Fire in a fertiliser warehouse

October 29th 1987

Nantes – [Loire-Atlantique]

France

Release of gases
NPK Fertiliser
Ammonium nitrate
Organisation
Electrical failure
Response difficulties
« ORSEC « (crisis) plan
Evacuation
Crisis

THE INSTALLATIONS CONCERNED

The site :

Specialised in the wholesale sales of sugar (brokerage) molasses and fertiliser (imported), cereals (export) and chemical products, the company has a storage building at the extreme West of the port of Nantes on the right bank of the Loire.

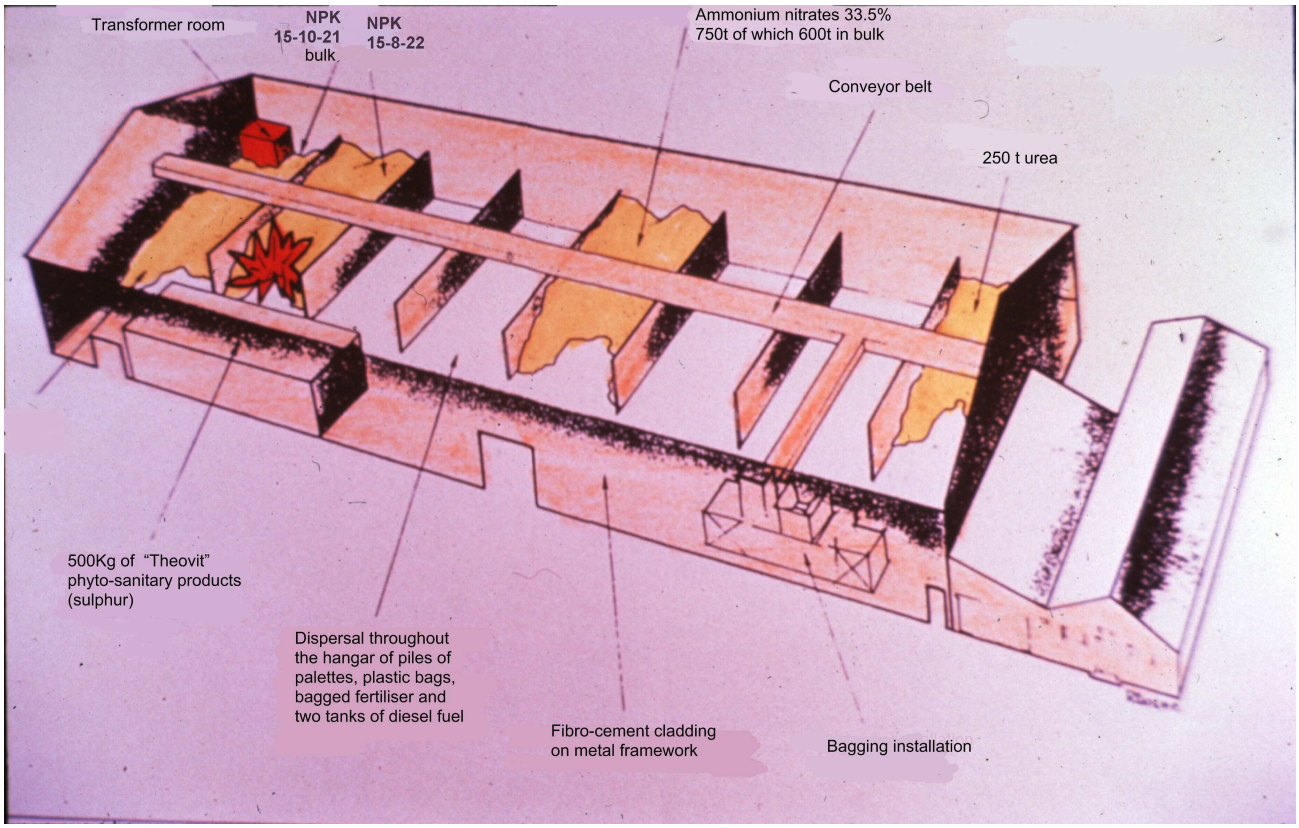
Built in 1973 for warehousing equal quantities of sugar and fertiliser, the warehouse was finally reserved for the storage of various imported chemical fertiliser products, the separation between food products and chemicals not proving to be very functional.

The warehouse was authorised for “general storage” by the decree from the Prefect dated 12th February, 1974.

The installations concerned :

The storage installations consisted of a rectangular metal framed building with curtain walls and roofing in fibro-cement of 107.5 m by 32 m and a height of 10 m, or 7 m useable and a total volume of 24 000 m^3. The ground surface area is divided into 8 boxes by mobile concrete partitions 3.5 m high.

A system of conveyor belts is used for the moving of bulk products from a trench communicating with the unloading quay to an airborne machine known as the “aeroplane” which spreads the products between the different sections. This device also supplies the products to a bagging installation.



On the day of the accident, the following fertilisers were stored in the warehouse, all imported and in conformity with European standards:

Position	Product	Quantities	Arrival date
Box n°1	NPK Fertiliser 15-10-21	600 t	End 1986
Box n°2	NPK Fertiliser 15-8-22	850 t	20/10/1987
Box n°3	Empty	-	-
Box n°4	Empty	-	-
Box n°5	Ammonium Nitrate 33,5 %	750 t of which 100 t bagged	September 1987
Box n°6	Vide	-	-
Box n°7	Vide	-	-
Box n°8	Urea 46 %	200 t	June 1987
Special premises	Thiovit (Sulphur 80-82% + lignosulfonate + minerals)	1 t	-
Hangar	Fuel oil for loaders	2 tanks of 1000 and 600 litres	-

THE ACCIDENT, SEQUENCE OF EVENTS, EFFECTS AND CONSEQUENCES

The accident

At 9:15 a.m. on 29th October 1987, an operator detected smoke rising from box n°2. **At 9:36**, having attacked the source of the fire with powder extinguishers, in the absence of activated fire hose reels, the personnel decided to alert the emergency services following a continuous increase in the volumes of smoke. In calling for assistance, the operator mentioned the presence of NPK 15-8-22 type fertiliser.

Arriving on the site at **9:43**, the firemen observed that the fertiliser stored in box 2 was emitting very thick smoke; it appeared that an invisible fire was burning beneath the mass. The positioning of fire-hoses was made difficult by the very rapid increase in the emission of smoke, which also incited the authorities to require the downwind neighbours of the factory to remain indoors.

Until 10:45, the intervention consisted of installing an indoor water curtain to isolate the burning material from the rest of the store and the creation of smoke vents in the upper walls. Very soon after the raising of the alert, the initial information concerning the nature of the chemical products involved was lost from sight : the only information retained concerned the presence of ammonium nitrate fertiliser.

At 11:15, the first confinement measures were taken in a radius of 1 km around the site ; 73,000 people were involved. Instructions were broadcast on FM radio stations and by loudspeaker vehicles driving around the zone.

Source : DR

Source : SNPE

At noon, the extent of the drifting cloud was defined by a helicopter from the gendarmerie. At that time It extended 6 km in length in the direction of the Loire and was 3 km wide. At 14, its length and width had doubled.

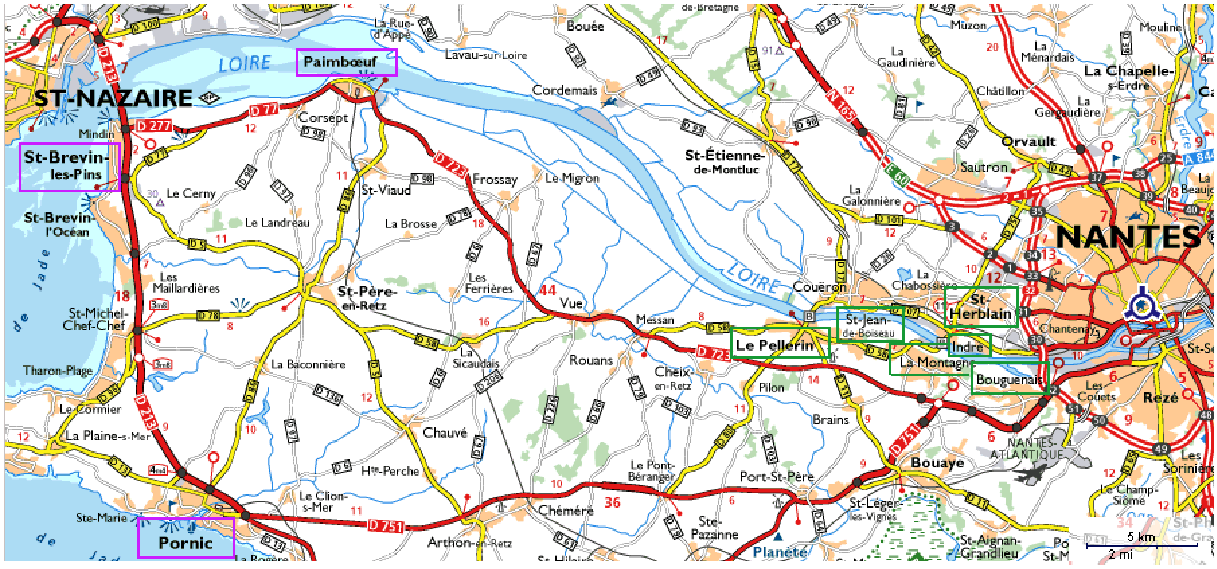
At 12:15, a discussion between experts generated contradictory information concerning the danger of explosion, the toxicity of the smoke emitted and the best procedure to follow (whether or not to drown the fire, taking into account the risk of explosion or of contamination of the Loire). Finally the crisis management group decided to suspend rail traffic between Nantes and Redon and to evacuate the population living within a radius of 1 km. This decision was essentially taken on account of the risk of explosion.

At 1 p.m., a major evacuation of the population of the communes situated under the cloud was decided. The entire transport resources of the city of Nantes were requisitioned (50 buses). In the absence of clear instructions, the firemen decided that the swamping of the fire was the least bad solution; the means for this were progressively assembled to this end. The water supply to the sector being fragile and limited the firemen had to install means to pump water from the Loire; this, however, only being possible during the high tide. Tug-boats equipped with fire-hoses were therefore used for the water supply.

The ORSEC (crisis) plan was put into operation at **2:15,** the evacuation of the populations of 7 communes (Saint-Herblain, Indre, Couëron, Bouguenais, La Montagne, St Jean de Boineau et Le Pellerin) commenced.

As from 4 p.m., the damping of the fire started to produce effects and there was a diminution of smoke emission; the smoke emitted was no longer russet coloured but white.

At 6 p.m., the smoke cloud extended as far as St Brévin, et de Pornic à Painboeuf following the Loire (see map below).



Source : www.viamichelin.fr

The results of the evacuation plan for the population was as follows::

- Indre : 75 %
- St Herblain and Couëron :major evacuation but numbers not counted.
- La Montagne : 35 %
- Le Pellerin : 100 %
- St Jean du Boineau : 20 %

At 7 p.m., rail traffic was re-established.

At 10 p.m., all those who had been evacuated were authorised to return home, the ORSEC plan was lifted the following day at 7 a.m., the fire being considered extinguished at 6 a.m.

In total, 200 firemen, 627 policemen, 489 gendarmes, 356 military personnel, 200 first aid personnel and around a thousand communal employees were mobilised during the crisis.

The consequences :

Human and social consequences:

The human cost was 3 employees slightly wounded, transferred to hospital: one of them remained under observation for more than 24 hours. Furthermore, only 25 people were slightly intoxicated by smoke inhalation and did not require admission to hospital.

Although the total number of people in the evacuation zone amounted to 70,000 people of whom 8,000 were schoolchildren, the number actually moved was evaluated at 38,000 people.

Composition of the toxic cloud :

Measurements taken by the anti-pollution cell of the city of Nantes and the CMIC (Mobile Chemical Intervention Unit) using reagent tubes made it possible to track the air contamination inside and outside the warehouse, as well as in the communes affected by the cloud. Gathered in the table below, these show that the cloud consisted of nitrous oxide (NO + NO_2), chlorine (Cl_2) and nitric acid (HNO_3) vapours.

Hour	Parameters	Warehouse		Communes (Indre, Coueron, St Herblain)
		Interior	Exterior	
29/10 11h00	HNO3 Cl2 NH3		50 ppm 3 ppm 0 ppm	
29/10 12h00	HNO3 Cl2 NH3		3 ppm 0.5 ppm 0 ppm	
29/10 15h00	HNO3			1 ppm (Indre) 0.5 ppm (St Herblain et Couëron)
29/10 22h00	HNO3 NO + NO2 Cl2	50 ppm 5 ppm 3 ppm	5 ppm traces 0.2 ppm	0 ppm 0 ppm 0 ppm
30/10 2h00	HNO3 NO + NO2 Cl2	15 ppm 5 ppm 0,3 ppm	5 ppm 0 ppm 0 ppm	0 ppm 0 ppm 0 ppm
30/10 2h45	HNO3 NO + NO2 Cl2	0 ppm 1 ppm 0,2 ppm	- 0 ppm 0 ppm	
30/10 4h00	HNO3 NO + NO2 Cl2	- 0 ppm 0,2 ppm	- 0 ppm 0 ppm	- 0 ppm 0 ppm
30/10 5h00	HNO3 NO + NO2 Cl2	- 0 ppm 0 ppm	- 0 ppm 0 ppm	- 0 ppm 0 ppm

Pollution of the Loire

The pollution of the Loire by the fire extinction water was limited by the dilution of the effluents draining from the accident site. In the event, the flow of polluted waters released to the river (0.3 m^3/s) should be compared with that of the Loire (1,000 m^3/s). This observation was based on analyses conducted by the regional hygiene laboratory on samples taken by the anti-pollution cell of the city of Nantes.

Analysis of the effects of fallout from the toxic cloud

Various studies conducted after the accident all came to the conclusion that vegetation (fruits and vegetables) exposed to the toxic cloud showed no detectable traces of contamination with nitric acid.

European scale of industrial accidents

In using the scoring rules of the 18 parameters of the scale officially adopted in February 1994 by the Committee of Competent Authorities of the Member States for the application of the 'SEVESO', directive, taking into account the available information, the accident can be characterised by the 4 following indices

Source : SNPE

The accident involved NPK fertiliser for which the Seveso threshold is 10,000 t. Of the 850 t of fertiliser involved (8.5 % of the Seveso threshold), the quantity actually burned is not known precisely, nor is the quantity of toxic gas emitted. Thus, the index" dangerous materials" released is to be found between 1 and 3 (parameter Q1).

The results of the accident involved 3 employees slightly injured but, above all, the evacuation of 38,000 people for a duration of 8 hours, the index "human and social consequences is therefore equal to 5 (parameter H7).

Finally, the lack of information concerning the environmental and economic consequences of the accident prevented the completion of the two last indices on the scale of accidents.

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

The observations made on the site and the witness statements gathered indicate that the incident was initiated in box n° 2, containing NPK 15-8-22 fertiliser and then propagated into the neighbouring box containing NPK 15-10-21 fertiliser.

Characteristics of the fertiliser:

The NPK 15-8-22 fertiliser involved, unloaded the day before the accident totally filled the box. The warehouse personnel did not notice any abnormality. The product showed no clumping (forming of masses). However, it was sufficiently hot (40 °C) to draw the attention of the employees.

As a result of the conditions of transport (in the holds of a ship which had previously stored wheat) and the storage conditions (on a bed of sawdust to dry the floor of the box), the fertiliser became

Source : SNPE

intimately mixed with organic matter which may have become highly concentrated in certain places.

Electrical Installation of the warehouse

The electrical installation of the site was very old as had been notified to the operator by a private verification organisation in its 1986 report, which was not followed up by repairs. In particular the following was noted :

- electrical installations not in conformance with security standards,
- numerous oversized fuses and relays,
- oversized circuit breakers,
- insulation controller broken down,
- incomplete grounding,
- non-isolated parts carrying current and electrical boxes and cupboards open.

Origin of the accident :

The zone in which the fire started was right below electrical cables which hung beneath the transport motor and the ends of which were found to be sectioned. Given the length of the cables wires as well as their position and given the age of the electrical installation, it is highly probable that electrical conductors were buried within the mass of fertiliser.

Under these conditions, it is equally probable that ignition took place in the depths of the heap of fertiliser, in immediate proximity with the mass which was contaminated with sawdust and doubtless close to the buried electrical conductors. Propagation of the fire was subsequently caused by self-generating decomposition of the fertiliser.

Thus several factors contributed to the development of the accident:

- storage of fertiliser made sensitive to the phenomenon of self-generating decomposition by an excessive temperature and an excessive concentration, at certain points in the mass, of organic matter (wheat and sawdust);

- absence of surveillance equipment to track the temperature of the fertiliser during storage;

- the presence in the heap of fertiliser of poorly insulated electrical conductors, the heating of which, made possible by the age of the installation and particularly by the oversize of the fuses and circuit breakers, could have provoked the outset of decomposition;

- the presence of wooden palettes in contact with the fertiliser which burned following the decomposition, adding to the heat of the fertiliser and accelerating its decomposition ;

- absence of any effective means of fire-fighting, such as a water riser and a self-propelled fire hose. A massive and rapid supply of water reaching the heart of the fire would have allowed for the halting of the process before it developed uncontrollably.

The birth and the growth of the incident were linked to 2 areas of inadequacy:

- inadequacy of equipment: the hangar, built on the port in 1973, was not designed for storage of flammable products of products subject to decomposition (absence of fire-fighting means…)

- insufficient training of personnel: insufficient knowledge of materials handled and their associated risks (absence of training, operation with defective electrical installation despite annual reports of an inspecting organisation, placing in contact of stocks of ammonium nitrate and complex fertilisers…)

SUBSEQUENT STEPS TAKEN

Administrative steps

Based on the proposal of the inspectorate of classified installations, the Prefect signed, on 23/11/1987 a decree designed to regulate the rebuilding of the site and its possible return to activity.

A modification to the nomenclature of classified installations and of the SEVESO directive was introduced following this accident. Previously, the storage of NPK fertiliser was not regulated, either in France or in Europe.

Penal steps

Failure to adhere to several legal dispositions for classified installations, particularly relating to the inspection and maintenance or electrical installations and the risks of placing in contact ammonium nitrates with foreign substances were noted in the course of the enquiry.

THE LESSONS LEARNED

Response and emergency plan:

The incident would certainly not have reached such proportions if efficient means for response had been applied as soon as the heating had been detected, preventing the rapid development of the fire:

- **Appropriate extinction equipment** for the products stored must be at the disposal **personnel trained** in the prevention of risks, the detection of abnormalities and in emergency response. In this case, the personnel of the establishment were not aware of the risk associated with fertiliser and only had powder extinguishers which are ill-adapted to this type of fire. No water extinguishing equipment, fire hose reels were available on the site.

- A **sound characterisation of the risks involved**, particularly involving an **understanding of dangerous materials** implicated is indispensable to the implementation of efficient fire prevention and fire-fighting plans. Doubtless the loss of information concerning the nature of the products involved in the fire in Nantes played a major role in the development of the incident. In the absence of characterisation of the products present and thus of the risks involved, disagreements between experts occurred which delayed the application of effective response methods. Furthermore, the establishment was not classified by the fire department and was subject to no emergency plan. It is essential that each emergency centre should hold an **inventory of potential risks** for its sector of intervention to enable efficient response from the moment that the alarm is given.

- Effective response requires also that there should be **adequate and permanently available sources of water,** including, for example, when the tide is going out. .

Prevention of risks in fertiliser storage

At the time storage of NPK fertiliser was not subject to special regulation, either in France or in Europe. It was following this accident in Nantes, that the nomenclature of classified installations and the Seveso directive were modified.

The operators of these warehouses, of which the risks were often considered as banal, were made aware of good practice for the prevention of spontaneous combustion and the limitation of possible consequences. This involved notably:

- limiting the presence of foreign matter within the fertiliser by :
    - checking, on arrival at the warehouse, the presence of contaminants, (either originating in the manufacture or on the conditions of shipping)
    - distancing all other substances which may be stored,
    - frequent cleaning to avoid dust, a particular source of flammable contamination,
    - using incombustible materials for the construction and internal arrangement of the warehouse;
- avoid the creation of hotspots by:
    - using electrical systems designed for explosive and dusty atmospheres,
    - using handling systems without unprotected hotspots
    - organising and checking with precaution all maintenance work,
- rapidly detecting any heating and constantly checking the temperature within the heap by means of detectors;
- limiting the extension of a potential incident by:
    - splitting up the heap to reduce the volumes,

- using compartments and firewall elements
- having available rapid extinction methods including those penetrating within the mass of reacting fertiliser;

- limiting possible water pollution by the preparation of waterproof flooring and means of collection and evacuation of fire-fighting water of sufficient capacity.

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