, Manager - EPSC Operations.

The European Process Safety Centre

Objectives

1. **Information**

To provide advice on how to access safety information and whom to consult, what process safety databases exist and what information on current acceptable practices is available.

2. **Research and Development**

To collect European research and development (R&D) needs and activities in the safety and loss prevention field, to inform members accordingly, to act as a catalyst in stimulating the required R&D and to provide independent advice to funding agencies priorities. "R&D" here includes experimental research and the development and review of models, techniques and software.

3. **Legislation and Regulations**

To provide technical and scientific background information in connection with European safety legislation and regulations, e.g. to legislative bodies and competent authorities.

4. **Education and Training**

To provide a single source of information on training materials for:

(a) the teaching of safety and loss prevention at undergraduate level; and
(b) courses and materials for training and continuing education at all levels of the workforce.

Benefits of Membership

- Improved cross-European co-ordination on safety standards
- Identification of areas where manuals and guidelines could be produced
- Improved co-ordination of safety R&D and handling of complex technical research programmes
- Stimulation of R&D in areas where there are gaps in knowledge
- Transfer of knowledge from elsewhere to Europe and between European countries
- Technical input to legislators and standard makers to ensure more realistic legislation
- Sharing and dissemination of information on safety technology and accident prevention
- Access to information from a single source

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1. Background to the Contact Group

The **Safety Issues in Batch Production** Contact Group was established in 1998 to focus on the safety issues that make batch processing different to continuous plant. The first exploratory meeting was held at the EC Joint Research Centre in Ispra, in October 1998, at which Dr George Suter, then Clariant International and now the Swiss Institute of Safety and Security, became Chair of the Group. At this meeting a brainstorming session was held to generate a list of suitable topics for the Group. From this session the first topic was chosen as **Safety management for process transfers of batch and semi-batch processes**. The aim being to focus on the approaches of different companies to the management of change with respect to process transfer in both single product and multi-purpose plant. The work on this topic took the form of benchmarking the approaches in member companies, with the goal of extracting best practices[1].

During the final meeting on the first topic the issue of the "mis-identification" of chemicals was raised. The response was such that members of the Contact Group agreed to hold a one-day meeting to exchange information on the topic. Prior to this meeting the EPSC membership as a whole was surveyed to distil further information on the topic. This meeting and the information exchanged has led to the production of this report.

Below is a list of Contact Group members and their company's who took part in the exchange of information on this topic.

1.1 Members of Safety Issues in Batch Production Contact Group

Mr J Cryan	Akcros Chemicals
Dr D Heitkamp	BASF AG
Dr U Hörcher	BASF Aktiengesellschaft
Dr J Hempel	Bayer AG
Mr F Altorfer	Ciba Specialty Chemicals
Mr W Roper	Ciba Specialty Chemicals
Dr K Dixon-Jackson	Ciba Specialty Chemicals
Dr K-J Niemitz	Clariant GmbH
Dr JS Duffield	EC JRC
Mr RD Turney	EPSC
Mr M Powell-Price	EPSC
Dr J Calzia	EPSC
Professor ML Preston	Eutech
Mr J Huber	Novartis
Dr U Widmer	Novartis International AG
Dr P Rouyer	Rhodia
Mr G Atkinson	Rhodia
Dr G Suter	Swiss Institute of Safety and Security
Mr G Riley	Unilever
Mr D Burrows	Unilever
Mr Y Malmen	VTT Automation

2. Foreword to the project

What is it, that justifies the existence of a special Contact Group on Safety Issues in Batch Production? This question is almost as old as the idea for this special Contact Group, and in fact, during the discussions it was found that the basic concepts of safety are the same in both continuous and batch processes.

However, certain safety problems are either particularly relevant to or of a specific nature in batch production. Mis-Identification of Chemicals is such a topic: whereas there is no doubt, that misidentification of chemicals has occurred in continuous processes and resulted in major losses, the nature of batch production, characterised inter alia by:

- The use of multi-purpose plants, with different chemicals used in different production campaigns
- The large variety of chemicals kept ready for use in a plant
- The use of containers (i.e. bags, pallets, FIBC, etc), as opposed to supply via fixed pipes
- The greater use of organisational versus technical safety measures

All of the above make batch production particularly vulnerable to such incidents. The human factor plays a crucial role in this area. Despite the sophisticated technical solutions to avoid misidentification of chemicals, it is in many cases the knowledge, reliability and self-responsibility of employees that forms the ultimate barrier against such incidents. On the other hand, human failure is the most frequent cause for incidents caused by mis-identification of chemicals.

Thus, procedures, organisational measures and checks that are in place to confirm the identity of chemicals should be reviewed to confirm whether they are "fit for human nature", e.g.:

- Ergonomically suitable
- Short and simple
- Not jeopardizing efficiency targets
- Not too repetitive; and this again is a rule that applies not only for batch production

Dr G Suter, Swiss Institute of Safety and Security
Chairman of Safety Issues in Batch Production Contact Group

3. Introduction

The aim of this report is to provide a summary of the information exchanged between EPSC members on their company's approach to avoiding the mis-identification of chemicals.

A member of the Contact Group whose company had recently had an incident where the incorrect chemical was added to a process initially raised the topic of the mis-identification of chemicals. The intention was to quickly canvass the Group members approach to avoiding mis-identification. The response was such that it was quickly agreed that the topic deserved further discussion. A dedicated meeting on the topic was held in March 2000 at which ten presentations were given by companies on their approaches to avoiding the problem and their experiences from incidents and the lessons to be learned. This report has been prepared so that the information exchanged at that meeting could be shared with the whole EPSC membership.

This report aims to give an overview of the procedures applied by member companies to avoid misidentification of chemicals. The appendices to this report are intended to give more detailed information, and examples, on the procedures employed by the companies that presented at the **Safety Issues in Batch Production** Contact Group meeting.

If you have any specific questions on any of the examples illustrated in this report please contact EPSC.

4. Cases histories:

4.1 Case study 1

4.1.1 The incident

Two operators were exposed to an emission of hydrogen sulphide gas released from the loading of an incorrect chemical into a reactor. This exposure occurred due to an error whereby one tonne of sodium hydrosulphide (NaHS) was supplied instead of one tonne of potassium hydroxide (potash) to be used in a neutralisation reaction using 2-methyl, 4-chloro-phenoxyacetic acid (MCPA) and potash. Despite a number of control “barriers” designed to ensure the correct chemical was used none proved to be fully effective.

4.1.1.1 The supplier’s

A truck driver was employed to take the potash from the supplier (Y) to the company’s site (Z). The storeman at the supplier’s gave the truck driver the delivery docket for company Z – to which the picking slip was attached. A second storeman on a forklift truck was pointed out and the truck driver was told to give the paperwork to that storeman, so that he would fetch the product for him. The driver gave the second storeman the paperwork and waited next to his vehicle for the storeman to return with the product. The storeman went to the location noted on the picking slip and selected a pallet of product from the stack.

4.1.1.2 The location

The product was located in the "bulk" storage area and could be accessed from both ends of the stack. This stack could take 40 pallets, and was normally reserved for caustic soda. As the volumes of caustic soda were low, potash was also placed in the row. Later, when four pallets of sodium hydrosulphide were received they were also placed in the row, as the storage racks usually used for small volume products were full. Whilst this was not a preferred process, and it has since been altered, it was reasonably common practice in these situations and all of the storemen were aware of the practice. Both products (potash and sodium hydrosulphide) were in 25 kg bags and piled forty bags to a pallet.

4.1.1.3 The collection

The storeman made a quick visual check of the product from his position sitting on the fork lift truck. Due to the bags being stacked unevenly he put the pallet on the floor, got off his fork lift and counted the bags to verify that there were 40 bags on the pallet. However, he failed to verify that the product was that ordered or that it did not correspond to the picking slip. The bags of sodium hydrosulphide were marked plainly on the top and bottom of the bags with the product name and other details — though they did not have any markings on the sidewalls. To check the product name it was necessary to look at the top layer of bags (approximately 1.4 m high), something that a person of normal height should have been able to do easily.

The storeman lifted the pallet onto the delivery vehicle, signed the delivery docket in the 'Assembled by' box and then asked a second storeman to 'check' the product. The second storeman asked for the product to be taken off the vehicle. He counted the product to check that there were forty bags on the pallet and as happened previously failed to verify the product. The second storeman ("checker") signed in the 'Checked by' box on the delivery docket and the product was placed on the vehicle. The truck driver secured the pallet on the vehicle and signed the delivery docket in the 'Carriers signature' area. However, he did not conduct his own check, as was required when transporting dangerous goods.

When the truck driver arrived at the plant of company Z, he drove to his usual unloading point, took off the gates on his vehicle and waited for a forklift driver to take the product off the vehicle.

The pallet was lifted from the vehicle and placed outside the main warehouse where an ID label was affixed. The ID label had been raised on the basis that the chemical was potash and not sodium hydrosulphide. A storeman signed accepting the goods. Normal procedure was for the on-site laboratory to be notified of new deliveries and a sample taken for analysis. Once analysed the chemical would have a "release" label affixed to the packaging indicating that the product could be used. However, a "release" label was not put on the pallet nor was the laboratory advised of its arrival in accordance with normal procedure.

Contrary to well-defined procedures the pallet was then taken to the formulating plant, and emptied into the vessel. Two operators who thought that the raw material was potassium hydroxide charged the vessel manually. The mixing vessel was then charged with water. The next ingredient, a bulkibag (FIBC) of MCPA, was positioned for emptying into the vessel. The neck of the bag was opened and some MCPA fell from the bag into the vessel. The flow stopped almost immediately as the MCPA formed into lumps and jammed the neck of the vessel. Seeing this happen the second operator joined the first on the loading gantry and together they set about poking the lumps clear of the neck and into the vessel.

A violent reaction then started in the mixing vessel. The operators stopped their actions and decided to leave the gantry. At this point, they had been mildly exposed to hydrogen sulphide liberated during the reaction. As they descended the ladder from the gantry they suffered moderate exposure to the gas that, as it is heavier than air, had flowed in cascade fashion over the top of the tank. One operator managed to get into semi-clear air outside the formulating unit but the other one fell to his knees inside the unit and suffered further exposure. The formulation plant was cordoned off and the vessel left to complete the unexpected reaction. The two operators were later released from hospital.

4.1.2 The cause(s)

Following an investigation it was found that:

- The warehouse location code system was defective in that it permitted the forklift driver to select from the wrong end of a pallet rack
- The forklift driver failed to observe/inspect the labelling on the bags as sodium hydrosulphide
- The truck driver failed to properly check a dangerous goods consignment loaded into his vehicle
- The warehouse checker failed to notice the error while the three of them examined the pallet for the second time
- The checking system had also failed on site
- The warehouse failed to follow company procedure and this led to the pallet not being checked by laboratory staff and thereby not receiving a “release label”. (Analysis would have shown the chemical to be incorrect and hence a “release” label would have been refused)
- Someone failed to observe that the pallet did not display the "release" label required by the system and delivered the pallet to the formulating plant
- The operator(s) failed to check the bags before decanting them into the mixing vessel. Given the number of bags involved this could be felt to be quite surprising

4.1.3 Flow process chart

Appendix A1 illustrates the incident through the use of a process flow chart detailing the procedures involved, the safeguards in place and the actions that led to the incident.

4.1.4 The lessons learned

From the investigation the following lessons were drawn:

- A product error may cause extremely serious accidents in terms of:
  - Safety of personnel
  - Environmental risks
  - The process
  - Quality of the product
  - Effects to the brand image

- A dysfunction may cross several control "barriers" devised on the basis of procedures. In this case the dysfunction crossed at least five barriers without being detected
- It is imperative that a product is identified in a clearly defined and pre-established manner before being used in a process

4.2 Case study 2

4.2.1 The incident

The company (A) located in the UK, had ordered a consignment of epichlorohydrin, a carcinogenic and flammable chemical, from a Supply Agent (B) in the Czech Republic. This supply agent had then contracted the carriage of the chemical across Europe to a Belgian tank container company (C). At the container company's premises in a Belgian harbour, the accompanying documentation was changed to one of the supply company's B delivery notes (a practice known as "neutral delivery"). In doing so the number of a different tank container, which by coincidence contained sodium chlorite also scheduled for delivery to the same site of company A was mistakenly entered. This transposition of tank number led to a tank containing sodium chlorite being sent to the site, with the accompanying documentation indicating that it was epichlorohydrin. Once the tank arrived at site the documentation was checked, the tanker cleared to enter the site and it began unloading. Shortly after the unloading began an external call was made to the company to alert them that the documents had been transposed and although attempts were made to stop the unloading a reaction had already begun between the sodium chlorite being unloaded and the epichlorohydrin in the storage tank.

Following the mixing of the two chemicals a violent reaction occurred which resulted in an explosion. An adjacent drum filling plant was destroyed along with pipework and fittings. There was missile damage on-and off-site and the shockwave broke windows and lifted the roof off the control room. Several people were injured in a nearby factory by the effects of the explosion, and others including members of the public were affected by the fumes. A motorway and river crossings were also closed temporarily. Contaminated water from the fire was contained in a rhyne and was later removed by road tankers, some 1250 m^3, for off-site treatment.

4.2.2 Cause(s)

Following the incident an investigation was conducted by the company. It found that:

- The tank containing epichlorohydrin had the following documentation:
    - Weighbridge note
    - Despatch note
    - Custom Clearance Document

- Transport Note
- Quality Certificate

- The tank containing sodium chlorite had the following documentation:
    - Advice note
    - Confirmatory copy of Quality Certificate

All parties involved in the incident were found to be certified to ISO 9000.

Following the incident the relevant Competent Authority began an investigation and later stated that there were two fundamental contributory causes to the accident:

- Firstly the practice known as “neutral delivery” was felt to be a contributory cause. Neutral delivery is when the documentation is altered to remove reference to the manufacturer and instead make all documentation under the name the chemical supplier. Though it should be noted that the company had not requested neutral delivery in this case, it introduced the errors that led to the wrong load being delivered to the site
- A second cause was the failure of work systems at the company’s premises to detect the errors made earlier, so that they could be sure they were getting the chemical they were expecting

4.2.3 Flow process chart

Appendix A2 illustrates the incident through the use of a process flow chart detailing the procedures involved, the safeguards in place and the actions that led to the incident.

4.2.4 Lessons learned / Recommendations

The Competent Authority that investigated the incident advocated a positive identification procedure based on four elements:

- Sampling of vehicle contents, where appropriate
- Identification / tagging of tank outlet valves
- Supply of a fax by the product consignor to the receiver confirming delivery
- Verification of original documentation

4.3 Case study 3

4.3.1. The incident

The incident took place at a railcar loading/unloading facility. Two substances were delivered in different railcars with different specifications. These being:

- **Substance A**: was supplied in a double axle, non-insulated rail tank car with standpipe
- **Substance B**: was supplied in a four axle, insulated rail tank car with a bottom drain

On this occasion substance A was transported to the facility in a railcar equipped with an additional bottom drain. Unloading began and when substance A had been emptied following the correct procedure, the railcar contained a remaining 20 kg of substance A. It remained at the transfer facility.

During the following night shift, two employees were told to empty a rail tank car containing substance B. They connected the emptied, double axle, non-insulated rail tank car still containing about 20 kg of substance A to the substance B transfer pipe via the bottom drain by mistake. This resulted in an exothermic reaction between substance A and B in the transfer line. Vapours escaped via the venting pipe of the rail tank car. Fortunately no personal injury, material or environmental damage occurred.

4.3.2 The cause(s)

The initial cause of the incident was the second shift mistaking the tanker to contain substance B because it had a bottom drain. However, other contributory factors included:

- That the shifts did not communicate what had been in the railcar; and
- There had been a failure by the second shift to correctly identify the railcar using documentation, as opposed to railcar design

4.3.3 The lessons learned

Following the incident a number of recommendations were made. These included:

- Ensuring that checks are made to identify the substance by comparing the number of the rail tank car, labels, plates and name of the substance
- To ensure correct identification the substances could be identified through sampling and analysis
- Ensuring that the name of the substance in the railcar is checked and compared with the transfer pipe prior to connecting the pipe and beginning unloading
- The shift supervisor should check and authorise the filling procedure on site
- Investigation should be made into the feasibility of providing technical measures (e.g. measuring Infra-Red, pH, conductivity or some other parameters and interlocking with the discharge arrangements
- Ensure that the available checklists are followed as part of the operational procedures when filling, or emptying the tanks

4.4 Case study 4

4.4.1 The incident

An explosion and fire occurred at a chemical plant producing silicone coatings. The blast occurred when some polymethyl hydrogen siloxane was accidentally fed into a reactor, together with the correct feedstock, allyl glycidyl ether. The two epoxides reacted, overheated and hydrogen burst out of a ruptured pipe into the building whereupon it mixed with air and exploded. Five workers were caught in the resulting fire, resulting in one fatality and four injuries. Damage to the plant was estimated at $6.7M (value in 1995).

4.4.2 The Cause(s)

Although both chemicals were labelled, they were stored in drums of the same colour and the cause was believed to have been due to human error.

4.4.3 Lessons Learned

Although the employees made an error in adding the wrong chemical, the underlying causes should be studied carefully. The routine of operation may have changed the habit of identification from reading the label/documentation to recognising a certain kind/type/colour of container. Where similar containers with different chemicals are in the same area the risk of mis-identification is increased. Procedures should be developed which will (i) where possible avoid similarities in containers and (ii) ensure that suitable methods are in place to verify that the chemicals are correct.

5. Risk Analysis

Risk Analysis with a special focus on mis-identification of chemicals and hazardous interactions is a prerequisite for safe material flow through any process and the effective use of any additional measures.

5.1.1 Hazard Identification

A procedure for Hazard Identification is a vital for safe operation. Hazard Identification can be used to highlight possible hazards and then enable the company to target resources, procedures, measures etc at the most significant hazards. There are many publications covering the topic of Hazard Identification including EPSC reports and books (see the section References and Sources of Information) and as such this report will not cover the topic.

Among the methods available both HAZOP and Task Analysis comprise systematic approaches to identifying the effects of using the wrong chemical(s) in any operation.

It was noted by the Contact Group that often Hazard Studies would “Start-at-the-gate” in so much that it was often assumed material entering the site was of the correct type and to specification. From experience, and the case studies presented in section 4 of this report, it is clear that this assumption is not valid. Hence care should be taken when selecting the boundaries for a hazard study and any assumption(s) made.

5.1.2 Interaction matrices

Interaction matrices represent in a concise manner the possible hazardous interactions between chemicals present in a given plant and between chemicals and construction materials. Appendix A3 contains an interaction matrix and illustrates one approach taken by a member company.

The large number of possible interactions in a multi-purpose plant may render a “one-by-one” consideration impractical if not impossible. Class formation (similar to that in "Bretherik’s") may be a good solution of this problem, classes being e.g. "strong acids", "peroxides", "amines" etc.

5.1.3 Risk Assessment

There are many forms of risk assessment that can be used to evaluate the risk of mis-identification of chemicals. The previous report produced by the Safety Issues in Batch Production Contact Group Safety management for process transfer of batch and semi-batch processes1 illustrates a number of risk profile methods used by companies for qualitative and quantitative approaches to risk assessment. One further example of risk assessment methodology used by a member company is given in Appendix A4 and A5.

6. Preventative and protective measures

A comprehensive and robust system of document verification is one essential element of a safe procedure for avoiding the possibility of mis-identification of chemicals. However, established procedures for handling documentation are not in themselves foolproof, and other methods of identification may be required. The Contact Group provided presentations on a number of other additional measures that various companies use and these are documented in this section.

6.1 Labelling

6.1.1 Description of measure

All packages should be clearly labelled to allow easy and positive identification of the contents. Essential features of such a labelling system are:

- Highly visible labelling
- Labelling on all packages of a delivery unit (e.g. a pallet)
- Robust labels (e.g. high adhesion, weather proof etc.)
- Material name written in large easily readable characters
- Avoiding the use of similar names, especially similar abbreviations

6.1.2 Cases were measure is applicable/suitable

Clear labelling is a must for any safe operation and is applicable to all situations.

6.1.3 Limitations/problems

The number of labels per package is necessarily limited by space, and as a result it is sometimes unavoidable that labels are "hidden" on the rear side or on the top of a package, where access may require a special effort.

Re-labelling is sometimes required in the logistic chain, resulting in a compromise being required between reliable adhesion and easy the replacement of the label.

The similarity of chemical names can be a significant problem when trying to avoid the mis-identification of chemicals. Shortened names or abbreviations have been introduced to allow easier communication and better distinction between chemicals with similar scientific names. But with increase in the number of these abbreviations, more of them will enviably become similar to each other. Moreover, cases have been reported where the abbreviation has inadvertently been identical to a molecular formula of a completely different chemical. In addition, the dynamic changes within the process industries, such as the increasing number of company mergers, has had the effect of merging different systems of abbreviations, a significant risk, if not carefully controlled.

6.2 Sampling and analysis

6.2.1 Description of measure

Sampling and analysis can often be the only truly comprehensive and definitive method of identifying a material. Many ways of sampling exist and are conducted by companies at various steps in the process. It would not be possible to comprehensively cover all methods of sampling and analysis in this report and as such these methods will not be covered.

6.2.2 Cases were measure is applicable/suitable

Analysis can provide the definitive identification of chemicals and as such sampling and then analysis can be suitable for almost all situations. On-line sampling systems are becoming more readily available through the development of miniaturised electronic systems. Specific physical/chemical parameters may be identified to ensure that the correct chemical is used. One member reported on the use of on-line infra-red analysis which may be used for both liquids and powders.

6.2.3 Limitations/problems

Although analysis can identify the chemical present there are some situations when analysis is not suitable or feasible. The first is when the product is hazardous to the extent that the exercise of sampling the product for further analysis can introduce a significant risk to the individual(s) involved. In these cases the risks associated with sampling need to be weighed against those of mis-identification.

Another limitation is when it becomes unworkable to sample every container of product (i.e. a pallet containing forty, 25 kg bags). In such cases it would be difficult to ensure consistent checking of all bags even if sufficient resources were available to sample all containers and conduct the necessary analysis. A system of sampling should then be employed which can provide the greatest level of accuracy for the given sampling rate.

Some companies utilise a “just-in-time” system of delivery for materials to site. This has the inherent safety improvement of reducing inventory, but can lead to pressures to allow material through from delivery to the production unit as quickly as possible. The procedures in place to analyse the chemicals should be suitable for both the hazard of the chemical, its possible incompatibility with other chemicals on site, the quantity and number of containers and the speed by which the product will be required for use.

For all of the situations mentioned above Hazard Identification and Risk Assessment must be conducted to ensure that safe operation is maintained and the most effective procedures are utilised.

6.3 Bar-codes

6.3.1 Description of measure

Bar-codes are an additional measure that can be used in the supply chain to avoid the mis-identification of chemicals. In addition to their use in the supply chain one member company has used a system of bar-coding for nearly two years at an individual plant.

On the company's site each vessel charge point and all transfer booths were equipped with bar-code readers. Operators, supervisors and managers were all provided with bar-coded name badges so they could be identified. This allowed for each charge to be coded/linked to a specific operator and where supervisory checks were required these could be programmed in. The computer control system verifies that the materials are correct and also automatically time stamps each input/charge/action.

Where practical the bar-code read charges were combined with load cell measurements to ensure exact charges. The system was felt to provide excellent document control necessary to meet he exacting quality control requirements of the US Federal Drug Administration (FDA) and the Medicines Act. It also allowed bar-coded batch labels to be printed that could further improve the accuracy and efficiency of the process.

6.3.2 Cases were measure is applicable/suitable

The system operated by the company was capable of further improving security/accuracy by issuing individual PIN numbers to operators etc. in addition to their name badges/bar codes, though in this case this was not thought to be necessary. Bar coding of sample bottles for analysis was being considered by the company to further reduce the risk of mis-identification. The system could also easily be adapted to provide worker-tracking facilities to monitor occupational exposure to chemicals etc.

It was considered that an industry wide standard on bar-coding would further increase the effectiveness of the system.

The company had found that the hardware (intrinsically safe) requirement for a medium sized system was approximately £15,000, while software costs would depend on possible integration with existing computer control systems but would typically be around £10,000.

The system provided excellent automated checks of all manual charging operations on both material type and quantity (either by number of bags etc. or via comparison with load cell results). Although not infallible it would clearly reduce the potential for "operator error" to very low levels. This was true if the current system used for manual charging operations and manual controls (bag counting etc.) were maintained.

6.3.3 Limitations/problems

Bar-code readers used on the site were of the "pen" and "gun" type. The gun type was found to be better for curved surfaces (drums etc.) and the "pen" type proved to be slightly less robust in use.

If bar-codes are to be used for safety reasons, rather than quality assurance, there would be a requirement for a management of change procedure whenever there was a change to the bar code. The Contact Group members felt there could be a benefit in a universal system of bar coding if such bar-code systems were implemented at more sites. However, ultimately, it was felt that bar coding was an aid to chemical identification and not a replacement for current procedures.

6.4 Key-locks

6.4.1 Description of measure

Key lock systems take many forms, the following system is used by one member company and was presented at the meeting. The system involves the use of locks and keys to stop any unauthorised use of materials from rail/road tanks entering the site. On arrival at the site all containers go through site security. Information on the tank contents is transferred and the analytical department notified. A sample is taken and analysed and a universal lock fitted by the analytical department that prohibits any unauthorised removal of the chemical. Once the tanker is analysed the universal lock is removed and a substance specific lock attached to the tank. The plant/unit requiring the substance is then informed and the tank moved to storage ready for use. When required the plant/unit is able to open the substance specific lock and unload the container. Once the chemical has been used the plant places an order with the purchasing department and the specification is sent to both the purchasing department and analytical department. The chemical is then reordered, the site security notified of its arrival and the process begins again. Appendix A6 illustrates the procedure detailed above.

6.4.2 Cases were measure is applicable/suitable

The system is applicable when there are regular consignments of chemicals in bulk quantity. It is particularly useful when deliveries of chemicals are scheduled on a “just-in-time” basis. The technique is suitable for any bulk quantity where there is only one “unique” method of removing the material from the transport container i.e. valve, coupling etc.

6.4.3 Limitations/problems

The technique is not suitable for use with chemicals supplied in FIBC’s, bags, on pallets etc. where there is no simple way of securing the load and preventing unauthorised access to the material. The technique also requires the use of analytical testing before the removal of the universal lock and the fitting of a chemical specific lock. Hence the site would require an onsite laboratory or there would be a delay in transferring samples from one site to another. This transportation of samples would require robust documentation and procedures to ensure the samples themselves were not mis-identified.

6.5 Second signatory or “4-eyes”

6.5.1 Description of measure

The second signatory or “4-eyes” principle is the method by which operations are first conducted by one operator and signed signifying that the correct procedure, operation etc had been followed. Then a second operator countersigns the form signifying that the procedure has indeed been conducted correctly. An example of the type of form used can be seen in Appendix A7 (General case) & A8 (Chemical specific).

6.5.2 Cases were measure is applicable/suitable

This technique of double signatories or “4-eyes” is most applicable when the operations being undertaken have the potential for producing hazardous situations if the procedure is incorrectly followed or the wrong chemical(s) is added. The procedure is particularly useful when used in operations that require a high operator input, but in which it may be difficult to provide physical means of ensuring correct operation. For example these can include batch operations, particularly multi-batch operations were there is a heavy load on operators. The procedure is also applicable for procedures that are only required intermittently (e.g. cleaning, maintenance, occasional batches etc.).

6.5.3 Limitations/problems

To work most effectively the “4-eyes” principle should be used sparingly and only when secondary checks are needed due to there being a significant hazard. If the method is used to frequently on low hazard situations there is the possibility that the method will be devalued and operators may begin to perform unauthorised tasks. When using “4-eyes” principles operators should be fully trained in the method and the reasons behind its use fully explained. The workload on any operator must be monitored with the requirement for any increase in workload fully explained to the operator, particularly when additional “4eyes” procedures are introduced.

Another possible limitation to the procedure is that the first operator can assume that the second operator will check the consignment, operation etc. and the second operator can assume the first has conducted the tests etc. This can lead to a situation where operations take place under the “safety” of double checks, but in effect these double checks mean that neither operator conducts the inspections, operations etc. This can be avoided through appropriate training and the explanation of the importance of the procedure, and again, only using the procedure when the hazard warrants it.

Case study 1 provides an example of where, for a variety of reasons, the secondary checks were not effective.

6.6 Segregated storage

6.6.1 Description of measure

A method that can be utilised both at the start of the supply chain, and at later stages, is that of segregated storage. Segregated storage can take many forms ranging from “soft” procedure based segregation to “hard” physical measures. Specific storage areas can be dedicated to specific products or barriers can be used to separate two or more incompatible materials. This can involve mechanical measures (e.g. walls, cages, separate buildings) or the use of a barrier of an “inert” chemical that does not have a hazardous reaction with either of the first two.

6.6.2 Cases were measure is applicable/suitable

A segregated storage approach is applicable to most facilities and is a significant first step in ensuring the correct delivery of chemicals. This approach must include a rigorous documentation procedure, be regularly audited and employees trained in its use and the reason for it.

6.6.3 Limitations/problems

Case study 1 shows a situation when a segregated storage system failed. It would appear that problems could arise when “temporary” storage is given to a product when other areas are full. This can lead to problems that are worse than when there is no segregation. Due to operators assuming the chemical is correct because of its location, rather than inspecting the chemical individually when no system is operated. Indeed as with the “4-eyes” principle a segregation system can lead to assumptions being made. For example, that the operator who placed the chemical in the location checked it was the correct chemical, hence the operator removing it may check the location and not the chemical. Again personnel must be well trained and understand the importance of the system and the necessary checks that go with it.

The physical properties of chemicals determine the type of container and packaging system used and the mitigation measures required if any spillage occurs. Problems may arise due to limited space at the warehousing/storage facility and it may be necessary to store incompatible materials together inone area if this area has the most effective mitigation systems (i.e. sprinklers, inerting etc).

Storage as with other areas of the supply chain poses problems to operators with respect to the similarity of chemical names, particularly when an operator may not have a chemistry background and slight changes in names may be overlooked or misunderstood.

6.7 Training

Training cannot be seen as an independent method of preventing the mis-identification of chemicals but as a requirement for the effective implementation of those measures that are in place. Training can cover formal "induction" training, refresher training and regular "group" discussions. In order to minimise the risk of misidentification it is important that training:

- Describes the measures that need to be followed for safe operation
- Emphasises the importance of the checks and cross-checks that are in place
- Provides the operators with an appreciation of the consequences that may arise if the systems fail. (A video produced following the incident described in Case study 1 provides and excellent example of support training material)

7. Bulk products

Bulk handling presents specific problems and provides certain benefits in the avoidance of misidentification. The use of bulk chemicals can make identification simpler as there will be less sampling and analysis required to establish the identity of the material. This is particularly true when compared to sampling methods required for pallets, bags, and FIBC's. Problems occur if there is a mis-identification, for whatever reason. Then the quantity involved are likely to be significantly greater (tonnes versus kilos) and hence the consequence of any incident will be greater. Therefore, bulk chemicals require similar techniques to those described earlier, but there will be variations in their application if the benefits of delivery in bulk are to be maximised while the associated hazards are minimised.

7.1 Supply chain problem

The supply chain is a vital component of any process and Case study 2 illustrates how problems with a supply chain can lead to the mis-identification of chemicals and ultimately an incident.

7.2 Additional prevention measures

The UK Chemical Industries Association (CIA) produced a guidance document2 in 1999 focused on offloading products into bulk storage. This guidance deliberately concentrated on the supplier and customer interaction with the bulk load. It advised the implementation of a system independent of the supply chain. This was seen as having the advantage that the supplier and/or customer can introduce systems that reduce the potential for product crossover and are independent of those parts of the supply chain over which they have little control.

7.2.1 Key elements of a positive identification procedure:

The guidance advised companies to consider the following methods for positively identifying the contents of a road tanker or tank container:

- Verification of original documentation
- Supply of a fax by the product consignor to the receiver's discharge point confirming the delivery
- The identification / tagging of tank outlet valves
- The sampling of the vehicle's contents

A robust system of document verification is one essential element of a safe procedure for the discharge of tankers and tank containers. However, established procedures for handling documentation are not in themselves foolproof. A risk assessment should always be carried out to determine the requirements for positive product identification. These elements need to be understood by all parties in the supply chain.

7.2.2 Responsibilities of other parties in the supply chain

The CIA guidance is primarily aimed at the supplier and customer interaction. However, any actions that can be carried out by other parties within the supply chain to lower the potential for crossovers are also important. The guidance suggests several actions that logistic service providers should ensure are carried out:

- **Container/tanker number**: whenever the container or tanker is moved into new "possession" within the supply chain, a check of the tanker or container number against the documentation should be made. Failure to carry out this check correctly is the most common reason for tanker crossovers in the supply chain
- **Warning placards**: before each step in the journey, the container/tanker placards should be checked to ensure they are correct for the product(s) being carried
- **Documentation transfers**: the correct documentation is transferred with the bulk load upon any change of "possession"
- **Supplier audits**: logistic service providers should audit their own processes and systems, to ensure that they are all operating correctly. Systems should encourage the reporting of any nonconformance, however minor it is. Adequate systems should also be in place to investigate and correct any problems

Though bulk handling creates many specific issues, there are many more that are similar, if not identical, to those described earlier in this report. These include:

- Hazard assessment of products: Sites should consider adopting a process of categorisation of products in terms of hazard and the possible effects if a product crossover or mis-identification occurs. This can be based on the information contained within the suppliers Material Safety Data Sheets. Measures adopted should be based on the potential for incidents if there is a crossover or mis-identification, and emergency plans prepared to deal with such and incident
- Risk assessment: A risk assessment should be conducted to decide whether sampling is required prior to offloading. Problems with access and exposure to the product may mitigate against sampling
- Selection of supplier: The selection of the supplier is an important step in the prevention of crossovers and mis-identification. Consideration should be made during the selection of suppliers that they are capable of meeting any requirements or procedures deemed necessary for the safe transfer of materials
- Offloading: A documented procedure should be in place prior to any delivery and the supplier should be aware of this. Some of the safeguards that can be used in bulk handling are similar to those mentioned earlier, and include:
    - A key/lock control system
    - The use of unique couplings; (though the use of unique couplings may hinder the offloading of a tanker's contents if an emergency occurs during transit)
    - The fitting of unique single-use seals, inscribed with the product name, which would have to be broken at offloading
    - A requirement for a plant operator to sign verification that it is safe for off-loading to proceed

8. Emergency planning

Should any measures in place to avoid mis-identification fail, for whatever reason, as they did in the case studies (see section 4) then an emergency plan and response must have been prepared, documented and implemented. This emergency plan will need to be explained to all personnel, who need to be trained and competent in both the plan as a whole and their specific roles. This report will not cover emergency plans as this was outside the remit of the investigation.

9. Findings

9.1 No unique solution to the problem

From the presentations made by members of the Safety Issues in Batch Production Contact Group, and from the ensuing discussion, it became clear that although there was agreement that the issue of misidentification was of importance to industry there was no single way of overcoming the problem.

Companies were found to be taking different approaches to the problem, ranging from purely procedural based methods through to physical measures. It was agreed that at present the issue presents a number of problems that cannot be easily or comprehensively overcome.

9.2 Most incidents caused by human error

From the incidents presented in this report, and from experience of the Contact Group members, it was felt that most of the incidents where chemicals have been mis-identified could be attributed, at least in some way, to human error. This may over simplify the cause as it can be argued that human error stems from procedural, training, and management system failures. Although it could be simple to say that to reduce the likelihood of mis-identification humans need to be taken out of the loop, in batch production (particularly multi-purpose) this is not feasible. All the case studies in section 4 can ultimately be attributed to a failure of the system of management.

9.3 The mis-identification of chemicals is a perpetual safety problem

The Contact Group felt that there was a perpetual safety problem in the mis-identification of chemicals within a supply chain. Within processes there are opportunities to use inherent safety principles to substitute or eliminate steps that have such hazards. However, short of producing all raw materials on each site there will always be the need for transportation of raw materials to a site, and the removal of product from a site. Thus, introducing the scope for mis-identification chemicals within the supply chain.

10. References and sources of information

10.1 General sources of information

AIChE – American Institute of Chemical Engineers
3 Park Avenue
New York
NY 10016-5991
Tel: +1-800-242-4363
http://www.aiche.org

CCPS – Center for Chemical Process Safety
3 Park Avenue
New York
NY 10016-5991
Tel: + 1 212 591-7319, Fax: +1 212 591-8895
Email: ccps@aiche.org or http://www.aiche.org/ccps

Chemical Industries Association
Kings Buildings
Smith Square
London
SW1P 3JJ
Tel: + 44 20 7834 3399, Fax: +44 20 7834
4469
Email: publications@cia.org.uk or http://www.cia.org.uk
Bulk storage - procedures for off loading products into bulk storage at plants and terminals, Chemical Industries Association, ISBN 1 85897 087 3, May 1999.

CHEMSAFE – a numerical database containing fire and explosion protection information and is produced by Dechema. (More information is available at (http://www.dechema.de/englisch/iud/pages/ch emsafe.html)

DECHEMA e.V.
Theodor-Heuss-Allee 25
D-60486 Frankfurt
Germany
Tel: +49 (0)69 75640, Fax: +49 (0) 697564201
http://www.dechema.de

DIERS – Design Institute for Emergency Relief Systems
http://www.aiche.org/diers

EC Joint Research Centre
http://www.jrc.org/jrc/index.asp

European Process Safety Centre
http://www.epsc.org
Safety Management for Process Transfer of Batch and Semi-Batch Processes, EPSC Report 17, 2000

IChemE – Institution of Chemical Engineers
165-189 Railway Terrace
Rugby
Warwickshire
CV21 3HQ
UK
Tel: +44 1788 578214, Fax: + 44 1788 560833
http://www.icheme.org

HARSNET – EU-funded thematic network aiming to produce technical guidance for SMEs.
http://harsnet.iqs.url.es

NAMUR – An international association of users of process control technology in the chemical, pharmaceutical and allied industries in the German speaking regions.
http://www.namur.de

Safety-net – EU-funded electronic network on industrial safety, fire and explosion protection. This network is operated principally through the World Wide Web using electronic newsletters, an on-line database containing summaries of research results and monthly electronic seminars. (More information is available at http://www.safetynet.de

SFK – Störfall-Kommission (Major Hazards Commission)
Gesellschaft für Anlagen-und Reaktorsicherheit (GRS) mbH
Geschäftsstelle
Störfall-Kommission und Technischer Ausschub für Anlagensicherheit
Schwertnergasse 1
50667 Köln
Tel: + 49 (0) 221 2068 715, Fax: + 49 (0) 221 2068 890

TAA – Technischer Ausschuss für Anlagensicherheit (Technical Committee for Plant Safety)
Gesellschaft für Anlagen-und Reaktorsicherheit (GRS) mbH
Geschäftsstelle
Störfall-Kommission und Technischer Ausschub für Anlagensicherheit
Schwertnergasse 1
50667 Köln
Tel: + 49 (0) 221 2068 244, Fax: + 49 (0) 221 2068 309

UIC – Union des Industries Chimiques
http://www.uic.fr

Zurich Hazard Analysis
Zurich Insurance Company
Risk Engineering
Mythenquai 10
8002 Zurich
Switzerland
Tel: +41 (0)1 205 3951, Fax: +41 (0)1 205 2600
http://www.zurich.com/Sites/CHK/Zfsfs.nsf/htmlmedia/re - main.html

10.2 Sources of information

10.2.1 Referring to storage of materials

- Guidelines for safe storage and handling of reactive materials, CCPS, ISBN 0-8169-0629-7, 1995
- Guidelines for safe warehousing of chemicals, CCPS, ISBN 0-8169-0659-9, 1998
- Bulk storage -procedures for off loading products into bulk storage at plants and terminals, Chemical Industries Association, ISBN 1 85897 087 3, May 1999

10.2.2 Referring to transportation of materials

- Guidelines for chemical transportation risk analysis, CCPS, ISBN 0-8169-0626-2, 1995.
- Bulk storage -procedures for off loading products into bulk storage at plants and terminals, Chemical Industries Association, ISBN 1 85897 087 3, May 1999

10.2.3 Referring to process safety documentation

- Guidelines for process safety documentation, CCPS, ISBN 0-8169-0625-4, 1995

10.2.4 Referring to batch processing in general

- Guidelines for process safety in batch operations, September 1999, CCPS, ISBN 0-8169-0780-3
- Guidelines for chemical reactivity evaluation and application to process design, CCPS, ISBN 08169-0479-0, 1995

10.2.5 Referring to process hazard identification and risk analysis in general:

- HAZOP: Guide to Best Practice, EPSC, CIA & IChemE, 2000
- Clariant: Leitfaden Gefahrenanalyse, 1999, (German)
- ESCIS: Einführung in die Risikoanalyse, ESCIS No. 4, 1996, (German)
- ESCIS: Thermal Process Safety; ESCIS No. 8, 1989, (English)
- Grewer, Th., Thermal hazards of chemical reactions, Elsevier, 1994. Pitblado, R. and Turney R., Risk Analysis in the Process Industries, IChemE, 1996

11. Appendices

11.1 Appendix A1: Process flow chart: Case study 1

No	ACTION	Personnel	Activity	Procedure	Safeguard	Failure Mode
1	Pallet of chemical awaits collection		Storage	Warehouse location system	Label on bags (top and bottom of bags)	Segregation of chemicals. Location system
2	Docket/ Pick up slip for chemical		Communication	-	-	-
3	Chemical selected by forklift driver	A	Selection / Inspection	Correlation of docket with chemical selected	Label on bags (top & bottom of bags). Location system Visual inspection	Segregation of chemicals. Location system. Failure to inspect name on bags against docket
4	Visual Check / Counted bags		Inspection	Correlation of docket with chemical selected	Label on bags (top & bottom of bags)	Failure to inspect name on bags against docket
5	Loaded onto vehicle		Transport	-	-	-
6	Second storeman checks and signs	B	Secondary Inspection	Second visual inspection and correlation of chemical with docket.	Label on bags (top & bottom of bags). “4-eyes” principle.	Checked number of bags, but not chemical name
7	Driver acceptance / signature	C	Tertiary inspection	Driver inspection and acceptance of materials to be carried	Label on bags (top & bottom of bags)	Failure to inspect bags
8	Driven to second site / gates removed		Transport	-	-	-
9	Pallet offloaded to outside warehouse by forklift driver	D	Transport	-	-	-
10	ID label affixed	E?	Inspection / Identification	Cross checking of chemical with docket	Label on bags (top & bottom of bags)	Failure to inspect bags/pallet

11	Storeman accepts chemical	E? or F	Inspection / storage	Check for correlation of chemical with docket and label	Label on bags (top & bottom of bags)	Failure to inspect bags/pallet
12	Release label and Lab examination		Analysis	Chemical analysis to confirm correct material	Release label not affixed until analysis completed	No failure as release label was not affixed
13	Pallet removed to formulating plant by forklift truck driver	G	Transport	Removal of pallet ONLY once release label affixed	Release label, confirming correct material	Removed without release label.
14	Chemical charged (40 bags) by operators	H & I	Charging	Manual loading of 40, 25kg bags	Label on bags (top & bottom of bags). Release label.	Failure to notice name on bags or no release label.
15	Second ingredient charged		Charging	-	-	-
16	Evolution of hydrogen sulphide gas		Incident	-	-	-

11.1.1 Safeguards in operation

Below is a list of the safeguards in operation and the respective activity(s) on which they were used:

- Procedures — 1/3/4/6/7/10/11/12/13/14
- Location systems — 1/3
- Visual inspections — 1/3/4/6/7/10/11/12/13/14
- Secondary inspections (Signatures) — 6/11? /12
- Chemical Analysis — 12

11.1.2 Failure modes

Below is a list of failure modes and the respective activity(s) on which they failed:

- Failure of segregation of chemicals in warehouse — 1
- Failure of location system in warehouse — 1/3

- Failure of visual inspections — 3/4/6/7/10/11/13/14 — Stages = 8, Individuals = (A, B, C, D, E? F, G, H, I) = 8 or 9
- Failure to follow procedure — 1/3/6/7/10/11/13

11.1.3 Possible underlying causes:

- Overload of paperwork
- Overload of staff
- Expectation that some else will/has checked chemicals
- Failure of personnel questioning labels

11.2 Appendix A2: Process flow chart: Case study 2

No	ACTION	Personnel	Activity	Procedure	Safeguard	Failure Mode
1	Sodium Chlorite (X) ordered from Italy		Procurement	-	Advice Note; Quality Certificate; ISO 9000.	-
2	Epichlorhydrin (Y) ordered from Czech Republic		Procurement	-	Weighbridge Note; Despatch Note; Custom Clearance Document; Transport Note; Quality Certificate; ISO 9000.	-
3	The container company used to transport both X & Y		Transport	-	Documentation	-
4	X & Y came through Belgian port		Transport	-	Documentation	-
5	Documents transposed "Neutral Delivery"	Container company personnel Driver	-	-	Documentation; Tanker numbers; Tanker drivers.	Failure in documentation. Failure of drivers to notice change?
6	Tanker arrived at site		Transport	-	-	-
7	Certificate of analysis checked against paperwork	Guard	Inspection	Correlation between paperwork and expected delivery. Correlation between paperwork	Documentation	Failure to correlate documentation with tanker no, and/or driver.

				and tanker no? Correlation between paperwork and tanker driver?		
8	Paper work cleared	Guard	-	-	-	-
9	Driver instructed to proceed		-	-	-	-
10	Offloading begins		Unloading	-	-	-
11	Notification of incorrect chemical		Communication	-	-	-
12	Explosion		Incident	-	-	-

11.2.1 Safeguards in operation

Below is a list of the safeguards in operation and the respective activity(s) on which they were used:

- Procedures — 5/7
- Documentation — 1/2/3/4/5/7
- Visual inspections — 5/7
- Secondary inspections (Signatures) —
- Chemical Analysis —

11.2.2 Failure modes

Below is a list of failure modes and the respective activity(s) on which they failed:

- Documentation failure — 5/7
- Failure of visual inspections — 5/7 Stages = 2, Individuals = 2/3 (Container company personnel/Guard/Driver)
- Failure to follow procedure — 5 (Question: what was procedure?)

11.2.3 Possible underlying causes:

- Overload of paperwork
- Overload of staff
- Expectation that some else will/has checked chemicals
- Failure of questioning labels/tanker numbers/chemical name
- Should the drivers have known what they were carrying?
- Should a second set of paperwork have been carried that stayed with the cab until destination? (Further paper overload?)

11.3 Appendix A3: Chemical interaction proforma

The purpose of the proforma is to identify any combinations of materials used in, or near, the process that are incompatible or have a significant hazard potential. For new projects, the compiled information is used by the design team in developing the design. For existing processes, the complied information can be used to ensure that hazards (both known and possibly unknown [new] – due to changes in process chemistry, operating conditions, materials, equipment or operating procedures) are reviewed. The adequacy of the existing process operating-, control-, protective- or emergency- systems and procedures can then be checked.

The proforma is usually used before the concept stage meeting and reviewed at the meeting.

Procedure

1. List all the materials on the proforma under "Chemical or Group of Chemicals". Be as descriptive as possible, i.e. use the recognised chemical name or names and include any trade names and abbreviations or product code name/numbers. Materials of construction should be listed in the lower section of the proforma: these include materials in direct contact with process fluids butconsideration should also be given to other tools and equipment or building/construction materials which may come into contact with the process material.
2. Use the matrix to consider possible hazardous interactions of each material with each of the other materials in the top section of the proforma and with materials of construction in the lower section.
3. The matrix should stimulate creative thinking and questions, and will probably involve obtaining data from experts in fire/explosion-, health- and environmental-hazards. Based on the information, the proforma should be completed with one of the 3 responses:

   "-" The material has no significant hazard in this aspect.
   "K" The hazards are known and well understood and available to the concept study and design teams and the process management.
   "#" See numbered notes attached. (These notes would be for use within the company and are note reproduced here.)

Key		
	"-"	Empty box indicates insignificant hazard
	"k"	Hazards known and understood
	"#"	See numbered notes

	Chemicals or Group of Chemicals		B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
A		A																				
B			B																			
C				C																		
D					D																	
E						E																
F							F															
G								G														
H									H													
I										I												
J											J											
K												K										
L													L									
M														M								
N															N							
O																O						
P																	P					
Q																		Q				
R																			R			
S																				S		
T																					T	
U																						U

Chemicals or Group of Chemicals	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
Materials of Construction																					

Figure A3: Chemical Interaction Proforma

11.4 Appendix A4: Degree of protection index (DPI)

One member company of the Safety Issues in Batch Production Contact Group uses the Degree of Protection Index (DPI) technique and the following paragraphs briefly explain the aims of the Index and its procedure.

11.4.1 The Aim

The DPI technique is both a measure of the danger/hazard to the company's workers, its neighbours, the environment (soil, water, air) and nearby equipment and also a measure of the company's business interests (business interruption, sales and market losses).

The relationship between "hazard potential" and "business case" can be represented in a matrix form. The DPI technique can help the line managers responsible for a project/unit with their choice of applicable solutions in terms of what they need and not what is "nice to have".

11.4.2 Procedure

The production of a DPI for an installation, production or infrastructure/building, always begins with the definition of the worst-case scenario (WCS). The process risk analysis, the accompanying project risk assessment or the insurers inspection (EML — Estimated Maximum Loss, PML — Probable Maximum Loss) delivers this information. All possible but realistic damage consequences including any production interruption or business loss will be based upon these.

Once the WCS has been established the matrix (see below) can be used to establish the DPI and Appendix A5 illustrates the application of DPI to a tank farm.

IMPACT on: Business Life & health Environment Installations, Buildings	No Business Interruption	BI < 3 mts	BI > 3 mts Loss of sales	BI > 3 mts Loss of sales Loss of market share
No significant impact	1	1	2	3
Threat to L & H, and/or damage to installations / buildings	1	1	2	3
The above and/or nuisance to neighbourhood	2	2	2	3
Threat to neighbourhood (people, public installations) and/or severe pollution of ground, water, air. Potential for shutdown of operations by authorities.	3	3	3	3

11.5 Appendix A5: Example of application of DPI for a tank farm

DPI	Minimum Requirements	
1	Alarming: Cooling/Extinguishing: Intervention Brigade:	Alarm buttons (only if personnel present around the clock otherwise automated) Semi-stationary, Monitors 15-30 min. by external fire brigade
	Alarming: Cooling/Extinguishing: Intervention Brigade:	Automated Semi-stationary, Monitors <10 min. by site fire brigade* * If not possible an automated or manually activated deluge system is required
3	Alarming: Cooling/Extinguishing: Intervention Brigade:	Automated Automated activation of deluge system or insulation (according to internal guidance) <10 min by site fire brigade

11.6 Appendix A6: Key-lock System with chemical analysis

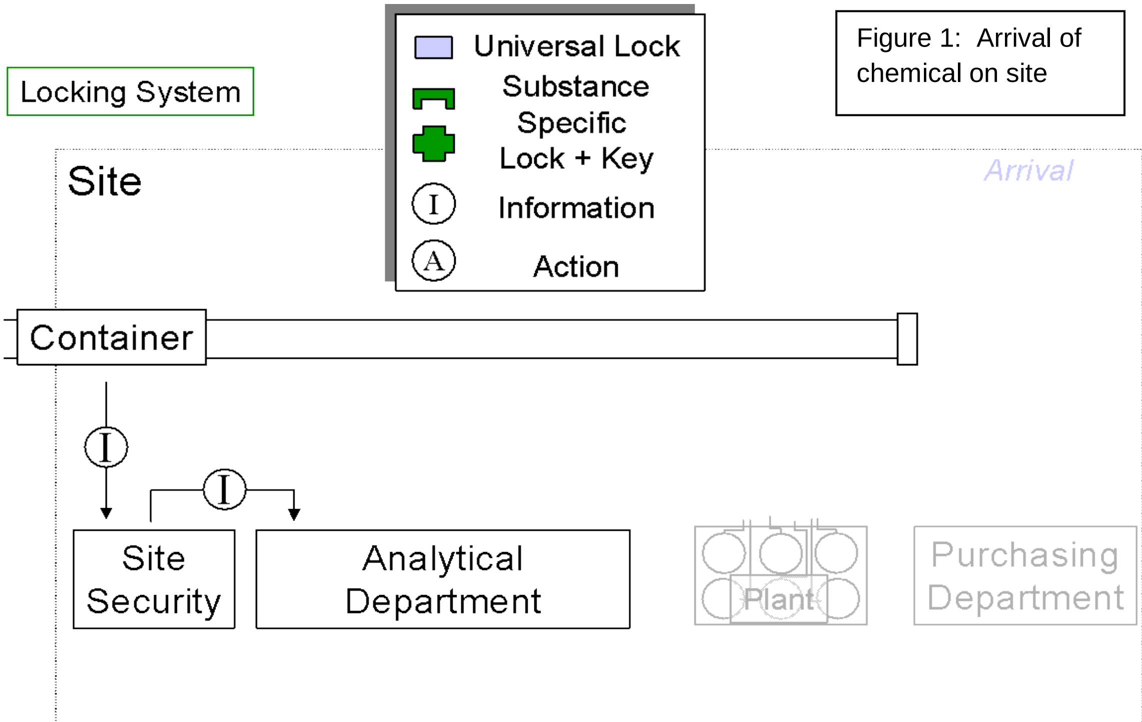


Figure 1: Arrival of chemical on site

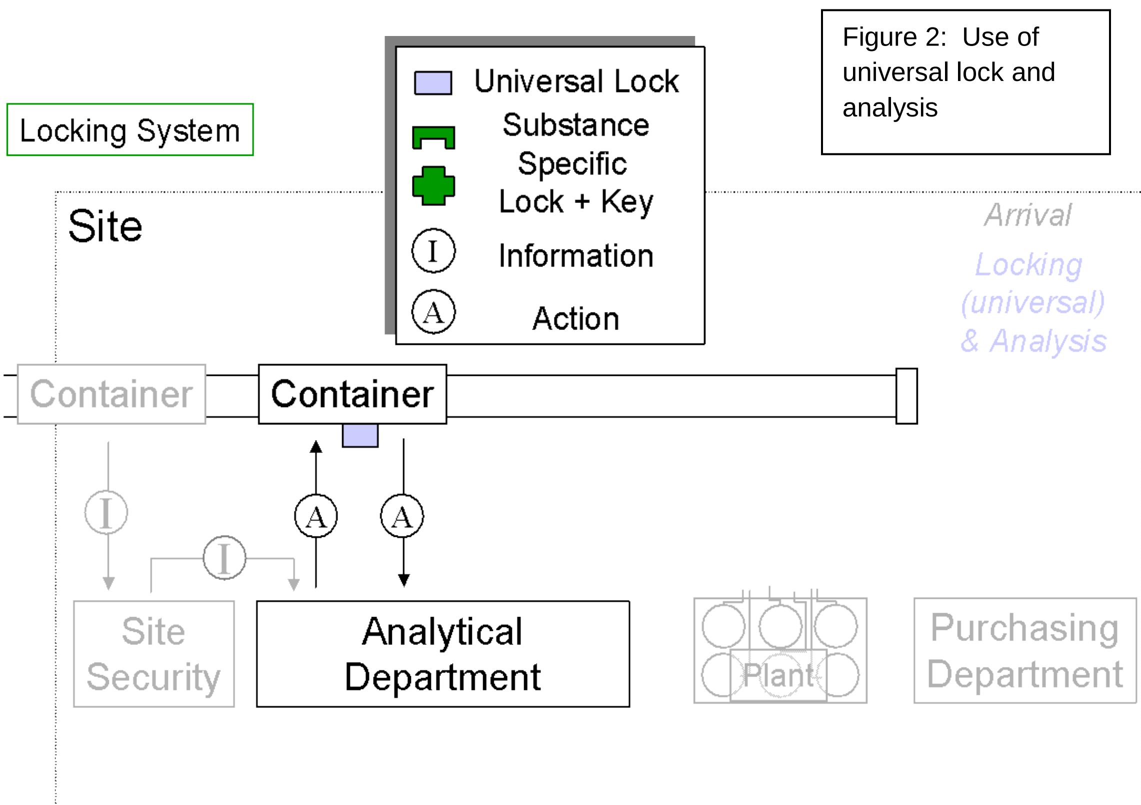


Figure 2: Use of universal lock and analysis

Figure 3: Use of substance specific lock

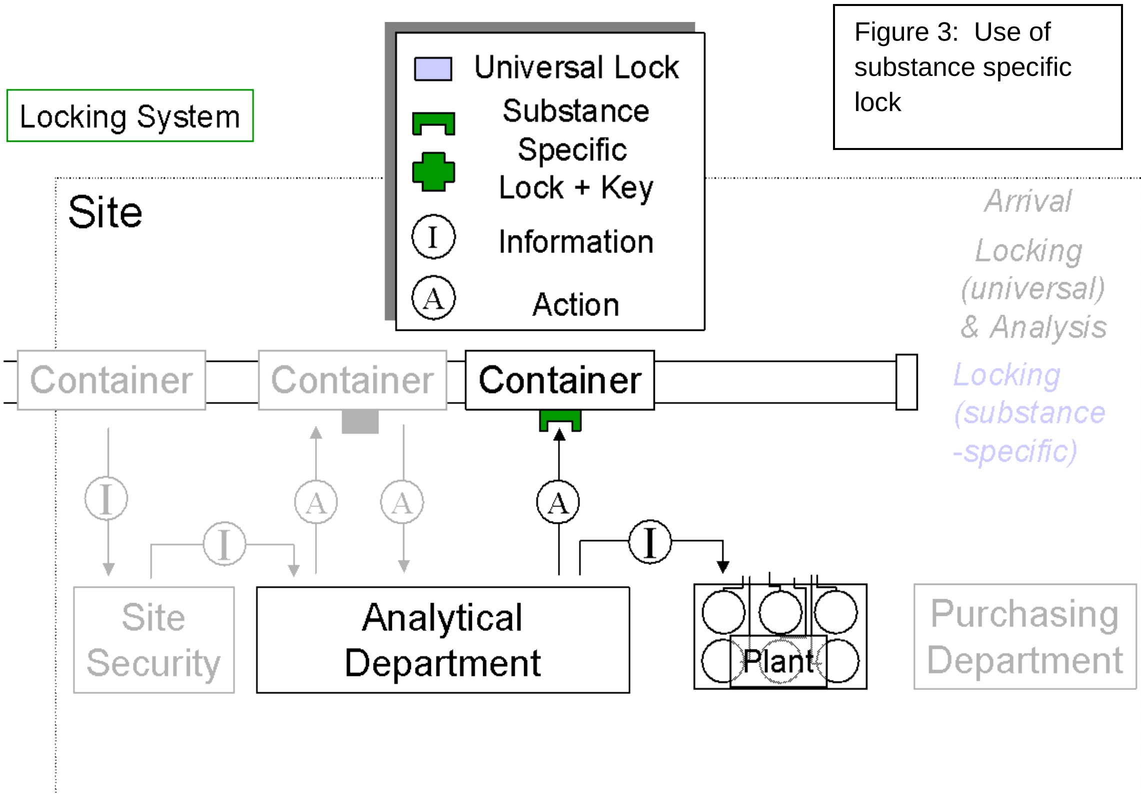


Figure 4: Unlock and unload

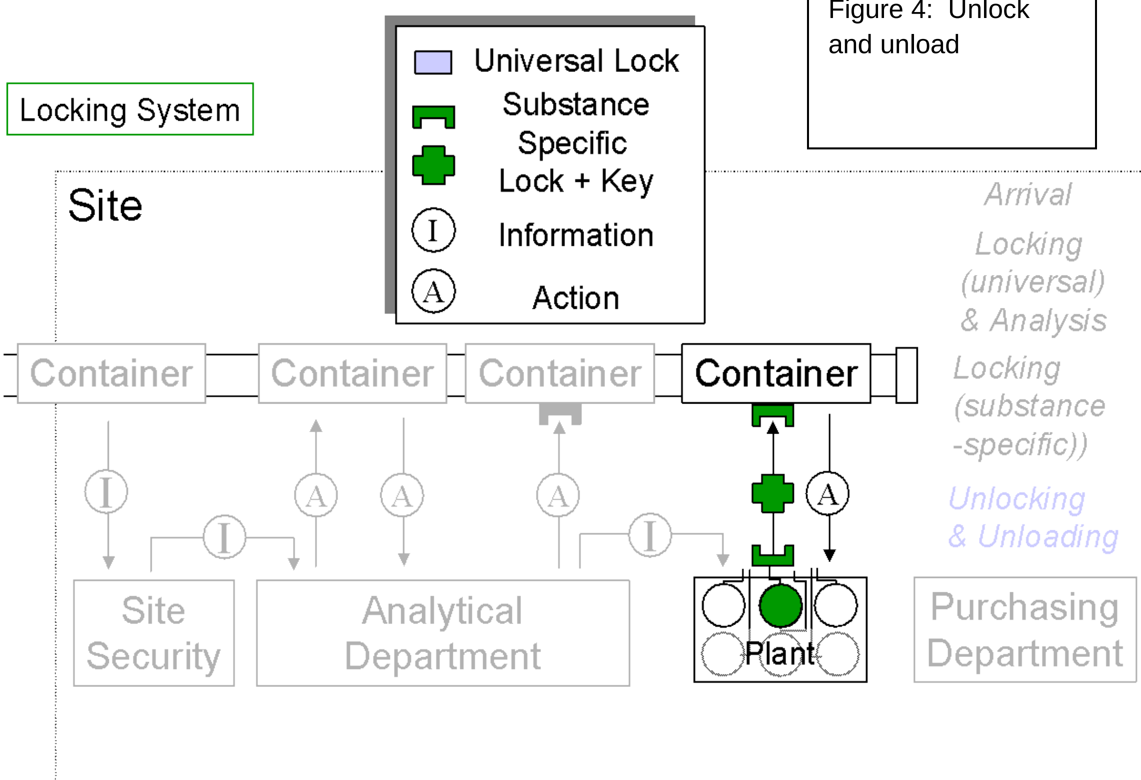
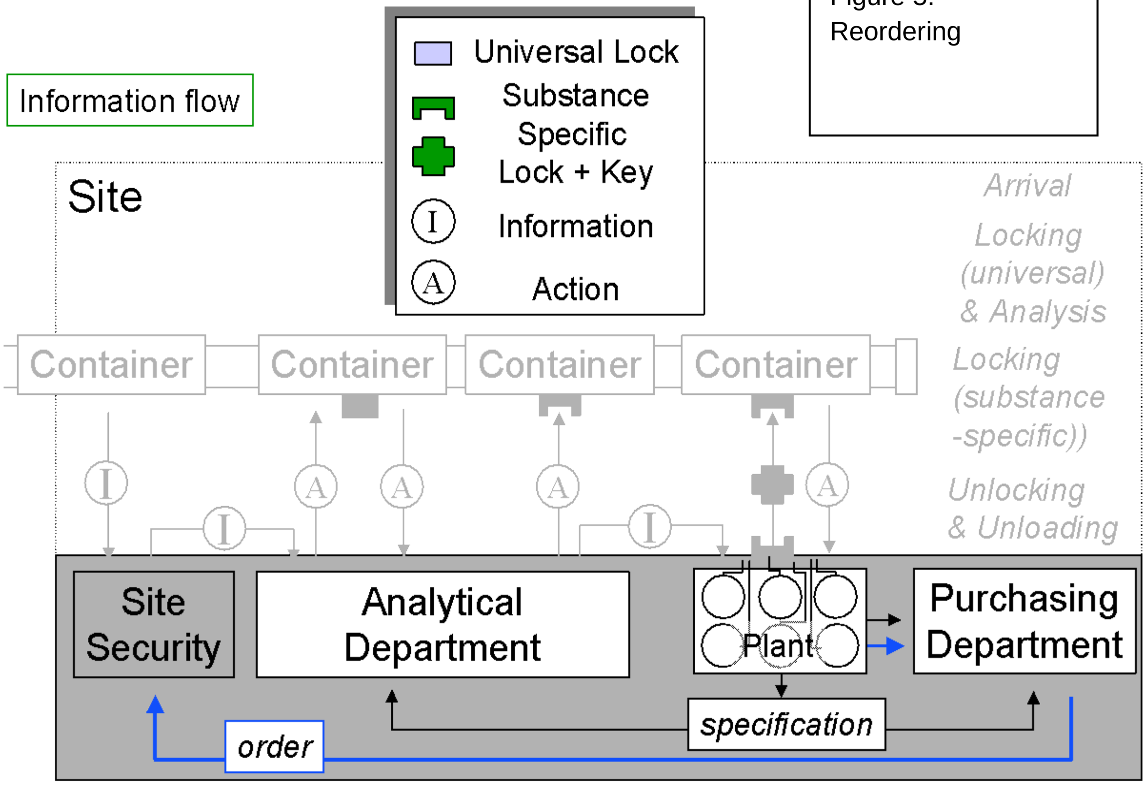


Figure 5:
Reordering



11.7 Appendix A7: Checklist Example from Ciba Specialty Chemicals (General)

Checklist for unloading rail and road tankers into storage tanks

Note: Only products which have been analysed or at least identified, may be transferred. For products which have only been identified (not analysed), the transfer orders must be initialled by the plant chemist or supervisor.

Checklist for unloading rail and road tankers via top of tank vehicle

Product Ident-no.:……………….. Transfer Order no.:……...

1. The foreman reads the level indicator of the receiving tank and checks whether sufficient tank volume is available. He hands over the transfer order, the checklist and the chemical instruction sheet to the operator who unloads the tank vehicle. ☐

2. The operator performs the following checks and tasks:

2.1 Tank car number on vehicle – no. -- return transfer order to raw materials office and transfer order identical?

Yes ☐

Ident-no., product-name, -- no. -- return transfer order to raw materials office tank no., correlate?

Yes ☐

2.2 Secure tank vehicle:
Vehicle at correct unloading point, drawbridge fits
Brakes applied
Wheel chocks
Roadblock
Danger panel ☐
Grounding

2.3 Manipulations on top of vehicle:
Switch aspiration system to correct position and open valve

Wear safety harness with chute brake
Lower drawbridge
Connect filling line, using aspiration system
Connect gas return line ☐
Inform foreman

3. The foreman verifies that all preparations have been carried out correctly. He opens the valve in the filling line and activates the key operated pump switch. He checks the manometer and the level indicator of the receiving tank. ☐

4. Supervision of the transfer operation:

4.1 The transfer operation must be controlled from time to time, but the operator can do some other work nearby

4.2 If the transfer operation or its observation is to be interrupted for any reason the pump must be switched off and the valve in the filling line must be closed

4.3 Any unusual occurrence during the transfer operation must be reported to the foreman immediately

5. When the transfer pump has been switched off, the tank vehicle is to be disconnected as follows:

5.1 - Wear safety harness with chute brake
- Close valve in filling line
- Disconnect gas return line
- Disconnect filling line, using aspiration system
- Take away aspiration hood, close aspiration line
- Remove drawbridge, ☐
- Disconnect grounding cable

5.2 Remove danger panel and roadblock

5.3 The operator marks each step on the checklist with to confirm the correct execution and hands the pump key and all papers back to the foremen

Date:…………..…   Signature of operator:……………………..

11.8 Appendix A8: Example from Ciba Specialty Chemicals: Checklist for the transfer of thionyl chloride from a rail tanker to the storage tank (Chemical Specific)

Consult chemical instruction sheet no. 69 for thionyl chloride

Mark each step on checklist ☐ when completed

1. Check whether product name (thionyl chloride, nr. 1944) and number of rail tanker displayed on the rail tanker and on the transport papers are identical. ☐

2. Take over rail tanker from rail service, move it to correct position, apply brakes and bring wheel chocks in position immediately ☐

3. Put up danger panel ☐

4. Read tank level indicator for tank 4203 on panel in ground floor of building 35 and weight gauge on 4th floor and check whether the contents of the rail tanker can be accommodated. (1000 kg = 610 1; 1000 1 = 1638 kg) ☐

5. Wear "acid suit", rubber gloves, and safety helmet with face shield for steps to and including step 11 as well as for steps 16 and 17. ☐

6. After completion of steps 1-4, connect rail tanker to the special dry transfer line marked 1944. ☐

7. Connect vent nozzle of rail tanker with dry metal hose to tank vent no. 1944 and open vent valve. ☐

8. With closed transfer valve, apply vacuum to surge vessel pos. 9234, to fill suction line and surge vessel. Close vacuum as soon as thionyl chloride is visible in the sight glass. ☐

9. If the material has not yet been analysed (note on transport papers: "not analysed"), take a sample in a labelled sample flask to the laboratory. Wait for the result. ☐

10. After approval of the sample by the laboratory, activate the level monitoring system at the transfer station. Thionyl chloride now flows from the rail tanker into the pump surge tank pos. 9234. Now check the entire systems visually for leaks. ☐

11. Move the switch on the thionyl chloride pump control panel in the staircase of bldg. 35 to "ON" position; the pump on the surge vessel 9234 is activated, thionyl chloride flows to tank 4203. Check pipeline for leaks. The flow is approximately 6000 kg/hr. The entire transfer operation must be supervised, the transfer line from the pump surge vessel to the storage tank must be observed for 30 minutes. In case of any unusual occurrence the operator must stop the transfer and call the supervisor. Warning: A rail tanker can contain up to 20 tons ($12m^3$) thionyl chloride. At the start of a transfer, the storage tank 4203 must not contain more than 3 tons. ☐

12. With the tank level indicator at 23000 kg, at most, the transfer should be terminated. Check on the sight glass of the transfer station that the flow has ceased. ☐

13. Switch the thionyl chloride pump on the control panel in the staircase of bldg. 35 to "REMOTE. This stops the pump. Allow 1 hour for the line to drain. ☐

14. Move the level control switch on the transfer station to "OUT"-position (valve in transfer line will close). ☐

15. Close the vent valve. ☐

16. Wear protective suit, disconnect transfer line and vent hose. Flush line and hose with water, vapours are sucked away via the large vent hose. ☐

17. Install blind flanges on the riser and on the vent nozzle of the rail tanker. ☐

18. Report rail tanker ready for moving. ☐

Date:……………. Completed by:…………………… (Operator)