# Explosion during maintenance in a refinery

October 6, 2000

**Port of Antwerp**

**Belgium**

**Explosion**
**Fire**
**Refinery**
**Cracker**
**Propylene**
**Small branch connections**
**Static electricity**
**Maintenance**
**Equipment failure**

## THE INSTALLATIONS IN QUESTION

### The site:

The refinery is located in the Port of Antwerp. The accident involved an olefine production unit. The installation is governed by the directive Seveso II for the storage of toxic substances (23,200 t) and flammable gases (39,350 t).

The plant is highly integrated and consists of 5 units, a product storage area and a loading/unloading zone.

### The installation:

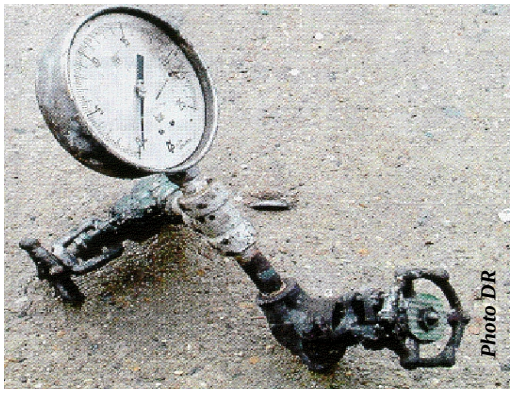
The installation involved in the accident was cracker 2 of the ethylene unit. In this unit, naphta, LPG and recycled thane are heated in 11 furnaces then converted into different products. After cooling, the cracked product is conveyed to the first tower where it undergoes an initial separation operation. The light gases rise to the tower head then are compressed and transferred to the various reactors and fractioning towers. The cracked product is recovered in the centre while in liquid phase. The heavy products remain at the base of the tower. Ethylene is the main product recovered in this unit. By-products include propylene, a mixture of the C4 fraction, petroleum and cracked heavy fuel.

The propylene leaves the site as a liquid via a pressurised pipeline (55 to 60 bar). It can also be transported via ship, train or truck.

## THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

### The accident:

At 00.27 am, a plant employee was attempting to replace a pressure gauge located on a branch connection on the hydraulic upstream side of the pump which conveys the propylene from a tank to the depropaniser (a tower designed to separate propane from the rest of the products). The pump is located at the limit of the unit, in an open space. Its discharge pressure is 20 bar. Using a wrench, the employee attempted to unscrew the pressure gauge on the branch connection. During this operation, the branch connection ruptured at the pump's discharge pipe connection. The employee was sprayed with propylene then product began moving toward the open space. A gas cloud formed near the production unit then ignited very quickly. This ignition was followed by an explosion and a fireball roughly 20 m in diameter.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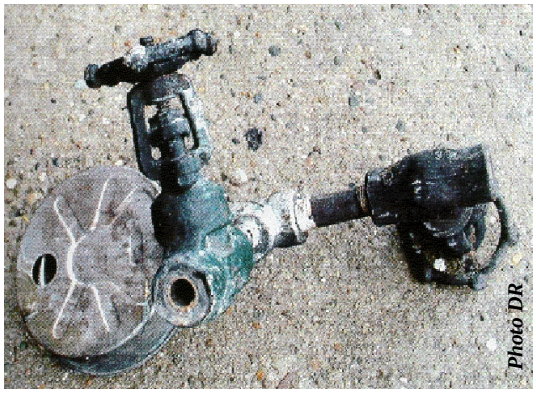


Photo DR

The fire then was limited to a "torch" which lasted a few minutes until the propylene leak was stopped. The flow rate of the leak was estimated to be 16 t/hour. Approximately 1 ton of product was released.

## The consequences:

The clothes of the employee performing the operation caught fire. The individual suffered 3rd degree burns, particularly to the face, arms and legs despite the fact that he was wearing clothing in compliance with safety regulations.
Property damage was limited. Damage was essentially located around the pump. Piping located on the other side of the open space, between the 2 units, was damaged by the fire.

## European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the events can be characterised by the following 4 indices, based on the information available.


The parameters that comprise these indices and the corresponding rating method are available at the following address: www.aria.ecologie.gouv.fr

The level 2 rating attributed to the "dangerous materials released" index corresponds to the approximately 1 ton of propylene released (parameter Q1).

The seriously injured operator justifies the level 1 rating for the accident's human and social consequences (parameter H4).

# ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The reconstruction of the accident and the intervention was based on facts collected and various hypotheses. The reconstruction team interviewed 24 people. External experts were also called in to determine the cause of the accident. The main conclusions of these investigations are outlined below:

**1 – Handling of the pressure gauge connection**

✓ No instructions were given regarding the gauge's replacement. This manoeuvre is considered to be a standard operation that the employees can perform themselves. The decision to replace the pressure gauge is made by the individual who inspects it. The replacement of a pressure gauge is included in the training program that the victim had undergone 2 years earlier.

✓ After the inspection of the damaged portion of the installation and based on the victim's testimony, it was concluded that the victim had followed the proper procedure during the gauge replacement operation.

**2 - Rupture of the pressure gauge connection**

✓ The connection was between a ½" branch connection and a 4" pipe. The specification indicates that, for this type of construction, a "model 80" connection must be used. In this configuration, the tube is 3.7 mm thick.

✓ The actual thickness measured (2.5 to 2.7 mm) tends to show that a "model 40" was used, for which the corresponding specification calls for 2.8 mm.

✓ In compliance with specifications, the junction between the valve and the pipe must be welded while on the section concerned, the junction was threaded.

✓ The calculations show that the connection, as built, had a rupture strength 5 time less that then one described in the specifications. Rupture during handling operations in such conditions is thus not abnormal. The construction of a non-compliant connection is the direct cause of the accident.

✓ The installation was built in 1972 based on a dossier that shows no design errors. It appears that the fault appeared either during the construction phase, or during a repair operation.

✓ The inquiry did not allow investigators to determine under what circumstances the abovementioned non-conformity appeared.

✓ The following causes of failure were mentioned:

- Deficiencies in the quality assurance system associated with the construction operations (in this case, verification of tube thickness not considered)
- Lack of a quality assurance system for repairs or modifications.

**3 - Ignition of the cloud**

✓ No ignition source was found in the immediate vicinity of the gas cloud. The leak was estimated at 16 t/hour. Considering the physical properties of propylene and the high speed of the leak, it is thought that the gas cloud was ignited by a discharge of static electricity. The presence of static electricity is a common phenomenon in these circumstances.

**4 - Implementation of the emergency plan**

✓ The inquiry showed no deficiency with regard to the implementation of the emergency plan.

## ACTION TAKEN

### Intervention:

An employee, other than the one performing the maintenance operation, noticed that the cloud had ignited and pulled the fire alarm. Other individuals then intervened to carry the victim to the nearest shower. He was then transferred to a health care facility in the city.

A water curtain was deployed to protect the cable networks and the racks of piping located opposite those on fire, on the other side of the open space.

At 00.29 am, roughly 2 minutes after the fire broke out, the members of the intervention crew initiated the low pressure on the pump by closing valves upstream, then downstream of the pump.

The fire department arrived at 00.31 am, i.e. 4 minutes after the fire broke out. Certain portions of the fire were brought under control with power fire extinguishers.

The fire alarm was deactivated at 00.50 am.

### Inspection:

At 3.30 am, the operator sent a fax to the local environmental office of the Flemish Community Ministry informing it of the accident.

Within the formal framework of the inspection, the operator received a letter requesting that it:

✓ conduct a thorough investigation of the accident. The letter lists a certain number of points to be completed, including the circumstances, the products involved, available data, measurements taken including those concerning the organisation, precise chronology of the events, the direct and indirect causes, the individuals present and their positions, the instructions given the personnel and the authorisations issued, the analysis and evaluation regarding the implementation of the emergency plan, and the means used to bring the fire under control.

✓ identify then compile an inventory of the site where a similar release may occur.

✓ examine the various scenarios that could lead to an identical situation.

✓ search for scenarios that may have effects outside the site in the event of a similar release.

✓ determine possible prevention and anticipation measures to prevent such situations and program their execution.

## Corrective actions:

Preventive measures were initially undertaken prior to any intervention on the pressure equipment.

A vast inspection and repair program was set up regarding the branch connections currently used and considered to be at risk. The other branch connections will be included in the periodic inspection plan. Assemblies that are not compliant with the construction criteria (in compliance with the construction rules governing small branch connections) shall be identified with a specific marking system indicating that they should in no case be manipulated with the installation in operation.

The implementation of the inspection and repair program showed that different specifications were used in the construction of the assemblies on the small branch connections. A new specification for these elements was thus drawn up, based on international practices on the subject.

The verification of tube thickness is included in the quality assurance system governing construction work.

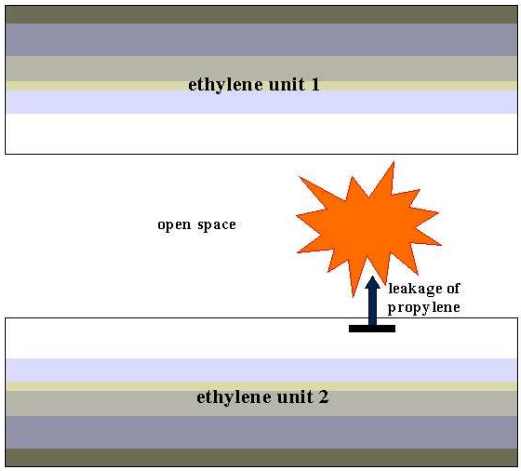
The implementation of a quality assurance system for modification or repair work has also been initiated.

# LESSONS LEARNED

A quality assurance system concerning the construction operations as well as for all repair or modification work, is essential if a repeat of this type of accident is to be prevented. The verification of the thickness is an indispensable criteria.

The small branch connections must have sufficient thickness and welded assemblies are preferable to threaded assemblies.

The internal emergency plan, comparable to the internal contingency plan (POI) in France, functioned correctly to limit the effects and the consequences of the accident by confining them inside the site.




However, the installation of the pressure gauge and its configuration on the pipe allowed the cloud to drift to an open space. The Inspectorate thus asked the operator to engage in reflective thinking focused on what may have happened if the cloud created by the leak had drifted in a different direction and had ignited near a production unit.