Case Study Three

Israeli Case Study: Paz-Chem, June 1991

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Issue

A cloud of undefined chemical vapor escaped from a chemical plant located in the southern region of Israel, near the town of Ashkelon. During the following hours, people in nearby towns, and more distant locations (including Palestinians in the Gaza Strip) made complaints about a foul smell.

The chemical plant, Paz-Chem was producing a di-methoate based insecticide named rogor. The incident was a result of a run-away chemical reaction that occurred after the reactor was shut down. The result was that a PVC tube connected to the reactor broke down. The cloud that emerged from the plant did not contain active organophosphates, but instead decomposition compounds, which affected the people in close proximity to the plant.

Background

The incident was the first of its kind in the Paz-Chem plant. However people around the plant had previously complained of unpleasant smells being emitted from the plant.

On April 28, 1991, the local environmental authorities and the Ashkelon municipality had issued implementation instructions to the plant. These focused on the plant's

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commitment to the environment and the implementation of strategies to deal with the unpleasant smells being emitted with the production of rogor. The main demands were:

- The use of raw materials with a higher purity level (at least 98%).
- The implementation of a scrubber on the formulation reactor until June 1, 1991.
- The reduction of the amount of stored di-methoate in the plant to less than 10 metric tons.

The assumption was that the unpleasant smells were caused by impurities present in the low-industrial grade raw materials and could be prevented through the use of materials with a higher purity*.

Three months prior to the incident the plant initiated these changes in its production process of di-methoate. The changes included the planning and construction of a scrubber, which was added to the reactor exhaust vents, and the construction of a new production line, completed at the beginning of June, 1991.

Safety standards applicable to the incident:

- Chemical Industry Safety Standards for production of low toxicity chemicals (O.P. – insecticides).
- Additional environmental requirements, as requested by the Local Environmental and Municipal Authorities.

Safety and maintenance records:

The plant kept records of its production, and worked according to the Standard Operating Procedures (S.O.P.), however we do not have at hand these safety and maintenance records.

Prior to the production renewal of the new di-methoate facility on June 10, 1991 (a day before the incident), the company had applied for a formal production approval from the Local Environmental Authorities and had received it the same day.

Precautionary steps:

The new production process was first run at 25% of its planned capacity. Only the general safety data concerning industrial chemical hazards was available on the site.

Due to the change of raw materials the plant had to change its suppliers, from a producer in the Far East to a European producer.

Main actors responsible for emergency support:

The main actors responsible for maintaining, monitoring and providing emergency support were:

- *Internal actors:* These included the production manager and chemical engineering manager who were in charge of safety.

- *External actors:* These included the police, firefighting units, Local Environmental Authorities and the Ministry of Environment's mobile crews.
- Medical assistance was provided by local hospitals.

Incident Description

Events – Step by Step

10.6.1991, noon:

- Paz-Chem received a license enabling it to start the production of the renewed di-methoate formulation production line.
- Solvents + 25% of the formula's di-methoate were added to the reactor.
- Nothing unusual was detected at this stage.

11.6.1991, morning:

- The rest of the di-methoate was added to the reaction.
- Mixing and heating by steam was started.
- The total amount of the production batch of di-methoate contained 13,000L of di-methoate solution, composed of 5.2 metric tons of di-methoate in 3250L Xylene, and 3250 Hexanon. This was then heated to around 40-50^{o}c to dissolve the di-methoate in the solvents. Overheating to temperatures above 70^{o}c would have caused the destruction of the di-methoate.

11.6.1991, 13:00 p.m.:

- A sample of the solution was taken to the laboratory for evaluation.
- The lab test showed two unusual findings:
  - The temperature of the sample was 56^{o} (higher than normal).
  - The sample had a stronger color than usual.
- These unusual findings were reported to the production manager by the technician.
- The reactor temperature gauge had showed a normal reaction temperature of 40^{o}C.
- The unusual color finding was neglected due to previous experience of similar results, which were considered non-problematic for the process.
- Nevertheless, as a precautionary step, the steam valves to the reactor were shut off.

11.6.03,14:00 p.m.:

- After the laboratory findings the heating system had been turned off and the emulgator was added to the reactor as needed.
- There were no signs of any problems.

11.6.03, 15:30 p.m.:

- The reaction was stopped and the mixer was turned off.
- Most of the factory workers went home.
- The main steam valves were shut off.

11.6.03, 19:00 p.m.:

- The reaction solution began to leak from the reactor. Following strong smells, the production manager present immediately shut off all steam systems in the factory.
- The production manager dealt with the incident by shutting down all the steam systems, calling in the factory chemical engineer who was in charge of safety, and by pouring water around the installation. He did not contact the police or any other authorities.
- The police received calls from citizens complaining of strong smells in the area, which were causing sickness.
- A message was sent by the police to the fire brigade informing them of the incident.
- The event was then dealt with by the Ashkelon fire brigade, with professional assistance from the chemical engineer from the factory and a representative from the Local Environment Authority.
- During the event, the Ministry of Environment's mobile monitoring laboratory sampled the atmosphere. They did not manage to detect a specific component in the surrounding area due to a lack of information on potential hazardous compounds. As a result, no immediate estimates on the dangers caused by the hazard could be achieved. Consequently improvisation was used instead of professional reactions to deal with the incident, such as cooling the reactor down by pumping water through the heating system.

Results:

- Six people outside of the factory were affected by the discharge, reporting symptoms of general malaise, dizziness and nausea.
- Chemical analysis of the samples taken from the reactor after the event did not detect traces of di-methoate.
- The Ministry of Environment appointed an Inquiry Committee.

Main Findings of the Committee

- The steam valve of the reactor, which was shut off at 14:00 p.m., was probably the correct action.
- Shutting down the steam valves at 15:30 p.m. definitely stopped the flow of steam to the reactor.
- The overheating of the reactor caused the exhaust of noxious compounds to be emitted.
- Decomposition compounds at a temperature higher than 120°C were dispersed after a PVC tube that connected the reactor and the scrubber melted, disconnecting the system.
- The temperature gauge of the reactor was known to be out of action, but was overlooked.

Committee Conclusions

- The lack of documentation on each activity carried out during the process, made it impossible to deny the occurrence of human error regarding the quantities and materials that were added to the reactor.
- The production manager did not have any written guidelines explaining what to do when a fault in the process occurred. There were no written guidelines outlining the potential hazards of the production process, or guidelines on the action needed to be carried out in the case of an emergency.
- The only data available in the plant concerning potential hazards was information leaflets issued by the Center of Industrial Hazardous Materials of the Home Front Command.
- Due to lack of control over the heating stages of the reaction, due to the dysfunctional temperature gauge on the reactor, the temperature reached levels of more than 70°C in the primary stages of the process. At this temperature the dimethoate product was destroyed.
- The exothermic reaction occurred about 6 hours after the start of production and therefore indicates that an autocatalytic chain reaction occurred inside the reactor.
- The chemical analysis of the reactor's contents after the event showed the presence of destructive products.
- The melting of the PVC pipe indicated that high temperatures of 120-130°C were reached.
- The main cause of the incident was the uncontrolled heating of the reaction, caused by changes in the structure of the reactor and the addition of the scrubber. These parameters changed the characteristics of the heat transfer and consequently resulted in severe overheating.
- The structural changes in the reactor required a gradual approach to the renewal of the production process, using conservative scale pilot experiments, before starting full-scale production.
- The operation of the pilot with a functioning temperature gauge could have detected the overheating process and would have avoided the incident.

External Actors' Reactions

Regional Environmental Authority (R.E.A.)

The Regional Environmental Authority's responsibility during the event includes:

- A hazard assessment of risks to the population outside of the plant.
- Possession of data and knowledge of the possible hazards the plant could cause.
- Providing professional safety guidelines to those first at the incident, such as the police and firefighters.
- Cooperation with other professional actors, such as the M.O.E. Mobile Environmental Monitoring Units, factory safety and plant engineering personnel.

Actual response during the incident (as concluded by the inquiry committee):

- The R.E.A representative showed great personal devotion and active involvement in controlling the incident inside the plant.
- The R.E.A. representative did not have any data (plant safety files) or information on expected exhaust pollutants.
- Estimates on the time-scale of the hazard were not carried out during the incident.
- No orderly sequence of reports, or timings during the incident were distributed to the relevant actors in the district, or to the M.O.E.

M.O.E. Mobile Monitoring Units (M.M.U.)

The M.M.U.'s main tasks are:

- Detection and Identification (D&I) of noxious exhaust pollutants.
- Quantification of the pollutants present in the area.
- Hazard estimates.

Actual response (as concluded by the inquiry committee):

- The O.P. detector was out of action (indispensable monitoring tool).
- The M.M.U. crew was not familiar with the expected pollutants in cases of dimethoate formulation. Furthermore, this information was not available from the plant or the M.O.E. professionals.
- The mobile laboratory did not use its drager kits, despite their suitability, due to a lack of knowledge on the nature of the pollutant.
- As a result of the above, the M.M.U. did not perform its main task of environmental hazard estimation.

The police force

The main responsibilities of the police are:

- Area control, according to the specific incident. This includes the establishment of a forward command post near the site, closure of intersections, evacuation of population, etc.

Actual response as concluded by the inquiry committee:

- The police patrol teams had suitable standing orders regarding intersection closures to be activated in such an event.
- The police were the first to arrive at the site and called for the firefighting units.
- The police left the site before the end of the event, but kept radio communications on.
- They did not establish a forward command post at the site.
- The committee reported that all police actions were well coordinated with the relevant actors, and that radio contact was well used.

Fire brigade

Actual response as concluded by the inquiry committee:

- The firefighting units acted positively and in a way to be praised, despite the conditions that developed. The cooling of the reactor by first pouring water externally, and later pumping it through the reactors heating system was the correct way to neutralize the incident.
- There was good cooperation with all relevant actors.

Incident Consequences

Human consequences

- Foul odors were discharged from the factory, which affected people locally.
- Six people received medical assistance at the local hospital as a result of the incident.

Evaluation and Suggestions

Evaluation of pre-incident preventive measures

Preparedness of relevant external forces:

- **Firefighting units:** Were well prepared (equipment and doctrine)
- **Police units:** Were well prepared (standing orders, equipment and doctrine).
- **Regional Environmental Authorities:** Did not have pre-prepared data on issues concerning safety, and did not have an adequate routine or standing orders procedure for the event.
- **M.O.E - Mobile Monitoring Units (MMU):** Did not have relevant safety data at hand and were not in a state of operational readiness when the incident occurred. Important equipment was not in good working condition and they were not professional enough to deal with the task.

Preparedness of relevant internal forces:

- **Management:** Did not apply the basic rules of industrial safety and did not take responsibility for the incident.
- **Safety and Chemical Engineering:** No safety or hazard files were prepared or available at the plant. The Standard Operational Procedures were not applied for the initial running of the new production unit (Pilot).
- **Maintenance:** Did not keep the temperature gauge on the reactor in full working order.

Missed opportunities and social and political limitations

The laboratory findings with unusual results were reported to the production manager, who considered them insignificant and therefore did not stop production. However these results did not inform him of the faulty temperature gauge. Another factor that impeded the effective preventive measures from being carried out was the weak relationship between relevant managerial actors.

Suggestions for pre-incident preventive measures

In order to minimize the probability of future incidents, implementation of the following suggestions should be helpful:

Safety Standards:

There should be a Safety Approval Procedure (S.A.P.). This approval procedure should be carried out periodically, at least once a year and in the case of:

- A new or renewed production line.
- Changes in the production line and its systems (heating, controlling, mixing etc).
- New products or processes.
- Changes in, or the replacement of raw materials (including suppliers).
- Any other essential changes in a production procedure.

This S.A.P should verify the existence of all safety procedures regarding each product and each production line, and should take care to update them when necessary.

All production procedures should include an Operators Checklist (O.C.) prepared by the engineering unit. This should include:

- The provision that all controlling meters and gauges are in working order.
- The existence of an updated and valid S.A.P.
- All productions should also receive prior approval from the safety engineer, after verifying the O.C. results.
- This list must be updated as part of the S.A.P.

Each production line should have a "Fault Handling - Step by Step Guide." This must be prepared prior to the approval of each line, and in the case of multi purpose lines, as well as for each product.

Each product produced should have a "Hazard Assessment Statement" that will be known to each safety engineer in charge, the production manager on duty, the line operators, maintenance and, the local Environmental Authorities.

Policies:

As described above, both the S.A.P. and the O.C. are the basic issues that need to be implemented to ensure a "Good Manufacturing Policy."

Operations:

- Should prepare the Fault Handling Guide and the Hazard Assessment Statement before the first production, and update them periodically and when necessary.
- Should prepare a communications list for emergency cases, which should also be included in the Fault Handling Guide.

- Should establish a command chain, including external and internal forces, known and understood by all involved in the production facility.

Training:

- All safety measures should be known by each worker, and especially by all managers (engineers, production managers etc.). In order to achieve this, periodic training should be implemented.
- Periodic exercises, with and without the external forces, should be done. These will improve environmental community awareness.

Plant modification:
This should be required as a result of the Hazard Assessment Statement and the Good Manufacturing Policy and should be followed up by the local Environmental Authorities instructions.

Evaluation of the Post-Incident Response:

- All relevant actors were on the site. Communications between the actors were good, except for the internal production manager, who did not decide to call for external assistance when necessary. The external actors involved were called in by the police force, following neighbors' complaints. The external professional forces suffered from a lack of information, knowledge and skills, as well as a low level of readiness. On the other hand, the police and firefighters were ready, and carried out their jobs as expected.
- Although the "environment professional" units were not able to do their job as expected, the internal forces, with assistance of the M.O.E. representative, together with the firefighters, took the right steps to deal successfully with the incident. Therefore, there was no missed opportunity.
- There were no irrelevant factors that limited or impeded the response of the relevant actors during the incident.

Post-Incident Response, Issues and Conclusions:

The police and the firefighters responded exactly as expected. The M.O.E and the M.M.U. also responded on time, however technically they were unprepared and therefore unable to do their job efficiently.

- It was the people in charge internally, i.e. the production manager and the safety engineer who should have contacted the external forces, yet did not. Had the safety engineer been aware of the danger level outside of the plant, he could have warned the police force sooner.
- In order to make the response faster and more efficient, the internal forces in the plant must notify the police of any incident, even if they estimate that they can

deal with the incident alone. The police will then take command and coordinate the rest of the forces upon need. This will be done according to a contingency coordination plan, prepared beforehand.

- As long as there is sufficient information in the hands of the police officer controlling the incident, he can operate and direct each force as needed, and can disseminate information to the surrounding residents, media etc. Proper preparedness and information sharing with all actors including the industry, local authorities and regional external forces will in the long run benefit all involved.
- In addition, there should always be a post-incident report filed. This will ensure that lessons are extracted from the incident and not repeated again in the future. The report should be based on a standard scheme and include areas where action is needed for the future. The coordinator, i.e. the police officer in charge, should also be in charge of controlling those action items. In order to make this system work, the police should be able to legally charge anyone who dose not complete his action item.

Lessons Learned

Pre-incident preparedness and information sharing is essential. It includes:

- Assimilating suitable factory policy as described above and maintaining Good Manufacturing Policy, Safety Approval Procedure, Operator Checklist, Fault Handling Step-by-Step Guide and Hazard Assessment Statement.
- Understanding of control and coordination.
- Nominating a chief police officer to serve as a coordinator.
- Carrying out exercises on a regular basis as part of the safety training.
- Establishing an information center for hazardous materials.
- Implementing and verifying of “by the book” and “scale-up” procedures.