Fire inside a barn and explosion of fertiliser

October 2, 2003

Saint Romain-en-Jarez [Loire]

France

Fire
Explosion
Farmer
Ammonium nitrate / fertiliser
Victims
Property damage
Emergency response (difficulties of)

THE FACILITIES INVOLVED

The site:

The barn involved in the accident belonged to a fruit growing farmer and had been built on a sloping parcel, adjacent to the centre of the small town of Saint Romain en Jarez, beneath a local service road. The dwellings closest to the structure were primarily located in the north-eastern / north-western sector. The neighbouring parcels in the other directions were all being used for farming activities.

The main structures built on the parcel where the accident occurred were as follows (see diagram on page 3):

- the barn, covering a floor area of approx. 1,000 m²
- the three-storey residence contiguous to the barn (a cold storage room had been set up on the ground floor)
- a garage adjoining the house, with a separate part containing fuel oil tanks
- an outbuilding, or shed, for storing farm equipment and machinery
- a hen house.

The barn involved in the accident:

This barn was composed of two adjoining buildings, one dating from 1972 the other 1987, built on top of a thick reinforced concrete slab and supported by exterior walls and columns on the side of the south-eastern facade. It featured a steel structural frame with concrete block filling. The barn roof consisted of steel cladding with none of the surface used for lighting purposes. Built on steeply-sloped ground, this structure required removing large volumes below the concrete slab. The barn was remodelled in 1995; this project involved creating an onsite dwelling on the mezzanine level that was further expanded in 2001 (the unit was unoccupied on the day of the accident, i.e. October 2, 2003).

A 150-m² cold storage room, composed of steel / polyurethane foam insulation panels, was set up at the back of the building; a Freon cooling system was installed abutting the barn. An 80-m² apartment served to separate a half-floor of the building as well as the mezzanine. Two wide barn doors provided access onto the main façade and a double-layered insulating skin was placed on building walls to guarantee the heat insulation necessary to preserve and pack fruits.

The barn had not been fitted with any interior fire-resistant walls.

When the accident occurred, the barn's ground floor had housed: a gasoline-powered forklift, a battery charger, two 13-kg gas bottles, miscellaneous farm machinery, 500 kg of quicklime, 500 wooden crates, 6,000 to 7,000 plastic crates, and between 3 and 5 tonnes of ammonium nitrate packaged in big-bags. Bales of hay and straw were being stored on the mezzanine and some 500 kg of apples kept in the cold storage rooms.

At the time of the accident, the activities taking place inside this barn were not subject to any special oversight, as per regulations applicable to Classified Facilities for Environmental Protection (ICPE designation). The threshold adopted to trigger authorisation of heading 1331 in the ICPE protocol relative to the storage of nitrate-based fertilisers was set at 1,250 tonnes (Decree 99-1220, enacted December 28, 1999), i.e. an amount that exceeds by a wide margin the 3 to 5 tonnes stored on this farm's premises. The declaration threshold for heading 1510 relative to the storage of over 500 tonnes of combustible materials within covered warehouses, set at 5,000 m³, was not surpassed either.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

On Thursday, October 2, 2003, at around 3 pm, a fire broke out inside the barn of the tree farmer at the mezzanine level used to store, among other items, bales of hay and straw. Alerted by his son who had smelled the emanating smoke, the farmer unsuccessfully tried to put out the fire using an extinguisher.

Fire-fighters were notified about a farm fire at 4:02 pm. Upon arriving on the scene, at 4:23, they had to battle an extremely violent barn blaze responsible for releasing an impressive plume of smoke. The crew set out to extinguish the main source of combustion, with the aim of saving the house adjoining the barn using 4 variable-rate nozzles, yet the team quickly faced water supply interruptions. The captain called for a "water supply backup" unit at 4:38 pm.

The fire-fighting strategy adopted had to be adapted to both the amount of water resources and the fire's progression. Once the house was out of danger, fire-fighters turned to two variable-rate nozzles in order to protect the flat that was still intact on the barn's first floor.


SDIS 42


SDIS 42

At 5:12 pm, with a large portion of the barn roof already collapsed and the fire source having lost intensity, a hissing sound was heard followed by a powerful explosion, without the fire-fighters having taken note of any preliminary signs or indications. Debris rained down all around the point of explosion. Heavy pieces of the structure's steel frame would be found hundreds of metres away. The toll from this disaster: 26 people injured; the barn totally destroyed; and many neighbouring village buildings, within a radius extending several hundreds of metres, sustained varying degrees of damage.

At 5:15 pm, the Head of the Loire Department Prefect's Cabinet activated the emergency response plan, confirming the need for responders to rescue many accident victims. A broad array of emergency resources were deployed to the scene: fire-fighters, members of the gendarmerie brigade, national police officers, emergency medical care providers, etc. The most seriously injured victims were pulled from the rubble before the arrival of backup rescue teams. A field medical post was set up inside a local gym some 100 metres from the farm.

The response effort was compartmentalised: medical services; fire-fighting; rescue operations (debris removal, search and rescue canine unit); chemical accident investigation; and information dissemination measures.

Following the explosion, the equipment onsite to fight the original fire was destroyed. The rescue team had to set up 5 new variable-rate nozzles and eventually had the fire contained by around 9 pm.

By 9:30, all victims could be safely evacuated to regional hospitals.

Since the hose streams were not able to reach the heart of the fire source, it would take another few days before all of the residual fire outbreaks could be extinguished. Fires were in fact still smouldering under the collapsed structures, making it impossible for rescue teams to attempt moving rubble prior to determining the exact cause of the explosion. The main source of combustion was identified at the initial cold storage room locations, as these rooms had contained several tonnes of apples kept in wooden and plastic crates.

A total of 94 local residents had to be housed elsewhere as a result of damage sustained by their dwellings.

On October 3rd, Prefecture staff laid out a 300-m perimeter of safety around the barn, which was still ablaze. The National Gendarmerie, with support from the Lyon police department's forensic laboratory, initiated the investigative work. Mine removal specialists accompanied by trained dogs were also called to the scene to inspect the rubble.

A number of experts, appointed by the Ministry of the Environment, arrived onsite on October 3 around 4:30 pm to provide technical assistance to both the Prefect's Office and the Court Prosecutor during this emergency situation.

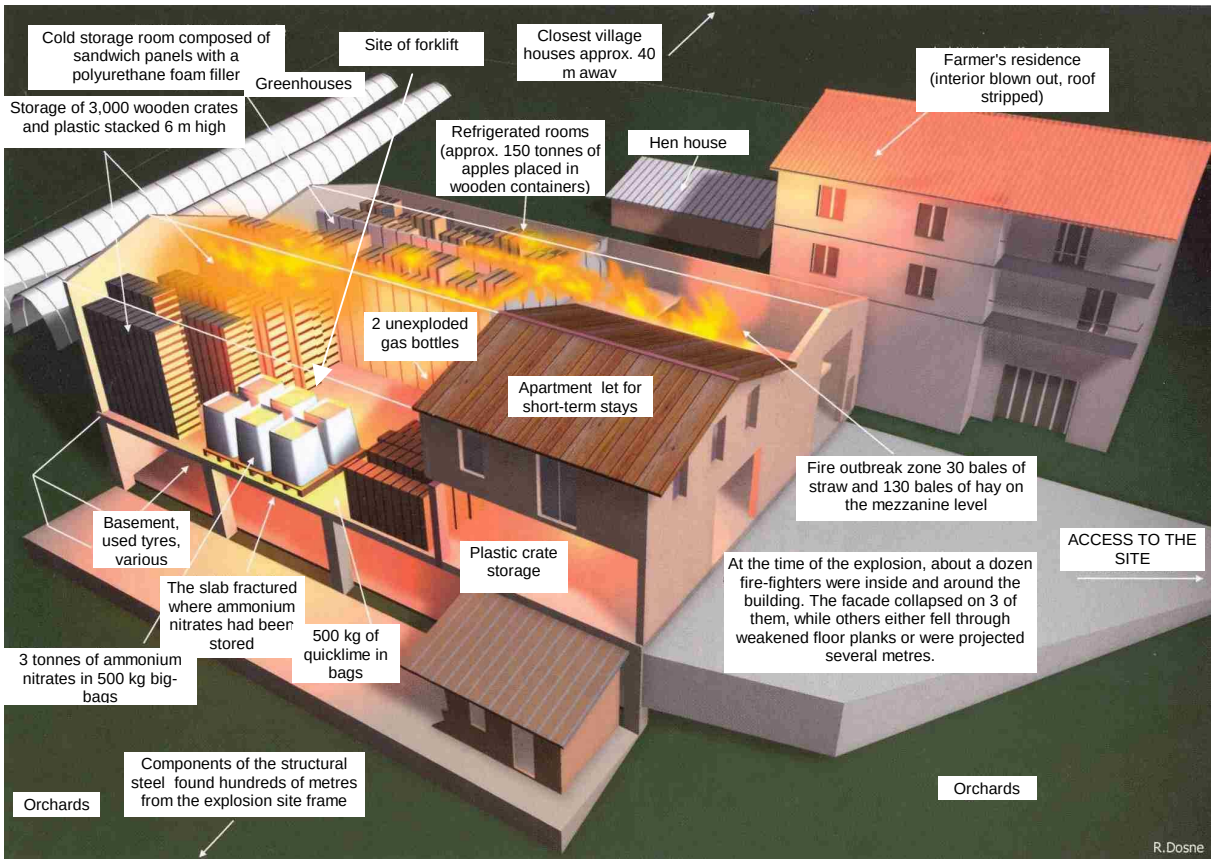
During the evening, a psychological support unit was made available for victims and recorded over 100 consultations.

On October 4th, the perimeter was scaled back to 100 m, allowing the majority of those evacuated to start repairing their homes: removal of debris and errant material, installation of tarps to cover roofs, roof tile replacement, restoration of openings or temporary caulking, etc. Neighbours closest to the blast site however had to wait a bit longer before returning to their homes; in the meantime, fire-fighters covered their roofs to avoid further damage from rains.

Around dusk on October 5th, the fire was completely extinguished.

On October 6th, the final crisis meeting overseen by the Prefecture's Office was held in the Saint Romain-en-Jarez Town Hall: the fire was now put out and any further risk of explosion completely eliminated; it was decided to remove the perimeter of safety. Some sixty residents were thus authorised to return home. Only access to the farmer's property where the explosion occurred was still cordoned off for purposes of the accident investigation.

Emergency personnel kept spraying the explosion site through October 7th, as large quantities of smoke were still being released.



*Explosion of ammonium nitrate solution inside the barn (drawing by René Dosne, "*Face au Risque*", issue 399, January 2004)*

Consequences of this accident:

The human toll of this accident amounted to 26 injuries:

- 18 fire-fighters, 9 of whom seriously;
- 3 gendarmes slightly hurt by effects from the blast (temporary hearing loss); these individuals were positioned some 50 m from the explosion site;
- 5 bystanders with slight injuries, knocked down by the effect of the blast or in some cases hit by hot projectiles.

Among the seriously injured, one fire-fighter experienced a phenomenon known as pulmonary blast (many lesions on the lungs, causing over 80% respiratory blockage). This crew member was not wearing a self-breathing apparatus since he had not been directly involved in the fire-fighting effort. On the other hand, members in contact with the blaze were wearing such apparatuses and did not have to be treated for similar lesions, even though some were actually closer to the explosion epicentre. It appears therefore that this respiratory device was able to protect against blast effects.

The two other fire-fighters sustaining serious injuries were not directly hurt by the blast effect, but instead by indirect shockwave effects (collapse of structural elements, projectiles, etc.).

Neither of the two 13-kg gas bottles exploded.

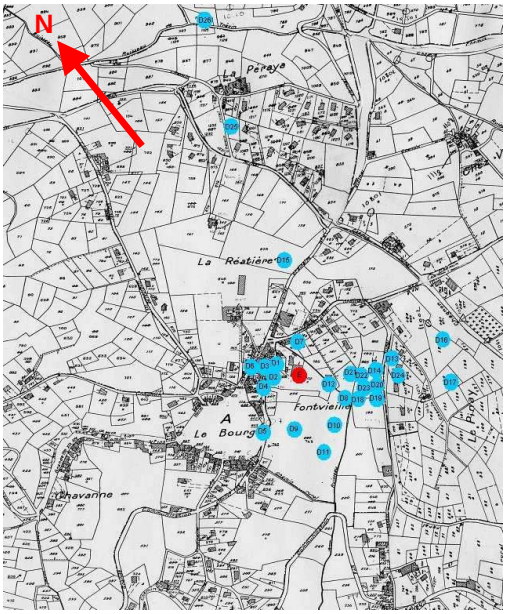
Analysis of damage caused by the explosion:

Experts appointed by the Environment Ministry were assigned to: collect all information necessary to understand the sequence of events, record the damage to structures, and identify the locations of various types of projected debris. The upper limits of the damage radius recorded onsite are listed in the following table:

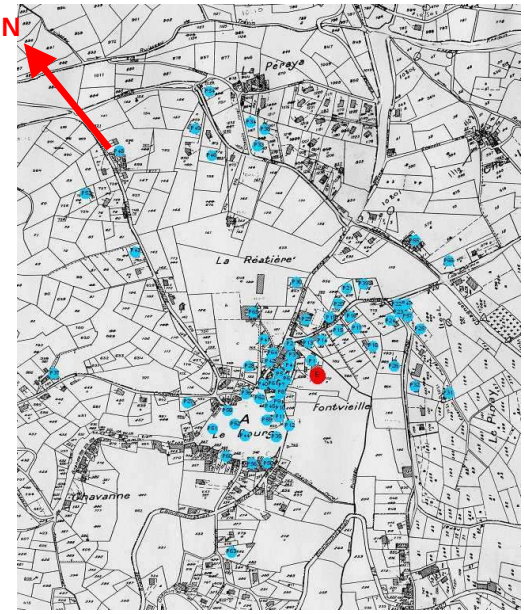
Maximum radius of lightweight damage *(broken glass panes, tile dislocation)*	650 metres
Maximum radius of major damage *(cracked walls, chassis degradation)*	350 to 580 metres
Maximum radius of serious damage *(structural deterioration, displaced partition walls)*	150 metres
Maximum radius of fragment projections	800 metres

Source: "Analysis of damage caused by the October 2, 2003 barn explosion in Saint Romain-en-Jarez", INERIS

The fragment projected the furthest ignited a fire in a prairie 800 m from the explosion site, yet it remains entirely possible that other fragments were projected even greater distances.



Locations of identified debris



Locations of actual damage recorded

Source: "Damage recording", INERIS

A rather pronounced directional effect heading northwards could be noticed at distances of up to several hundreds of metres. Conclusions drawn by the panel of experts cited a number of possible causes of this phenomenon, including:

- Steeply-sloped terrain: The explosion occurred on the slope of a north-south oriented valley, which might have given rise to both a large-scale reflective effect between the valley's two hillsides and a north-south propagation tendency for the pressure wave. It remains very difficult however to estimate the actual influence of site relief, although indications suggest that this influence cannot be excluded.
- Directional effect at the very source of the explosion: The north-western wall of the barn was not destroyed by the explosion, implying that it would have been protected from the pressure wave by a screening effect due to the presence of cold storage rooms filled with fruits, located between the explosion epicentre and this wall; the south-western wall was partially destroyed, while both the north-eastern and south-eastern facades had come down completely.
- During the accident, a light breeze was blowing from the south and could have accelerated pressure wave propagation further northward. As a matter of fact, at greater distances from the epicentre, the dynamic pressure exerted by wind was no longer negligible in relation to pressure wave amplitude.

The innermost ring of houses around the explosion epicentre, along with several houses in the central part of the village (for a total of some twenty dwellings within a 150-m radius), were heavily damaged.

Eight facilities open to the public also sustained damage, including a private school and gymnasium.

Hazardous effects could be observed beyond distances of 600 m, given the characteristics (velocity, mass, shape) of the fragments recovered during the investigation.

Moreover, an analysis of explosion impacts leads to deducing that the projection of structural debris beyond 300 m from the epicentre was due to the detonation of a TNT equivalent mass on the order of 300 kg.

The European scale of industrial accidents:

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the '*SEVESO*' directive on handling hazardous substances, and in light of information available, this accident can be characterised by the four following indices:

The parameters composing these indices and their corresponding rating protocol are available from the following Website: www.aria.developpement-durable.gouv.fr.

Given the distances over which explosion effects were felt, the "Hazardous Materials Released" index received a "2" score (TNT equivalent of approx. 300 to 500 kg, with broken glass reaching distances of 650 m for index Q2).

The "4" value assigned to human and social consequences reflects the need to evacuate local population, as some sixty residents had to wait 4 full days before being allowed to return home (index H7); the level "3" rating was scored as a result of the number of injured fire-fighters, police officers and members of the public (indices H4 and H5).

The "Economic Consequences" index equalled at least a "3", given that an insurer paid out 320,000 Euros to compensate 22 accident victims (index €17).

Lastly, this accident did not cause any known environmental impacts.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

The origin of this accident:

This explosion would have been caused by the detonation of a portion of the 3 to 5 tonnes of ammonium nitrate solution present inside the barn. The explosion epicentre was actually located in the southern quadrant of the building, corresponding to the assumed fertiliser storage zone. At this particular spot, the ground floor concrete slab was cracked. During 2003, fertiliser inventories among local farmers were running especially high since much had gone unused following a late freeze in April 2003 that destroyed nearly all of the stone fruit crop.

While offering a certain level of safety, the compliance of ammonium nitrates with Standard NFU 42 001 or with the equivalent European Directive 80/876/EC, as enacted by modified French Decree 80-478 dated on June 16, 1980, does

not allow excluding the occurrence of detonation in the inventory. This detonation phenomenon cannot be ruled out in cases involving significant degradation (formation of fine powders) or outside contamination (organic and/or combustible materials) whenever the target product is in either the solid state and exposed to a powerful explosive or in the liquid state (e.g. melted at above 170°C in the case of fire) and initiated by a major shockwave or within a heavily-confined situation, thus preventing the free release of gases normally emitted at this temperature (i.e. nitrous vapours). According to the assigned experts, the melted plastic from the crates was likely to have expanded and mixed with ammonium nitrates, which themselves would have melted under the effect of such heat. This mix might have created one of the instability factors that caused the explosion.

The forensic laboratory's investigation did not indicate the presence of any explosive product onsite other than ammonium nitrate.

As reported in the legal expert's results, several ignition sources could have triggered the fire, evidently on the barn's mezzanine level. Cited as possibilities were: an electrical overload on the facility, which shortly before had undergone remodelling to accommodate the cold storage rooms; fermentation of stored hay; or simply a lit cigarette. The most plausible explanation however would be a burst light bulb on the mezzanine that apparently had been left on (the switch was found in the "on" position during the field investigation).

The abundance of combustibles inside the barn allowed the fire to quickly propagate and become widespread. Plastic from the crates would have melted when exposed to the effects of heat flux; moreover, according to the experts' report, this polypropylene (i.e. crate component) is, chemically speaking, similar to fuel oil in liquid form. Since the bags of ammonium nitrate were placed close to the crates (within 10 cm), the two products could have spilled out onto the barn floor until mixing with one another. Such a mix, under certain conditions, is capable of detonating. Given that the explosion epicentre was in the building's southern quadrant, in a zone assumed to have stored between 3 and 5 tonnes of fertiliser with a cracked ground floor concrete slab, this phenomenon would have likely caused the explosion.

Emergency response difficulties:

During the emergency response, responders had to face several difficulties:

- Unfamiliarity of the presence of fertilisers inside the building as late as 8 pm on October 2nd, as the tree farmer probably had no knowledge of the hazards associated with ammonium nitrates and only mentioned them to rescue personnel after another farmer pointed it out. According to testimony, fire-fighters had not been forewarned about the potential dangers of ammonium nitrates via a nationwide operations memorandum, although being informed of the presence of such products probably would not have led to taking any special precautions in the immediate future.
- Inadequate public water supply network, with access to a number of fire hydrants being obstructed by mud while others lacked sufficient pressure, requiring responders to set up a shuttle system with tanker trucks in order to ensure continuous fire hose supply throughout the intervention.
- Presence of large quantities of combustibles inside the barn (crates stacked over 6 m high, straw, hay, fruits, insulating materials from the cold storage room, etc.).
- Communications constraints due to the lack of mobile phone network coverage.

A short while before the accident, the town hall had set up a 200-m³ stormwater collection basin that also served as a backup fire-fighting water supply. Since the summer of 2003 was so dry, this storage capacity was never filled prior to the accident.

ACTIONS TAKEN

At the local level:

A meeting was held on March 25, 2004 at the Saint Romain-en-Jarez Town Hall; in attendance were: the Prefecture's Secretary General, the town's mayor and municipal council members, as well as representatives from national public works offices, public safety agencies and a farmers' trade union, along with members of the association to defend accident victims, the barn owner and his architect. The farmer, who was awarded a subsidy of nearly one million Euros, agreed to rebuild a specific barn structure for storing fertilisers, as well as all of the hazardous and phytosanitary products, 3 km outside the village. Another measure announced was the regular inspection of a control commission assigned to verify that the site was only housing equipment and fruit. This building was to be constructed in full respect of the technical specifications set forth in the January 21, 2002 circular relative to the storage of fertilisers and on a site picked 3 km from the farm on the village's high ground. As an added precaution, fertilisers were to be insulated within a

special cellular structure. Backup water capacity would also be planned onsite to compensate for potential recurrent supply shortfalls in the event of fire.

On April 30, 2004, a local information and monitoring commission, presided by the Loire Department's Prefecture, was created with the stated intention of informing the local population by organising an inspection of the forester's new farm, once completed. The visit took place on July 24, 2007 and led to announcing that the farmer had satisfied all requirements stipulated by government agencies, i.e.:

- Separation of sites to enable storing feed outside the village,
- Ammonium nitrates for possible delivery in limited quantities suitable for immediate spreading and moreover for offsite storage.

Workplace inspection authorities reminded the farmer of the conditions required for the storage of phytosanitary products: appropriate signs, aeration, ventilation, retention tanks, an accessible backup supply of absorbent materials, deadbolt locking system, etc.

Following this inspection visit, the commission was disbanded.

Local residents, whose dwellings sustained damage, along with the injured fire-fighters filed a civil suit. A legal enquiry was initiated against unknown persons on counts of involuntary personal impairment and involuntary property deterioration due to the effect of explosion or fire. On December 9, 2004, the enquiry issued a ruling of no grounds for prosecution, with the farmer not being held liable for any wrongdoing. An appeals process through the penal courts issued the same judicial ruling on February 14, 2006.

A civil procedure had also been initiated in order to identify liabilities involved, for the purpose of determining compensation awards regarding property for the local residents and bodily injury for the fire-fighters. On March 21, 2007, the Saint-Etienne Court of First Instance found insufficient evidence to convict the farmer. This decision was upheld on March 10, 2009 by the first Examining Chamber of the Lyon Appellate Court, which ordered the fire-fighters to absorb the costs directly incurred due to the legal counsel retained by the forester and his farming operation. In April 2009, the fire-fighters filed a judicial appeal seeking annulment.

On February 18, 2008, the insurer of 22 village residents undertook legal proceedings against the town of Saint Romain-en-Jarez and the Loire Department fire rescue services for failing to properly manage their fire-fighting resources when battling the blaze. The municipality, in turn, filed suit against the company responsible for local water supply distribution.

It should be noted that subsequent to this event, both the Mayor and all acting municipal council members resigned and a new governing team was elected in December 2003. Between October and December 2003, the Loire Prefecture stepped in by naming a delegation to run the municipality.

At the national level:

Following this accident, oversight of ammonium nitrate-based fertiliser storage conditions on farms and agricultural supply cooperatives was incorporated into the 2004 programme of priority actions aimed at field agencies involved in agricultural inspections. The Ministry of Agriculture detailed the measures and objectives of this action campaign in a memorandum dated May 25, 2004, which proposed among other things a standardised control sheet for inspectors.

An assessment of the 332 inspections performed (116 suppliers and 116 users) within the scope of this priority campaign was derived by the General Directorate of Water Affairs and Forestry, underscoring:

- a serious lack of knowledge on hazards relative to ammonium nitrate-based fertilisers and single evaluation document focusing on an incomplete set of risks;
    - among fertiliser users, the risk of detonation, which is the best known of all, shows up in barely 56% of inspected farms, most likely due to the tragic accident that occurred in Saint-Romain-en-Jarez;
    - nearly 3/4 of suppliers were aware of the hazards tied to the decomposition or detonation of fertilisers (but only 61% knew about the self-sustaining decomposition of compound fertilisers);
    - risks associated with fertiliser decomposition (especially toxic fumes) were not known in over half, and in some cases up to 75%, of the inspected farms for self-sustaining decomposition of compound fertilisers;
    - suppliers were required to inform end users not only of hazards related to ammonium nitrate-based fertilisers, but also of prevention measures to be introduced during storage: more than 25% of the inspected sellers were not in a position to satisfactorily perform this information mission;
    - safety data sheets were only available in barely half (56%) of seller offices and among an extremely small minority of users: 12%.

- fertiliser storage premises most often well designed, yet not always adequately maintained and very poorly signed (this would apply to both suppliers and users);
    - well-maintained and clean premises among 85% of suppliers, yet only 65% of users: this weak maintenance record among users could exert serious impacts should a fire break out near open bags of fertiliser (e.g. the case with big-bags), or on a floor dirtied by oils or fuels (e.g. originating from farm machinery): fertiliser shows heightened sensitivity to both decomposition and detonation in the event of fire outbreak;
    - a sign indicating the presence of hazardous products is only on display in 10% of the inspected sites and the "no smoking" sign in barely a third of the sales outlets;

- "hot spots", especially those related to materials handling equipment;
- disturbing proximity of incompatible products or fuels in a majority of fertiliser storage facilities;
- a highly-insufficient organisation of emergency response resources and intervention procedures.

LESSONS LEARNT

Even though the hazards related to fertilisers containing ammonium nitrate (either in solution or compound fertilisers containing ammonium nitrate) are well known and despite both the publication of an information brochure by fertiliser manufacturers and the inspection of ammonium nitrate-based fertiliser storage conditions on farms and farming supply cooperatives by local agricultural inspection offices, this accident reveals that such hazards are all too often underestimated in the field, and in some cases unknown to farmers. Besides compliance with Standard NFU 42 001 or European Directive 80/876/EC, as transcribed into modified Decree 80-478 enacted June 16, 1980, the risks induced by storing ammonium nitrate may be limited by adopting a number of technical and organisational measures, namely:

- ✓ Clean, well ventilated and appropriately signed premises (up-to-date and visible posters of safety guidelines to be followed, in particular "no smoking" signs), with electrical circuits and equipment in good working order, compliant with standards and verified on a regular basis;
- ✓ Workplace and safety guidelines developed by the farmer, who is also responsible for ensuring that the content is known to and applied by all, including external contractors working onsite, along with regular personnel training sessions, particularly for employees involved in accident prevention;
- ✓ Bag storage, intended to reduce the risks of fertiliser contamination by means of incompatible products;
- ✓ Fertiliser storage in a barn that contains none of the following:
  - o products capable of igniting during a fire: straw, hay, cereals, livestock feed, sawdust, wooden crates, pallets, sulphur, etc. Fertilisers are combustive products that cause fires to grow (fertiliser bags carry the "combustive agent" warning logo);
  - o products capable of contaminating fertilisers: organic materials, fuel, fuel oil, gasoline, gas, phytosanitary products, and a number of incompatible products (chlorates, copper salts, etc.);
- ✓ Prohibition of fertiliser storage in zones with direct access to hot spots, flames, bare light bulbs, electrical wires, heating ducts, welding operations; in the absence of personnel or operating activity, it is recommended to proceed by turning off the general electrical supply;
- ✓ Fertiliser storage only within a fire-resistant cell, to the greatest extent possible;
- ✓ Vehicle parking at safe distances from fertilisers and proper maintenance of motorised vehicles so as to avoid:
  - o fertiliser contamination by eventual fuel or oil leaks,
  - o vehicle hot spots (engine, exhaust pipe, etc.),
- ✓ Room equipped with fire-fighting gear (equipment in appropriate quantity and quality for the specific risks encountered, enabling either internal or external response).

Moreover, in the event of fire or risk of fire, the farmer must be able to identify products, with the assistance of commercial documentation, as well as indicate to responders the quantity of fertilisers present onsite and their exact storage locations.

This accident has also highlighted the benefit of being able to quickly detect all fire outbreaks in farm buildings and then inform emergency personnel with a very short turnaround. In this particular case, fire-fighters were actually notified a full hour after the fire had broken out and came onto a scene that had already deteriorated. A smoke detector coupled with an alarm could, for example, have helped reduce the detection period and consequently accelerate the arrival of rescue teams, perhaps limiting accident impacts.

In an agricultural context, with the widespread presence of very small operations relying on management techniques that are either insufficiently experienced or organised (according to the enquiry conducted), information and awareness remain the basis for preventing such accidents.

Fertiliser suppliers must still be reminded to inform end users of the hazards these products represent and the critical prevention measures to be adopted for their safe storage. Suppliers must therefore be the first to show awareness of existing risks, as limited as they may be, as well as be knowledgeable of the prevention measures to be implemented.

Other accidents involving the use of ammonium nitrates:

- ARIA 17972 - 29/04/1904 - BELGIUM - TESSENDERLOO
- ARIA 14373 - 21/09/1921 - GERMANY - OPPAU*
- ARIA 12271 - 15/04/1947 - UNITED STATES - TEXAS CITY
- ARIA 14732 - 28/07/1947 - 29 - BREST
- ARIA 11145 - 30/08/1972 - AUSTRALIA - TAROOM
- ARIA 5009 - 29/10/1987 - 44 - NANTES*
- ARIA 535 - 28/11/1988 - UNITED STATES - KANSAS CITY
- ARIA 12439 - 03/09/1991 - GREAT BRITAIN - IMMINGHAM
- ARIA 6268 - 13/12/1994 - UNITED STATES - PORT NEAL
- ARIA 21329 - 21/09/2001 - 31 - TOULOUSE*
- ARIA 26980 - 22/04/2004 - NORTH KOREA - RYONGCHON

** A detailed accident report is available on www.aria.developpement-durable.gouv.fr.*

Information sources:

- Definitive "no grounds" notice from the Saint-Etienne Court of First Instance, December 2, 2004.
- "No grounds" order issued by the Saint-Etienne Court of First Instance, December 9, 2004.
- Confirmation of the "no grounds" order issued by the Examining Chamber of the Lyon Appellate Court, February 14, 2006.
- "Analysis of damages caused by the explosion of a farm barn on October 2, 2003 in Saint-Romain-en-Jarez (Loire Department)", O. Dolladille, E Leprette, INERIS for the Ministry of Ecology and Sustainable Development, January 2004.
- Order issued on January 10, 1994 relative to simple solid, nitrate-based fertilisers (ammonium nitrates, sulpho-nitrates, etc.), corresponding to specifications set forth in Standard NFU 42.001 (or the equivalent European standard), or to nitrate-based compound fertilisers (storage).
- Circular promulgated January 21, 2002 relative to classified facilities: Prevention of major accidents inside fertiliser warehouses dependent upon authorisation under heading 1331 of the protocol.
- "Prevention of professional risks generated by ammonium nitrate-based fertilisers", Ministry of Agriculture and Fisheries, Directorate of Farming Operations, Social Policy and Employment, Division of Labour and Employment - Office of Workplace Regulations and Safety (http://agriculture.gouv.fr/IMG/pdf/fiche_nitrate_ammonium-1.pdf).
- DGFAR/SDTE/N2004-5015 memorandum dated May 25, 2004 relative to the 2004 priority action campaign regarding the safe storage of solid, ammonium nitrate-based fertilisers.
- DGFAR/SDTE/N2005-5030 memorandum dated September 14, 2005 relative to a summary of the 2004 priority action campaign regarding the safe storage of solid, ammonium nitrate-based fertilisers.
- "Explosion of ammonium nitrate solutions inside a farm barn", René Dosne, "*Face au Risque*" No. 399, January 2004.
- "Elements for conducting a danger study of a nitrate-based fertiliser storage facility", UNIFA, 2005.
- "Explosion in Saint-Romain: Presence of ammonium nitrates and plastic", article from *La Gazette*, October 22, 2004.
- Major Technological Accident Report – Saint Romain-en-Jarez – Explosion of ammonium nitrate storage on a farm – conducted by students enrolled in the 2006-2009 graduating classes, in the option Engineering and Risk Management, Huber Curien School.
- Photographs and video footage from the Loire Departmental Fire and Emergency Response Unit.