

Leak and ignition of toluene

December 3rd, 1998

Saint Vulbas – [Ain]

France

Fine chemistry
 Production workshop
 Commissioning
 Design / Ergonomics
 Underdimensioning
 Material selection
 Organisation / Management of modifications
 Procedures
 Human factor
 Automatic control systems / Instrumentation
 Electrical defect
 Victims

THE INSTALLATIONS IN QUESTION

The site

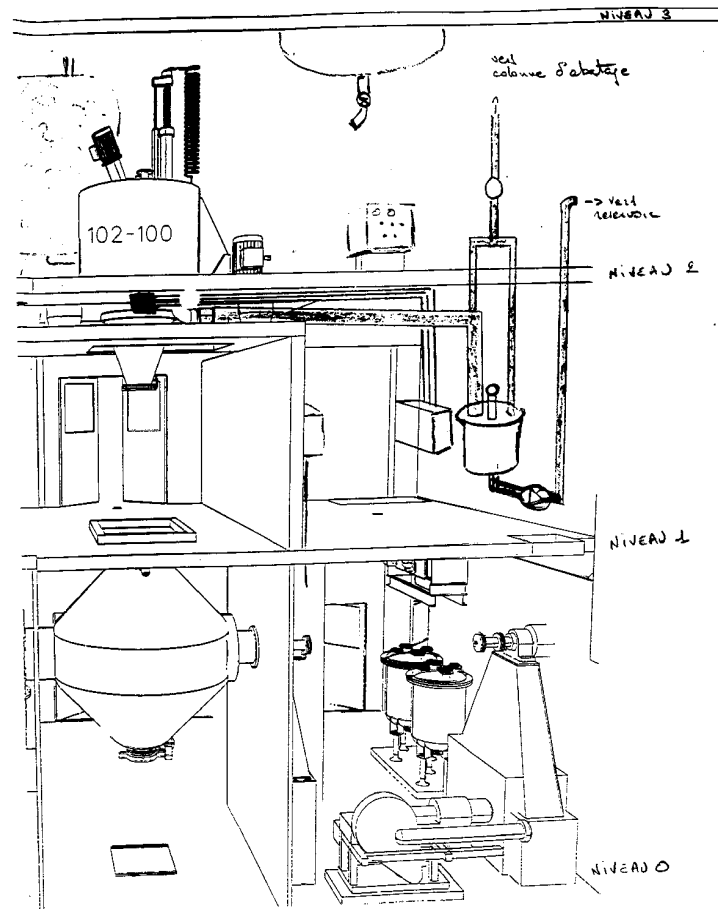
Located in Saint Vulbas in the département of Ain, the plant was commissioned in 1993 and has since undergone 2 extensions. It synthesises active pharmaceutical materials and employs 80 people.

The establishment, operating under a quality assurance program, features 2 production shops, including:

- 27 2,500 to 6,300-liter reactors,
- 22 multi-purpose devices in which standard chemical reactions are performed (esterification, hydrogenation, amination, halogenation, etc.),
- 5 reactors reserved for phosgenations,
- a phosgene production unit (30 to 600 kg/h),
- several dangerous product storage areas (hydrogen, chlorine, carbon monoxide, alcohols, solvents, acids and bases, etc.).

Installation concerned

The installation which is associated with the manufacturing reactors includes a dryer (3,000 l) connected by pipe with hydraulic seal to a plastic 300-liter solvent collection tank located 2 metres below in a room without a retention system and for which the electrical equipment are explosion-proof. The collection tank, designed to resist a pressure of around 45 mb, is fitted with a cover (60 to 70cm in diameter) and a high level sensor which is slaved to a transfer pump. The solvent (sea water) is stored in a container prior to evaporation and recycling or disposal.



The new equipment was received 12 days earlier in the presence of the various intervening parties (operator, constructor, engineers, etc.). Several anomalies were found during the qualification procedure. As a consequence, during the "lack of inerting pressure" emergency shut-down tests, leaks were reported on the cover which was secured by 4 bolts. The pressure of 45 mb could not be obtained. The decision was made to add an additional 4 bolts.

THE ACCIDENT, ITS BEHAVIOUR AND CONSEQUENCES

The accident

The accident occurred on December 3rd at 9 am while the installation was in its toluene cleaning phase. The solvent (the temperature of which is near ambient temperature) filled the collection tank and the pipework (hydraulic seal included), began to leak at the level of the cover's seal and burst into flames. The flash and the resulting overpressure blew the shop's doors open. The plant engages its POI.

The consequences

Approximately twelve employees are slightly burned. The individual with the worse injuries (3 days sick-leave) was located near the collection tank at the time of the accident.

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 accident can be characterised by the following 4 indices.

Dangerous materials released		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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

The toluene that ignited represents less than 0.1% of the corresponding Seveso threshold (50,000 t – easily flammable liquids 3b2), which equals level 1 of the "dangerous materials released" index according to parameter Q1 (Q1 < 0.1%).

Two parameters are involved in determining the level of the "Human and social consequences" rating: H4 and H5.

- Parameter H4 is rated as level 1: 1 employee burned, 3 days without work (H4 = 1 employee seriously burned).
- By default, parameter H5 of the "Human and social consequences" is rated as level 2: ten or so employees were slightly burned (H5 between 6-19 employees injured).

As a result, the overall "Human and social consequences" rating is 2.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The accident occurred during the 1st fabrication operation. Due to an electrical malfunction on a terminal strip (lug poorly tightened), the tank's drainage pump did not start and thus lead to the overflowing of the tank. The tank's hydrostatic pressure resistance was insufficient (cover not leakproof). The vapours most certainly self-ignited due the toluene's dielectric characteristics.

The unit which had just been received exhibits several design defects :

- a collection tank too small in relation to that of the centrifuge implicating numerous pump starts, lacking retention and too low resistance level in relation to the maximum possible hydraulic load (at least 150g),
- the presence of a single high level sensor (no backup),

- a questionable choice in terms of the materials used for the tank and its pipelines (plastic poorly adapted to the dielectric characteristics of toluene).

In other respects, the Inspectorate noted the following during a visit of the installations:

- the presence of 7 bolts instead of the original 4; the location for an 8th bolt is provided but is replaced by a clamp. The fastening system had been modified at the time of installation acceptance (qualification). The pressure of 45 mb could not be reached (leaks at tank cover), the centrifuge could not start; the cover mounting system was reinforced to improve the tightness of the assembly (a missing bolt was replaced by a clamp). The fabrication process was launched 12 days later, with the temporary repair having been forgotten...
- anomalies in unit operation. The procedure during the accident dictated that the operator make a log entry (time - action taken). The log was completed in advance up to 10 am (centrifuging and sampling considered as completed), even though the accident occurred at 8 am.

ACTIONS TAKEN

Manufacturing operations were immediately stopped (emergency shutdown). Upon the Inspectorate's request, a third expert conducted a two-week long audit of the site and proposed approximately fifty recommendations. Apart from the damaged installation, a general comment was made on the lack of level measurement equipment for stored products. Procurement management was based on automatic monitoring and operator vigilance. The weakness of certain pipelines in relation to the pressure was also highlighted.

The operator corrected the anomalies reported :

- ➔ changes made in certain operating sequences,
- ➔ holding under pressure and instrumentation of centrifuge drainage tanks,
- ➔ improvement of the explosive atmosphere detection system,
- ➔ overflow prevention during automated delivery of solvents via the storage yard,
- ➔ by-pass of the mobile safety valve on the reactor supply line.

LESSONS LEARNED

This accident is the 4th that occurred in the installation for the last four years. This situation demonstrates not only material discrepancies but also definite lacks in the safety management:

- ➔ the design defects of an installation associated with insufficient risk analysis (specifications insufficient for the collection tank, a level sensor used as the sole safety device, lack of explosive atmosphere detection equipment in the facility),
- ➔ anomalies in the commissioning conditions of a potentially dangerous unit associated with an insufficiently rigorous qualification protocol (oriented only on the production equipment to be received, tightness achieved under precarious conditions),
- ➔ poor management of modifications (temporary clamping of the cover maintained during commissioning, drawings not updated),
- ➔ unacceptable derivation in the operation of installation (operations log poorly kept),
- ➔ poorly adapted alert methods (numerous comings and goings of individuals more or less well informed in the area after the toluene leak is reported and slightly before its ignition, facility evacuation order given late, etc.) and the disrespect for individual protection instructions,
- ➔ easy co-operation of the Inspectorate with the judicial expert (necessity for a quick diagnostic due to the commercial stakes involved).