

## **Base de données ARIA - Etat au 15/02/2012**

### **Fireworks accidents in France Sorted by date of event**

n°de requête : ed\_11974\_bis

La base de données ARIA, exploitée par le ministère du développement durable, recense essentiellement les événements accidentels qui ont, ou qui auraient pu porter atteinte à la santé ou la sécurité publique, l'agriculture, la nature et l'environnement. Pour l'essentiel, ces événements résultent de l'activité d'usines, ateliers, dépôts, chantiers, élevages,... classés au titre de la législation relative aux Installations Classées, ainsi que du transport de matières dangereuses. Le recensement et l'analyse de ces accidents et incidents, français ou étrangers sont organisés depuis 1992. Ce recensement qui dépend largement des sources d'informations publiques et privées, n'est pas exhaustif. La liste des événements accidentels présentés ci-après ne constitue qu'une sélection de cas illustratifs. Malgré tout le soin apporté à la réalisation de cette synthèse, il est possible que quelques inexactitudes persistent dans les éléments présentés. Merci au lecteur de bien vouloir signaler toute anomalie éventuelle avec mention des sources d'information à l'adresse suivante :

BARPI - DREAL RHONE ALPES 69509 CEDEX 03 / Mel : [srt.barpi@developpement-durable.gouv.fr](mailto:srt.barpi@developpement-durable.gouv.fr)

     **ARIA 39303 - 29/05/1866 - 75 - PARIS**

20.51 - *Fabrication de produits explosifs*

     20.51 - Manufacturing of explosive products

     An explosion occurred around 5 pm inside the production workshop operated by a pyrotechnician. Fire spread to the charger workshop, which was adjacent to the production shop, as a consequence of changes introduced by the manufacturer following expropriation of a portion of the facility. The fire also spread to the composition workshop, located 7 m from the workshop where the explosion first erupted. However, 65 kg of powder, along with the entire inventory of fireworks, the fireworks colour room and other lightweight buildings were all spared. Fire-fighters counted 23 dead and 12 seriously injured, all of whom were transported to the nearest hospice facility. The press announced a total of 40 victims. The Public Health & Hygiene Council made a site inspection. The suddenness of the explosion, coupled with the fact that the most heavily damaged wall was the one with the lightning rod attached, suggested that lightning may have been at the origin of this catastrophe. The pyrotechnician moved his set-up to Prés Saint-Gervais and introduced prevention measures, namely: safety distance between the fireworks depot and the charger workshop and then between the charger workshop and the colour warehouse; separation of production facilities from storage areas; buildings designed for rapid evacuation; heating by the circulation of hot water; lighting by lamps with reflectors positioned outside the workshops; and protection of window surfaces (using blinds) in order to avoid materials heating up and prevent malicious intent.

     **ARIA 38267 - 12/04/1977 - 84 - MONTEUX**

20.51 - *Fabrication de produits explosifs*

     20.51 - Manufacturing of explosive products

     In a fireworks manufacturing facility, a succession of explosions (perhaps 5 in all), 3 of which were more violent, destroyed a coating workshop (where black powder was being coated) and spread fire to neighbouring workshops (through the domino effect). The building (cement floor, cladding and fibre cement roof, without any doors) was completely demolished. The technician inside was killed on the spot; another, located 180 m from a building, was seriously burned and died at the hospital. A total of 19 employees were injured by flying glass, 2 of whom in critical condition. Windows were shattered within a 800-m radius. Beyond the site boundary, broken glass panes were recorded on homes as well as in a secondary school 200 m further away. The site's other buildings were damaged, with doors ripped out and windows smashed, etc.

The fall of a tray or star triggered the reaction, which was then exacerbated by an accumulation of chlorate products with great sensitivity inside the coating workshop. The rated value of the building was set at 40 kg; according to experts, the quantity present would have reached near 260 kg. Moreover, the safety organisation was shaped around the fire hazard, as the explosion risk had not been identified. Experts recalled the importance of detailed workplace safety reports that take into account the risks presented by chlorate products; they also emphasised the need to conduct operations on sensitive substances and split loads (decoupling) within a protected environment. The authorised workstation quantities must be closely respected and the schedule set to ensure avoiding all product accumulation.

     **ARIA 36014 - 08/08/1983 - 84 - LORIOL-DU-COMTAT**

20.51 - *Fabrication de produits explosifs*

     20.51 - Manufacturing of explosive products

     In a fireworks production plant, a handling error (dropped material) inside a packaging workshop caused a "revolving sun" fireworks display to ignite around 2 pm.

The technician was unable to extinguish the fire using the extinguishers at his disposal; he escaped the building and sounded the alarm, while incandescent projections were reaching the neighbouring containers.

All hangars and buildings on the site were one-story metal frame structures with walls and a roof made of sheet metal profile section (movable roof), all of which was supported on a concrete slab. The fire, which quickly gained in intensity, spread within 20 minutes in all directions, by means of rockets and ignited debris, reaching pallets of fireworks awaiting shipment nearby, then anti-hail rockets stored 20 m away. The successive explosions of anti-hail rockets in turn caused fire outbreaks inside other buildings, in addition to igniting onsite vegetation (cypress hedges) and a field 800 m offsite. Backup was called to help contain new fire outbreaks in the vicinity of the depot.

The fire was contained around 3:15 pm through a deployment of major fire-fighting resources: two 1-tonne capacity pump trucks and 12 tanker lorries used for fighting forest fires. This equipment was fuelled via suction points set up along a canal crossing the area of intervention and constituting a 1,200-m<sup>3</sup> water reservoir. All individual fire sources were extinguished by 6 pm. Fire-fighters' effective knowledge of the site and of fire-related risks, thanks to joint drills performed with the company's safety unit, led to a successful intervention. No injuries were reported; property damage consisted of 7 collapsed buildings and a few vehicles (trailers, handling devices).

Powder storage areas were split into small distant structures located in a wooded zone that was not reached by the blaze. The high-quality site design made it possible to mitigate fire development and thereby avoided a more widespread accident. Nonetheless, due to the extreme heat, employees had opened building doors for ventilation, which in turn allowed flaming projections to enter into these premises and thus spread the fire to 2.8 tonnes of fireworks. The operator wound up adopting the following measures:

- Reinforcement of the protective features on the part most sensitive to the revolving fireworks ignition device, i.e. of the "hawthorn" type: a plastic design was to replace the brown wrapping paper;
- Closure in the packaging centre where anti-hail rockets were being stored; this zone was directly responsible for the fire spreading and moreover gave rise to many secondary fire sources;
- Protection of building openings by means of a grating;
- Construction of fire walls across from buildings whenever the building orientation so dictated;
- A 25-m spacing for all buildings used to store fireworks, with this distance being reduced should screens be installed to resist both projections and heat radiation;
- Strengthening of operating rules in order to ensure continuous compliance with maximum allowable quantities in the various storage locations (even for short periods on intermediate storage facilities, given the risk of a relay effect);
- The doors to intermediate storage depots were to be kept closed in the absence of employees.

          **ARIA 37120 - 12/09/1985 - NC - NC**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 Packages of fireworks caught on fire during their loading into a metal container. Three technicians were moving boxes containing fireworks into a larger container. The boxes placed on pallets were then conveyed to the neighbouring storage depot by forklift. While arranging a box at the bottom of the container, one of the technicians heard a thud and saw a white glow emanating from this particular box. The fire quickly spread to all boxes in storage. Ignited elements were then projected, causing fire to spread to the surrounding vegetation. The staff closed the storage depot doors, protected the pallets in the queue by means of sprinkling, and then responded to the vegetation set ablaze. A total of 65 boxes of fireworks, i.e. approx. 400 kg, were destroyed, as were the container and forklift. A cypress hedge located 50 m away was burnt.  
 A shock or friction caused the fireworks to ignite inside the packages. The operator proceeded by: prohibiting the use of an igniter not fitted with a protective cover, wedging the parts contained inside the boxes, and systematically short-circuiting the electric igniters prior to their assembly. The operator also reminded technicians to handle the boxes with great care and decided to choose a loading dock slot by taking into account the risk of propagation created by projections of ignited products.

          **ARIA 37089 - 16/02/1987 - 84 - LORLIOL-DU-COMTAT**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 During the manual assembly of pyrotechnic signals, the technician repositioned the pull igniter on a signal, thus triggering it. In violation of protocol, he left the object still ignited at place and left the premises. The fire spread to the hundred signals present in the workshop.  
 The fire was contained by the site's first response team with extinguishers, while in the presence of many onlookers (from among the staff). Products in the queue were to be separated from those implemented via the screens. A reminder was issued about safety guidelines, focusing on the indication to push down on the ignited object into the sand tank placed next to the workstation. The steps of the evacuation plan for installations in the event of accident were also emphasised.

          **ARIA 37097 - 11/05/1987 - 09 - MAZERES**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 A strong explosion occurred during the compression of a 1.5-kg pyrotechnic composition made from potassium and barium nitrates, aluminium and black powder wetted in water. The press, placed in the unit, was automatically fed by a hopper. Friction at this level due to poor maintenance of the machinery caused this deflagration. All lighter weight parts of the unit were destroyed and equipment was degraded. The adjacent units were slightly damaged.  
 Additional testing on this composition demonstrated that its critical explosion height was in fact very low (10 cm) and moreover that the wetting step did not flegmatise the composition. Experts have highlighted the importance of in-depth knowledge on implemented products as well as on preventive installation maintenance.

          **ARIA 37114 - 18/12/1987 - 84 - LORLIOL-DU-COMTAT**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 A technician weighed out 150 g of red phosphorus in a pyrotechnic composition used for fireworks within a bowl. A small quantity fell onto the weighing tray. When the technician picked up the material using a brass measurement spoon, friction caused the spilled product to ignite, followed by ignition of the entire bowl contents. The technician immediately removed the bowl from the shop space and extinguished the fire with the extinguisher found on the premises. The operating protocol was specified in greater detail; the cleaning step will be performed with a brush and wet cloth.

          **ARIA 37039 - 15/01/1988 - 84 - LORLIOL-DU-COMTAT**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 Traces of a pyrotechnic composition made from potassium perchlorate and aluminium exploded during disassembly of a jack screw support. The technician was loosening a fastening screw when a flash occurred along with a very loud sound effect, as initiated by rubbing during a maintenance operation. This pyrotechnic element had been preliminarily cleaned in a cursory fashion with water.  
 Experts have recalled the importance of ensuring prior to any disassembly step the complete decontamination of all machinery; moreover, if such a step cannot be guaranteed, then appropriate measures would need to be adopted to ensure the technician's protection.

          **ARIA 37058 - 29/01/1988 - 40 - SAINT-PAUL-LES-DAX**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 A fire broke out in an oven for fireworks stars at the time a technician remotely opened the oven doors to cool the contents. The 30 kg of composition made from barium chlorate, accroides gum, fine coal and sulphur were consumed by the fire, accompanied by projections of ignited stars. The oven control commands were damaged.  
 Additional tests, conducted subsequent to a similar incident that occurred on 10th March (ARIA 37060), demonstrated that the reintegration of manufacturing rejects into the normal cycle served to drop the spontaneous ignition point of the composition to 75°C, which was a temperature potentially reached during oven heating phase. Rejects would no longer be added back into the production cycle, but instead directly destroyed. Also, the heating control commands were moved away from the oven itself.

     **ARIA 37060 - 10/03/1988 - 40 - SAINT-PAUL-LES-DAX**

    *20.51 - Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
  A fire broke out in an oven for drying fireworks stars at the time a technician remotely opened the oven doors to cool the contents. The 30 kg of composition made from barium chlorate, accroides gum, fine coal and sulphur were consumed by the fire, accompanied by projections of ignited stars. The oven was completely destroyed.

This incident was the second in two months (see ARIA 37058) following a process modification that called for the reintroduction of manufacturing rejects into the normal cycle. Further testing on the composition revealed that this step of reintegrating manufacturing rejects into the normal cycle served to drop the spontaneous ignition point of the composition to 75°C, which was a temperature potentially reached during oven heating phase. Rejects would no longer be added back into the production cycle, but instead directly destroyed. Also, an additional safety device would be installed on the oven heating unit.

     **ARIA 383 - 22/03/1988 - 16 - LE GOND-PONTOUVRE**

    *20.51 - Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
  A technician was producing red comets by applying a compressive force with a mallet in a mould containing a chlorate pyrotechnic composition (featuring potassium chlorate, strontium oxalate, aluminium, magnesium and black powder). Two other employees were performing different operations on the same work table.

Excessive compression, combined with either abnormal friction or the presence of a foreign object, caused an explosion at the compression station, in turn leading to the death of the technician and serious burns to the other two workshop employees. The building was also damaged.

Experts in the field point out that:

- the compression of chlorate compositions is in fact hazardous and must be performed in a protected zone;
- the sensitivity and behaviour of the products implemented must be well understood;
- to the greatest extent possible, it is necessary to substitute hazardous compositions with less sensitive ones;
- the execution of various activities on the same premises must not be undertaken without first adopting special measures;
- an individual apparatus must be used to complement the technician's protective gear;
- technicians must be made aware on a regular basis of the risks they incur through a well-designed training programme.

     **ARIA 37066 - 01/04/1988 - 84 - MONTEUX**

    *20.51 - Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
  A fire broke out during the assembly of a batch of fireworks. The pyrotechnic composition was based on a pulverine sodium oxalate, antimony sulphide and aluminium. The operation consisted of closing the firework by a cardboard disc and then compressing it by means of a manual press. The fire spread to a portion of the elements present at the workstation. In following the protocol, the technician immediately left the premises and alerted emergency response teams; he was unharmed. The machinery on the premises was degraded. The station's cleanliness and organisation helped limit the extent of damage and speed of fire spreading. The operator decided to widen the screens in order to improve their efficiency.

     **ARIA 384 - 28/06/1988 - 40 - DAX**

    *20.51 - Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
  6.4 kg of a pyrotechnic composition prepared during the morning were temporarily stored in a building at lunchtime. A very powerful explosion spontaneously occurred on this composition containing barium chlorate, aluminium powder and paraffin oil. The most likely cause of this accident was heating by means of chemical action due either to fouling

of one of the components by impurities or to a mix design error (confusion between two products). The transition from combustion to an explosive state had not been taken into account as part of the workplace safety report.

Since plant staff had left the site (lunchbreak), no injuries ensued. Property damage was extensive inside the facility: complete destruction of one building, deterioration to nine adjacent buildings. Sprayed debris could be observed within a 60-m radius.

The operator proceeded by: suspending production of the composition, performing a series of tests on similar compositions to evaluate their likelihood of exploding, and revising workplace safety report conclusions. The operator also issued a set of guidelines: the contents of each container were to be clearly marked, and only those essential to the current activity could be stored inside the facility.

     **ARIA 37073 - 19/07/1988 - 01 - SAINT-JEAN-DE-THURIGNEUX**

    *20.51 - Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
  A fire erupted during the operation of stapling ignition fuses onto firework shells. The fire spread to the installation's equipment and machinery and caused sporadic explosion of the completed fireworks. Personnel were able to evacuate the building, and no injuries were reported. The effects were limited to the building interior; all equipment and machinery were destroyed. The process for decoupling the site's various explosives was improved.

     **ARIA 521 - 05/08/1988 - 40 - DAX**

    *20.51 - Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
  In a pyrotechnic production plant, a technician assembled and linked a batch of fireworks. He completed tying a blinking rocket on its fuse and set the assembled package on the work table when he began to feel, in his left hand, ignition of the fireworks (perhaps due to friction?). The projection of stars contained within the firework quickly spread

the fire to products stored inside the building. Personnel were evacuated from the site. The technician sustained slight burns on his left forearm. The building was totally destroyed and a sharp surge in thermal radiation felt up to 25 m away.

Pyrotechnic experts recall the importance of possessing extensive knowledge of the product introduced, particularly through the safety fact sheet. Both the workstation layout and premises organisation have to undergo an in-depth assessment in order to facilitate personnel evacuation. Special measures have to be adopted so as to mitigate the risks of transmission from one workstation to the next. The mass of

explosive material allowed on each workstation should be lowered to the strict minimum required.

          **ARIA 37084 - 20/10/1988 - 84 - MONTEUX**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 In a pyrotechnic facility, a technician was producing fireworks (jets with coloured grains). After compression of the pyrotechnic composition, one of the "sticks" used as a punch was still stuck in the matrix. The technician used a bronze sledgehammer to loosen it, and in so doing triggered the composition. The fire was confined to the products on the particular workstation. Excessive machinery wear was found to be the cause. The operator produced a new set of machines and instituted a periodic equipment control procedure.

          **ARIA 37080 - 18/11/1988 - 30 - MANDUEL**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 A technician crushed the elements composing a pyrotechnic ignition powder using a mortar and pestle apparatus; he was protected by a polycarbonate screen, a lab coat (with sleeves lowered) and leather gloves. The friction of pestle on mortar caused combustion of the 4 g of composition, made from lead oxide, silicon and collodion cotton. The onset of fire, which arose under normal operating conditions, was of no consequence for personnel safety. The protective screen was slightly blackened. Another identical incident occurred on 25th November, 1988.

          **ARIA 993 - 26/09/1989 - 84 - MONTEUX**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 In a fireworks production facility, a violent deflagration occurred inside the unit containing an automatic loading hopper for 75-mm shells carrying 2 kg of pyrotechnic composition made from potassium nitrate, sulphur and aluminium. The phenomenon seemed to have been triggered outside the unit and would have propagated by dust deposited on the machinery. The blast caused one injury; the unit and its equipment sustained serious damage. Some of the protective features did not properly respond, e.g. armoured windows and doors. The implementation of certain compositions by means of automated installations produced dust that was difficult to control. The site operator developed a solution that would prove "less sophisticated" for distributing this type of composition. A granulation step prior to implementation was also to be evaluated. The electric vibrating bowls were replaced by pneumatic systems.

          **ARIA 36874 - 20/12/1989 - NC - NC**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 During a workstation preparation operation, a technician moved a machine and caused a glass receptacle containing a residue from a priming composition awaiting destruction to drop to the ground. This action caused the contents to explode (10 g of priming composition made from red phosphorus, antimony, potassium chlorate, powdered glass and binder). The technician was struck by shattered glass on his legs. The container material was to be replaced. The storage, transfer and waste destruction procedures were all reviewed with the relevant technicians.

          **ARIA 36876 - 01/06/1990 - NC - NC**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 A technician was preparing 250 g of an explosive mixture to produce firecrackers used as alerts by divers. The technician noticed at the end of the mixing process the presence of lumps in the composition and decided to run it through a sieve. In order to streamline the operation, he added a porcelain bead into the composition. Turning on the sieve triggered the blast (due to friction), which ejected the technician 1.5 m; he suffered from noise-induced hearing loss. The door to the shop room was blown 10 m off its hinges, a partition wall and the suspended ceiling both collapsed. The technician's decision to initiate an additional work step not included in the protocol was the cause of this accident. The operator recalled to staff the need to strictly apply and not deviate from the protocol.

          **ARIA 22851 - 28/11/1990 - NC - NC**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 In a pyrotechnic plant, an explosion detonated during fireworks production when exposed to compression. The technician was manufacturing 27-mm calibre violet stars through the use of a pyrotechnic composition based on potassium perchlorate, sulphur, copper oxychloride and dye. The quantity involved was approx. 3 kg. This production operation consisted of compressing the composition by means of a punch and rubber mallet within a bronze mould composed of 10 cylinders. The deflagration occurred as the material was settling in one of the cylinders. A blast was felt along with the projection of metal pieces stemming from the mould. The technician was injured on the thigh by shattered debris. Property damage was limited; only the machinery was destroyed. This incident was caused by the percussion of the punch on the bronze prong lying at the bottom of the matrix. The operator installed a protective screen in front of the workstation between the mould and the remaining composition, in addition to completing technician protection with a copper apron and modifying the machinery layout (elimination of 4 cylinders on the mould, increase in cylinder height, creation of a thrust bearing to avoid all contact between the punch and the prong).

          **ARIA 3036 - 06/02/1991 - 84 - MONTEUX**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 Inside a pyrotechnic production plant, black powder ignited suddenly during the pelleting step. Personnel working in the vicinity of the black powder pellet-making unit heard a deaf sound. The first person arriving on the scene noticed that the door to the unit was open, the pellet-making machine shut off and a few black powder capsules strewn on the

floor on both sides of the bin for finished products.

Friction on a punch press would have caused the blaze, which remained confined to the pellets already produced and undergoing compression (witnessed by powder in the intact hopper). The automatic quenching system, which was still operational, did not activate. The operator moved the fire detection unit to allow detecting the onset of fire at an earlier point in time. He moreover increased the compression tooling inspection frequency, modified the hopper in order to limit its physical capacity to just that authorised by the workplace safety report, and lastly moved the pellet machine activation control to a location outside the facility's Z1 zone.

  □ □ □ □ □ **ARIA 22852 - 03/04/1991 - NC -**

  □ □ □ □ □ 20.51 - *Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

 □ □ □ □ □ An explosion occurred inside a pyrotechnic unit devoted to producing fireworks while a subcontractor was engaged in renovation work. The vibrating bowl to be modified had been cleaned earlier by the site operator. The company assigned the job was performing arc welding at the time of the deflagration. A blast was felt along with the projection of material debris. One person sustained 2nd-degree burns on the thorax, hands and face, in addition to slight injuries to the eardrums. The facility was not damaged extensively. Following an investigation, it appeared that only the upper helicoid had undergone decontamination. The lower one, which proved less accessible, had not been cleaned. Pyrotechnic experts have recalled that in general, it is helpful to: systematically soak in water or an appropriate solvent any device submitted to an aggressive intervention; and ensure that all devices not permitting full disassembly for control and cleaning be devoid of traps capable of accumulating explosive products. When it becomes impossible to avoid hollow parts, such parts must be filled by an inert product (polymers).

  □ □ □ □ □ **ARIA 5843 - 28/02/1992 - 84 - MONTEUX**

  □ □ □ □ □ 20.51 - *Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

 □ □ □ □ □ In a pyrotechnic production plant, a fire was ignited from residues of a pyrotechnic composition during the renovation of a workstation performed by a subcontracted firm. In an abandoned room that had previously been used for a praline-coating operation (covering the paste with a black powder), two workers sliced through threaded rods with a plough disc just above the product sieving screens that had been cleaned but not yet decontaminated and still contained traces of the composition, which then ignited upon contact with the burst of sparks. The two workers sustained 1st and 2nd degree burns to their hands and face; both required hospitalisation. An insufficient cleaning within the works zone was responsible for this accident. The Classified Facilities Inspectorate filed a report of these various findings.

The operator then focused on evacuating all pyrotechnic products from the premises prior to any modifications, in addition to treating the polluted screens like a pyrotechnic object and improving the management of all maintenance operations performed by subcontractors.

  □ □ □ □ □ **ARIA 3445 - 05/03/1992 - 59 - VILLENEUVE-D'ASCQ**

  □ □ □ □ □ 85.59 - *Enseignements divers*  
85.59 - Miscellaneous instruction

 □ □ □ □ □ A fire, followed by a series of explosions, broke out during the handling of fireworks at a pyrotechnic training centre. 6 slight injuries were reported. Property damage was extensive: the centre's buildings were heavily deteriorated and had to be torn down.

  □ □ □ □ □ **ARIA 3895 - 07/10/1992 - 34 - MONTPELLIER**

 □ □ □ □ □ 47.78 - *Autre commerce de détail de biens neufs en magasin spécialisé*  
47.78 - Other retailer selling new goods in a specialised store

 □ □ □ □ □ In a gunsmith's, a cartridge exploded during a practice shoot using a rifle undergoing repairs. A fire broke out, causing hundreds of fireworks rockets and munitions to explode. The fire spread to both floors of the building. A safety perimeter was set up and the building evacuated. The store and several apartments on the upper floor were destroyed. A motorcycle was burnt out. A pungent smoke smell permeated the premises of neighbouring buildings.

  □ □ □ □ □ **ARIA 36820 - 05/11/1992 - 65 - TARBES**

 □ □ □ □ □ 25.40 - *Fabrication d'armes et de munitions*  
25.40 - Firearms and ammunition manufacturing

 □ □ □ □ □ A deflagration occurred during the pelleting of black powder (BP). After a few minutes of pelleting operations, BP dust friction between the hopper and the table (or between the punch and the matrix) caused the deflagration of BP stored in the hopper, whose compression step had already been carried out, accounting for 200 g of product. The movable unit sidewall was jettisoned, the punch and matrix very slightly deteriorated. The operator shortened the interval between cleanings of the various machine control devices in order to mitigate the risks of BP dust accumulation.

  □ □ □ □ □ **ARIA 22848 - 23/02/1993 - 84 - MONTEUX**

 □ □ □ □ □ 20.51 - *Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

 □ □ □ □ □ In a pyrotechnic plant, fire broke out in conjunction with a tremendous release of smoke during the loading of fireworks. The composition involved was produced from barium nitrate, aluminium and sulphur. The automatic extinction system was not activated and the automatic compressed air shutoff was inoperable. A portion of the machinery (composition distributor and compressed air pipe) was destroyed. The fire was contained by the armour plate covering the loading equipment. This incident was caused by either: a poorly adjusted machine, the presence of a foreign object in the composition, or else a static electricity phenomenon. Lessons drawn include a verification of safety report conclusions on product behaviour and workstation design; moreover, the need was revealed to multiply the number of systematic controls on the various fire or safety devices (grounding braids, extinction ramp subassemblies and automatic air shutoff switches).

     **ARIA 22845 - 13/04/1993 - 14 - TOURVILLE-EN-AUGE**

     *20.51 - Fabrication de produits explosifs*

*20.51 - Manufacturing of explosive products*

  In a fireworks production facility, an explosion accompanied by a fireball occurred during a resumption in production. The compression operation on the first composition batch (made of barium nitrate, sulphur, aluminium and pulverine) was underway when an initial detonation took place, causing a fire to break out along with, 3 seconds later, a violent reaction (deflagration or detonation) of products awaiting processing in the adjacent honeycomb chambers. A series of intense blast and thermal effects were observed. A technician was very seriously burned; plant premises sustained heavy damage.

One cause of this accident was ascribed to an improper press setting: an inspection of the press did in fact reveal a setting that had remained fixed at 70 bar, which was the pressure used for the "pipe claying" operation conducted during the previous work session, whereas the pressure indicated for 14-calibre jet fabrication was 40 bar. The application of this excessive pressure, ultimately combined with an overly weak composition concentration for the first phase, was able to generate a shock between the compression fuse and the matrix prong, thereby initiating the composition reaction. Other shortcomings contributed to the accident as well: no internal workplace safety report, no workstation safety guidelines, lack of structured personnel training, and the presence of an abnormally high quantity (12 kg) of active ingredients on the premises. Experts stressed these company shortcomings in the area of basic pyrotechnic safety principles.

     **ARIA 36509 - 07/05/1993 - 84 - MONTEUX**

     *20.51 - Fabrication de produits explosifs*

*20.51 - Manufacturing of explosive products*

  At a pyrotechnic plant, a composition made from potassium chlorate and coal caught fire during its preparation. At the beginning of the workstation shift, the operator had positioned the bowl containing the composition on the pneumatic stirrer. She removed the dry parts on the edges using a wooden spatula and then homogenised the mixture. In trying to release the magnetic stirrer, she dipped a magnetised bar into the bowl. She then heard a hard banging sound (perhaps a spark?) and observed a very upright flame. She dropped the bar to the ground, quickly exited the premises and closed the doors behind her. She was not injured and the workstation only sustained minor damage.

An electric discharge caused solvent vapours to ignite. The system seemed to act like a charge accumulator, especially due to stirring of the solution within the non-conductive plastic box.

The pneumatic stirrer was grounded by means of an earth strap. A conductive bowl was to be used for the mixtures. The operator verified the appropriate grounding of all working surfaces and updated the workplace safety report relative to this specific workstation.

     **ARIA 4959 - 13/05/1993 - 26 - ETOILE-SUR-RHONE**

     *49.41 - Transports routiers de fret*

*49.41 - Road freight transport*

  A Spanish lorry, travelling on France's A7 motorway, transporting 3 tonnes of recreational fireworks hit the road's guardrail, ignited and exploded. The explosion, heard up to several kilometres away, ejected the driver's cab into a field some 100 metres from the point of impact. The driver had fallen asleep at the wheel; his body was found a few metres further in the field. Limited traffic on the road at the late hour of this accident occurred avoided a greater number of casualties. The motorway remained closed throughout the emergency response. Sparks generated by friction from the vehicle's trailer when slamming into the guardrail would have caused the fireworks being hauled to ignite.

     **ARIA 4936 - 15/05/1993 - 24 - BERGERAC**

     *20.51 - Fabrication de produits explosifs*

*20.51 - Manufacturing of explosive products*

  In a gunpowder factory, a very intense combustion with a pressure surge effect occurred within a hopper containing powder. Maintenance work was ongoing: 2 workers were connecting by means of a copper cable the recently-installed metal sentry boxes around the loading hoppers of a cartridge production line ("grounding" of the equipment).

The line was shut, but sizeable quantities of powder remained both inside the hoppers (which had not been drained prior to the maintenance intervention) and in nearby plastic cans. The perforation (by an employee using a "standard" electric drill) of the wall of the third sentry box caused the heating that initiated the fire. The employee was killed on the spot due to burns. The fire spread throughout the corridor and to both of the juxtaposed platforms, on which cardboard boxes, lead bags and barrels of powder had been stored. The second employee, who was working in the room adjacent to the powder corridor, was severely burned and succumbed the next day. The third technician was thrown from the first floor and slightly burned; he was off work for a full month. Two fire-fighters also sustained burns. The cartridge-filling shop and machines were partially destroyed.

The operator stated having given a verbal order to empty the powder before starting these works, which however were not written up in a workplace safety report. Regular ongoing safety training was not being performed onsite. The construction measures adopted by the workshop proved ineffectual (missing or incorrect calculations): the roof designed to serve as an unloading surface resisted the pressure surge, which in fact contributed to spreading the fire to nearby powder cans.

     **ARIA 4534 - 27/06/1993 - 09 - MAZERES**

     *20.51 - Fabrication de produits explosifs*

*20.51 - Manufacturing of explosive products*

  A series of explosions occurred on a Sunday afternoon inside a pyrotechnic facility, when only the guardian was onsite. He sounded the alarm.

The fire would have been ignited in warehouse D22 by the fall (most likely caused by rodents, whose presence had been noted in this depot) followed by the untimely triggering of firecracker igniters and flares. During several minutes, the fire spread to other igniters as well as to cardboard boxes. After some time, the blaze reached the detonation fuses, which wound up exploding and forming a small crater (0.5 m diameter over a 0.25-m depth). The products dispersed by this low-intensity explosion in turn caught on fire (anti-hail rocket launchers and a Class 1.1F nitrate explosive): they partially detonated, also forming a crater, 1.6 m in diameter by 0.25 m deep. Some 20 seconds later, nitrate explosives plus other explosives containing trinitrotoluene / pentolite detonated by domino effect, forming yet another crater, this one 5.4 m in diameter with a depth of 1.5 m. Such a violent explosion, whose power was estimated at 1.77 tonnes of TNT, blew out the metal frame of building D22. The blast effect severely damaged both neighbouring warehouses (D13 and D19, separated from D22 by 60 m) and deformed the structure of the D19 building. Flying hot metal particles reached building D19, which had already lost its

cladding, and triggered the powder stored inside along with the successive explosions of black powder crates. Depot D13 burned rather slowly, triggering an explosion of the signal flares. The combustion of smoke-producing substances released a thick black plume of smoke and formed a column that could be seen from Pamiers.

The explosion, felt up to 30 km away, also damaged the site's workshops, storage depots and offices. After extinguishing the dry grass fire in order to protect the remaining facilities, fire-fighters were able to bring the blaze under control around 9 pm. The next day, the burned warehouses were quenched to avoid any renewed risk of explosion, and the damaged depots were covered with a tarp. Since the accident took place on a weekend, no casualties were involved. Property damage was extensive (3 warehouses completely destroyed, damaged cladding and roofs on the other depots, broken glass panes). The plates used for roofs or walls became detached like petals on a rose, while inside the buildings all machinery remained in its place.

The plant's 145 employees were furloughed and resumed their posts at the beginning of August. The extent of property damage amounted to 14.6 M francs (equivalent of Euros 2.22 M). The operator modified onsite storage conditions to avoid incompatibilities between substances while improving management controls on stored quantities (rated value). The operator also reviewed building construction techniques and protections against rodent intrusion. The reconstruction of destroyed installations had to be submitted for a new approval procedure.

        **ARIA 22844 - 19/08/1993 - 84 - MONTEUX**

       *20.51 - Fabrication de produits explosifs*  
       20.51 - Manufacturing of explosive products

       Within a pyrotechnic plant, a deflagration occurred during the compression loading of fireworks jets. Though half the plant's daily production of fireworks jets had already been completed (i.e. 50 in all), the technician stationed in the adjacent premises heard a loud noise and saw a glow. A compression of the preparation (composed of magnesium, nitrate and the chemical lucovyl) was underway and had reached the final phase when the fire struck, causing a blast impact and creating a fireball. The automatic quenching device operated successfully; no injuries were reported and the machinery was only partially damaged. All unfastened parts wound up being ejected.

The compression process created significant mechanical loadings capable of generating friction or jamming, which in turn caused the explosion. The operator proceeded by:

- reassessing the choice of oil for lubricating tubes by focusing on its viscosity and resistance characteristics over time;
- revising the tube phosphatation;
- defining acceptable wear tolerances for the punch, matrix and guide, in addition to scheduling a periodic inspection;
- setting up an accurate position sensor for the machinery controlling cycle initiation.

       **ARIA 15029 - 12/10/1993 - 09 - MAZERES**

       *20.51 - Fabrication de produits explosifs*  
       20.51 - Manufacturing of explosive products

       Inside a pyrotechnic plant, an explosion occurred on a granulation machine dedicated to a fireworks pyrotechnic composition (a boron/nitrate mix, with a 1.3.a classification). A very intense combustion followed, along with a slight blast. The technician sustained very severe burns (3rd degree at the level of the abdomen and thighs). The wall of the honeycomb chamber was blown apart and the machines inside were seriously damaged. The accident happened when plant machines were undergoing cleaning following a period of operations. A large quantity of active material (2 kg) would have ignited in response to a shock. According to initial investigation findings, the procedure applied had called for discharging all active material prior to machine cleaning, but this precaution had not been respected. The operator increased personnel awareness to this procedural step and analysed the machine design as well.

       **ARIA 5118 - 22/03/1994 - 83 - MAZAUGUES**

       *20.51 - Fabrication de produits explosifs*  
       20.51 - Manufacturing of explosive products

       At a pyrotechnic plant, an explosion occurred inside a (200-m<sup>2</sup>) non-pyrotechnic shop area during the handling of recreational fireworks. This explosion was followed by a fire that ravaged the entire shed facility. The investigation revealed that the onsite technician had been manually loading the 65-mm star shells in this shed, which was also being used to store combustible materials (wood, cardboard boxes, etc.). He had been working alone, without any supervision, and had only recently been hired by the company. During this handling operation, one of the products involved had reacted, causing a chain reaction with other products nearby. The technician, unable to flee the workspace in time, was burned alive. According to the initial findings, the company had failed to respect basic safety rules relative to a pyrotechnic activity: absence of a workplace safety report, lack of procedural guidelines, no personnel certification process, use of products with poorly-known characteristics, inadequate work environment...

       **ARIA 22843 - 10/05/1994 - 09 - MAZERES**

       *20.51 - Fabrication de produits explosifs*  
       20.51 - Manufacturing of explosive products

       In a pyrotechnic plant, the onset of fire followed by a localised blaze happened during the manufacturing of fireworks. Following a black powder coating operation, performed remotely, the products were laid out on a tray positioned on a cart for subsequent transfer into a drying oven. The accident occurred as the technician was setting a 5th tray onto the cart; he left the premises upon hearing the crackling sound of fire, which was followed by the actual outbreak, completed with the spraying of pieces of burning material. The technician suffered 1st-degree burns on 20% to 25% of his body, with some 2nd-degree burns as well. The shop room and machinery were also damaged.

The pyrotechnic composition treated and used to manufacture flexible stars was made from barium nitrate, magnesium and the chemical lucovyl. The exothermic reaction was due to an incompatibility, in the presence of humidity, between the pyrotechnic composition and sulphur contained in the black powder. Electrostatic discharge was another possible cause.

The lessons drawn from this accident basically relate to prevention efforts focused on both static electricity (design of a conducting can system to enable the flow of charges during the coating operation, plus the systematic use of metal trays for drying) and chemical incompatibility (use of a colour code for trays and other tools to distinguish their application; tray storage exclusively inside closed premises in order to avoid the presence of atmospheric humidity). The guidelines and operating protocols would be modified accordingly.

          **ARIA 22842 - 26/10/1994 - 84 - MONTEUX**

20.51 - *Fabrication de produits explosifs*

       20.51 - Manufacturing of explosive products

       In a pyrotechnic plant, the untimely activation of a fireworks shell (composed of black powder and a pyrotechnic composition) occurred during a manual firing. An initial series of 5 shells had been shot off without incident; each firing had been accompanied by altitude measures and proceeded at a rate of one shell per minute. A second series

of 5 shells was then placed in the same battery. After a normal firing of the 6th shells, the next shot was triggered on its own, before the technician assigned to load the round had the time to strip the fuse wire to an adequate length, in accordance with the corresponding guideline (to allow delaying the projectile launch relative to lighting the fuse). The technician sustained 2nd-degree burns to his left hand and forearm in addition to suffering bilateral noise-induced hearing loss. The accident was caused by the presence of an incandescent object, more likely located inside the mortar shell than outside the shell. This object might have originated from a previous round. Pyrotechnic experts generally recommend wearing additional individual protective gear as well as verifying the absence of any incandescent objects inside the mortar shell as part of the launch preparation procedure.

       **ARIA 6115 - 28/10/1994 - 26 - CLERIEUX**

20.51 - *Fabrication de produits explosifs*

       20.51 - Manufacturing of explosive products

       In a shotgun cartridge loading shop, welding work was being conducted on the railing of the distribution platform, on the side of the wall adjacent to a shooting tunnel. The connecting door between the shop and the tunnel was definitively shut and locked from inside the tunnel; it had not been opened in 2 years. The threshold of the door was

positioned below the loading shop ground level, increasing the accumulation of dust, which subsequently ignited with the sparks generated by the weld. A flame must have been lit on the other side of the door (i.e. on the tunnel side), causing combustion of the soundproof lining covering the tunnel walls and ceiling. The fire outbreak was contained by fire-fighters before spreading to the neighbouring production workshops. The welder was not injured. The measurement equipment (speed sensors) and suction device located in the tunnel were damaged and had to be replaced; the soundproof lining was completely destroyed. On the other hand, the building structure remained intact and both the computer and electronic equipment in the control room adjoining the tunnel were submitted for verification.

       **ARIA 6819 - 14/04/1995 - 09 - MAZERES**

20.51 - *Fabrication de produits explosifs*

       20.51 - Manufacturing of explosive products

       In a pyrotechnic facility, a fire followed by an explosion ripped through a warehouse storing anti-hail rockets and rocket motors charged with black powder. The effects of this blast and projected debris were readily observable. 2 employees were slightly injured and the warehouse entirely destroyed. Property damage and production losses

amounted to 7 M francs. An incompatibility between the nitrate explosive components (ammonium nitrate and pentolite) and impurities introduced during a splitting step (intermediate container used in the operation inadequately cleaned) caused this accident. Regarding these aspects, pyrotechnic experts generally recommend a careful cleaning of all tooling, yet still prefer (whenever possible) the use of tools dedicated to each single product.

       **ARIA 36349 - 24/05/1995 - 84 - MONTEUX**

20.51 - *Fabrication de produits explosifs*

       20.51 - Manufacturing of explosive products

       Within a pyrotechnic facility, fireworks candles exploded at the time of their destruction. The candles to be destroyed, measuring 30 mm, were composed of 8 "salute" displays with sound effects.

The destruction operating protocol specified that the articles were to be destroyed inside a concrete nozzle (1-m diameter, 80 cm high) buried vertically up to 10 cm from the upper edge. The candles were placed vertically into the nozzle; they occupied nearly all of the allocated space. They were fitted with fuses individually to ensure simultaneous ignition of the entire set. Previous destruction operations allowed disposing of 22, then 80, candles of this type. On the day of the accident, 360 candles were placed in the nozzle. After ignition, 4 or 5 volleys were fired, followed by the deflagration of the entire set, through a triggered activation of the "salute" displays, most likely due to the confinement created inside the nozzle. The quantity of material released by the blast was estimated at 25 kg, i.e. approximately half the initial charge.

This accident resulted in no injuries. The nozzle was destroyed, leaving in its place a crater 1 m deep by 1.5 m in diameter. Concrete pieces were projected in all directions, including outside the designated destruction zone.

The operator limited the quantities of candles for simultaneous destruction to 100 candles of 30-mm dimension, or 50 candles of 45-mm dimension, or 50 candles of the 65-mm dimension per operation. The noise effect candles will be buried directly into sand or else in ground devoid of materials capable of generating hazardous projections.

       **ARIA 36357 - 13/06/1995 - NC - NC**

20.51 - *Fabrication de produits explosifs*

       20.51 - Manufacturing of explosive products

       In the laundry area of a spherical powder production workshop, cotton drying cloths caught on fire due to contact of the plastic baskets where the cloths were kept with a steam-heated (to 170°C) gilled radiator. The baskets were destroyed and the wall of the premises slightly burned by the fire.

After testing both components (plastic and cloth) by heating to 170°C for 2 hours without triggering a ny reaction, the only explanation for this incident was the presence of powder residue on the cloth.

The operator improved the procedure for verifying the absence of powder on the cloth and modified the feed on the radiator pressure relief valve so that the temperature could not exceed 100°C.

     **ARIA 7181 - 19/07/1995 - 09 - MAZERES**

     *20.51 - Fabrication de produits explosifs*

     20.51 - Manufacturing of explosive products

     In a pyrotechnic plant, an explosion followed by fire destroyed an 8-tonne capacity depot storing recreational fireworks, smoke grenades, flares and simulation fireworks. According to employees working nearby, a white smoke was released first, with the explosion occurring 20 to 30 seconds later. Coloured stars were then projected. The alarm was triggered and the internal emergency plan activated. A safety perimeter was established. Areas of fire outbreak were ignited by projectiles over a widespread area extending more than 1 km around the premises, reaching zones beyond the site boundary and causing grass fires, which were fanned by the drought exacerbated by heat wave temperatures. The other depots were protected by fire-fighters, and the fire was brought under control within about 90 minutes. An aerial reconnaissance mission flew in a helicopter over the affected zone. Fire-fighting units monitored the situation through the night for any eventual resumption of fire. The intervention of emergency responders was complicated by the risk of potential explosion as well as by a limitation of access to gasoline-powered vehicles (compliance with safety rules). The fire extinction network, which had been appropriately designed, proved to be operable. The accident caused no injuries, but the storage depot was entirely destroyed.

The initial findings of the subsequent investigation revealed a breakdown in the manufacturing process adopted for some of the fireworks: an uncontrolled modification in raw materials (due to pollution) would have altered product behaviour. A chemical incompatibility stemming from these anomalies wound up causing heating and ignition of the materials present onsite.

As a general consideration, pyrotechnic experts advise the following:

- compliance with basic manufacturing rules, in order to avoid pollution, e.g. dedicated equipment to specific product families;
- for manufacturing purposes, only the use of products certified by the inspection department;
- adoption of clear and comprehensible operating protocols;
- systematic labelling of products, especially after any operation involving product splitting.

Moreover, the local Prefect enacted an emergency measure order upon the proposal of the facilities inspection unit, requesting a detailed report on the incident, with submission of an assessment on monitoring and detection instrumentation to be implemented, and requiring additional measures throughout renovation works on the destroyed premises.

     **ARIA 7879 - 27/11/1995 - 40 - DAX**

     *20.51 - Fabrication de produits explosifs*

     20.51 - Manufacturing of explosive products

     A fire broke out during the handling of firework stars in a production facility devoted to recreational fireworks. A technician was transporting a 20-kg container of stars, used to produce fireworks rockets, from the car into the small (6 m x 4 m) workshop. The second employee, on hand to assist with this handling operation, was held up on the phone. One of the container's 2 handles broke off, causing it to fall onto the floor. The shock due to this dropped container triggered ignition of the material. The fire spread to the shop, which was eventually destroyed in part. Seriously burned as a result of his clothes catching on fire, the 36-year-old technician died a few days later.

Experts recall the hazards associated with handling tasks and the importance of characterising, in great depth, all products implemented during operations in order to understand their sensitivity to various types of aggressions.

The judicial investigation exposed some safety shortcomings within the company, citing in particular: the lack of a safety plan and certified containers, noncompliant storage rated value, materials whose level of hazard prohibited transport and necessitated working with quantities of 5 kg max. The lack of any formalised training for technicians was also noted. The operator was sentenced on 26th January, 1998 to a fine of 20,000 francs and 18 months in prison with probation for manslaughter and infraction of regulations.

     **ARIA 21270 - 16/02/1996 - 21 - VONGES**

     *20.51 - Fabrication de produits explosifs*

     20.51 - Manufacturing of explosive products

     In a black powder manufacturing shop, a fire broke out on charcoal / saltpetre dusts (binary mix with, in principle, no pyrotechnic components). At the end of the one-tonne drainage cycle, the dropping of a 40-kg counterweight first on the drive pulley, then on the floor, caused the dust to ignite. Damage was limited; a few cans and lids were destroyed by the fire. The operator proceeded with a systematic inspection of all welds on both the counterweight (welds on lids) and pulleys.

     **ARIA 8233 - 16/02/1996 - 09 - MAZERES**

     *20.51 - Fabrication de produits explosifs*

     20.51 - Manufacturing of explosive products

     In a pyrotechnic facility, the outbreak of fire followed by a broader blaze took place within an intermediate storage room during a handling operation. A technician placed a container filled with lighting devices, which had just been assembled and were awaiting definitive packaging, on top of other containers. When he left the premises with another container, it got caught and spilled the contents of the one he had just deposited. The lighting flares, which had been partially assembled and hence more sensitive to mechanical aggressions, ignited due to the shock and spread fire to the entire storage facility. The premises sustained major damage (insulation, roof, access door). The fire could be controlled using internal resources; the adjacent rooms remained intact. No injuries were reported. The operator modified the facility's operating protocol (i.e. order of rocket assembly) and updated safety guidelines, in addition to building awareness among personnel regarding handling-related risks.

**ARIA 21309 - 31/05/1996 - 83 - TOULON**

84.22 - Défense

84.22 - Defence industry

The accidental ignition of a yellow smoking marker occurred when a technician removed it from the wood pallet where it had been stored. The technician, who detected the anomaly by the sound emitted at the time of initiating the pyrotechnic delay sequence, called another pyrotechnics employee. Given the type of phenomenon involved, featuring a flameless smoke outside the object, the two technicians decided to remove the munitions device from the building. Fire-fighters who had been previously alerted sprinkled heavy quantities of water, then a crew member wearing protective gear sprayed water on the marker, which was being held by a rope at the shore. Combustion continued until the smoky composition had been entirely spent. During marker handling, the ignited nautical rope, which had not been confined, got stuck in the storage pallet. The technician triggered the ignition system by simply lifting the marker, which had not been fitted

with its rope protection and remained exposed outside its container.

For markers received onsite, the operator imposed installing a rope protection, should one be missing, and then placing the markers in their individual containers, should the delivery arrive unpacked. The operator built awareness among users of the risks incurred of the untimely ignition by pulling on these nautical ropes and moreover proposed a modification to the marker design.

          **ARIA 21310 - 21/06/1996 - 09 - MAZERES**

          *20.51 - Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

          At a pyrotechnic plant, a violent explosion erupted inside a production unit due to compression in the triggering delay on recreational fireworks (delay referred to as "espolette"). The explosion took place at the level of the loading machine housing, during a black powder compression phase, and was followed by 2 less intense bursts. The spread of debris and shattered material were noticeable. The technician sustained multiple injuries (thorax, forearm, face, including an eye and neck). Property loss was considerable: the machine was damaged (broken protection screens, inoperable black powder flow system, a portion of which had been projected through the back partition on the box embedded within the aluminium frame on the blast-proof wall, a compression piston split into several pieces strewn over a 6-m radius), deterioration as well to the adjacent workstation (broken side screen, ruptured piston, burned hopper contents).

The accumulation of explosive product, combined with poor positioning of the socket and trajectory of the piston through the delay mechanism, would have caused this accident (punching, thus causing a friction-rubbing contact). The violence of the explosion, along with an analysis of the projection paths, suggests that the black powder had gradually accumulated inside a cavity at the level of the clearance hole on the power feed system inside the machine housing (with a free air volume of 67.2 cm³). This cavity had not been identified as a dust trap and, as such, no guideline was issued calling for its periodic disassembly for cleaning. The disassembly of devices on other workstations led to observing a case where powder was effectively present.

Before restarting the unit, the operator eliminated tube confinement and pyrotechnic powder trapping in the openings; moreover, the operator established a general machine cleaning instruction sheet and revised the screen protection procedure by avoiding the use of metal elements as much as possible. It was also proposed to modify the pneumatic casings (through the use of programmable automatons?). Experts have emphasised the risks of dust accumulation and underscored the importance of implementing appropriate cleaning guidelines.

          **ARIA 9732 - 09/08/1996 - 44 - SAINT-AIGNAN-GRANDLIEU**

          *YY.YY - Activité indéterminée*  
YY.YY - Undetermined activity

          Fire broke out in a warehouse located along the periphery of a road near residences; the facility housed 250 kg of fireworks and black powder. Packaged in small plastic balls, the powder was responsible for an explosion. The balls were ejected as far as 100 m in the vicinity. The fire quickly engulfed the 500-m² wood frame building. Present at the time of the accident, 3 warehouse employees were able to escape the blaze in time. The fire was extinguished an hour later, following the intervention of a crew of 40 fire-fighters.

          **ARIA 21299 - 16/09/1996 - 21 - VONGES**

          *20.51 - Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

          Inside a pyrotechnic facility, traces of black powder ignited during maintenance work on the roof of a blackpowder production building. The roof tiles were composed of plates with an asphalt lap joint. To replace a defective joint, a technician from a subcontracted firm removed the tile, sprinkled the working zone with water and lit a blowtorch to reseal it. The blowtorch flame then triggered combustion of black powder dust that had accumulated in the overlap zone between 2 plates; combustion spread to other dusts accumulated in the roof boarding extending from the plate overlap. This roof boarding had previously been washed with water from inside the building. Since the interstice located at the level of the 2-plate overlap was inaccessible to washing water, the black powder had not been neutralised.

The technician was not injured; the building's roof was partially damaged. The operator inspected all overlap joints of this type on all production buildings; other joints would be developed using silicone mastic by means of a cold bonding process.

          **ARIA 23051 - 24/02/1997 - NC -**

          *20.51 - Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

          In a pyrotechnic facility, a deflagration occurred during the pelleting of black powder. A technician, after verifying the hopper feed line, turned on the pelleting machine. The blast took place just a few seconds following start-up of the compression cycle. This incident was the fifth of its kind on the particular machine. The cause could not be determined with certainty. The hypothesis of static electricity seems to have been rejected. The presence of a foreign object or powder accumulation in the blind hole of the punches constituted the most likely hypothesis. The pelleting machine and adjacent devices were damaged, the building roof and facade were destroyed, and 30 kg of powder was lost. The technician suffered a slight concussion. The operator adopted a number of equipment-related measures to avoid the presence of foreign objects in the black powder. The machine configuration was modified in order to limit the mass of active material capable of entering into reaction.

          **ARIA 11736 - 23/09/1997 - 59 - ROUVIGNIES**

          *20.51 - Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

          An explosion and fire occurred within a pyrotechnic plant, most likely during assembly of fireworks inside a storage unit. One employee was killed. The depot was destroyed and tens of glass panes shattered in the vicinity. Total damage amounted to 1.4 M francs. Pyrotechnic experts recall the importance of complying with pyrotechnics production rules, especially the separation between activities (storage/bonding, etc.) and storage-related conditions (compatibility of stored products, quantities, etc.), in order to decrease the probability that such accidents recur.

        **ARIA 13371 - 03/08/1998 - 38 - BILIEU**  
 52.10 - *Entreposage et stockage*  
 52.10 - Warehousing and storage  
       A powerful deflagration followed by several explosions, heard more than 3 km away, and a fire happened during the transfer of pyrotechnic substances (fireworks) temporarily stored in a barn using a delivery van. The bodies of two adults and one child were found amidst the building rubble. A house and the entire stockpile of fireworks were destroyed. The local gendarmerie and an expert appraiser performed an investigation in order to determine the origin of this accident. As specified in the pertinent regulations, unspent fireworks due to poor weather conditions were to be returned to the manufacturer. The head of operations at the site was well experienced. The accident may have been due to an igniter neglected on a rocket that would have been triggered when exposed to a shock or equipment design flaw. Pyrotechnic experts generally note that fireworks must be handled with extreme precaution, especially once the steps of assembly and coordination have been completed, as these serve to significantly modify the initial product characteristics, primarily their sensitivity.

        **ARIA 14448 - 26/11/1998 - 56 - LORIENT**  
 47.78 - *Autre commerce de détail de biens neufs en magasin spécialisé*  
 47.78 - Other retailers selling new goods in a specialised store  
       An explosion struck in the basement of a gunsmith's, where the site's depot and shooting tunnel were also located. A violent deflagration blasted out the windows. One man was killed and another seriously burned. Fire-fighters were able to isolate a few small sources, but the thick black smoke resulting from combustion of the powder hindered access to the basement. The site remained under close watch throughout the night. According to initial findings from the investigation, a client had been trying out a firearm. A stray bullet would have exited the shooting tunnel after perforating an armoured plate, spraying many small pieces of the plate. Some of these fragments ignited fireworks, and the combustion spread to powders located above, gradually making its way to the cans of black powder, which in turn exploded. Experts insist that depots must not be installed on basement levels, nor should they serve any other uses or contain products other than those specifically designated in their permit. Moreover, better adapted extinction equipment needed to be introduced.

        **ARIA 19132 - 22/12/1998 - 31 - MURET**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
       In a pyrotechnic plant, a blast struck during the destruction of recreational fireworks measuring < 75 mm in calibre. Shortly after ignition, a 74-mm electric nozzle would have burst and caused a chain reaction of the other products, spraying around materials on fire. The burning place was partially destroyed; its metal sheets were projected up to a distance of 50 m. Pyrotechnic experts note the need to destroy small quantities of material at a time, knowing their fire responses and effects at best. Defective or older products should be destroyed in an open air zone without confinement.

        **ARIA 14230 - 01/01/1999 - 68 - MULHOUSE**  
 47.11 - *Commerce de détail en magasin non spécialisé à prédominance alimentaire*  
 47.11 - Retailer specialised in food operating in a non-specialised store  
       A fire destroyed the inventory zone of a supermarket. All products held in storage burned. The fire would have been sparked by one or more fireworks rockets launched by youth from the store's parking lot that fell onto the supermarket store room and on top of palletised bags of potting compost. The fire did not spread into the supermarket, though the ensuing smoke did force removal and disposal of all merchandise from the sales floor. Damages were estimated at several millions of francs. The business remained closed throughout the renovation period, which was anticipated to last several weeks.

        **ARIA 19145 - 01/04/1999 - 84 - MONTEUX**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
       In a pyrotechnic plant, a fire broke out in the material destruction zone while unloading a lorry containing boxes of pyrotechnic products (fireworks and other chemical products). "Mad peas" firework products or chemical materials caught on fire and triggered a violent blaze consuming those products already placed on the slab and in the lorry. One employee was seriously burned and another sustained more minor injuries. The lorry, which had been parked near the slab and not in back of the fire resistant wall, was destroyed. Initial investigation findings included the following observations: the types of products being transported were poorly known and poorly catalogued. Incompatible products, like for example chemical materials and pyrotechnic devices, were able to make contact with one another. Similarly, products sensitive to friction or shock could have been spread on the ground, thereby increasing the risk of ignition by stepping on one. Moreover, the employee severely injured was not wearing any safety clothing. Pyrotechnic specialists have stressed the following recommendations:  
 - the need to reduce the quantity of material to be destroyed as well as the quantity located within proximity of the destruction zone;  
 - the benefit of keeping destruction zones cleared of materials in order to facilitate emergency exit paths;  
 - the importance of training provided to destruction technicians (wearing of protection equipments, knowledge of specific risks, etc.);  
 - the emphasis on efficient emergency response and communication resources.

        **ARIA 15658 - 20/06/1999 - 47 - FRESPECH**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
       In a pyrotechnic facility, an explosion followed by a fire occurred during the extrusion of coloured stars (as part of a fireworks pyrotechnic composition). The facility manager was thrown violently by the blast and hospitalised in critical condition; he succumbed as a consequence of inhaling toxic products. The production unit was completely destroyed. Fire-fighters had the situation under control in 1 hour, 45 min. The company had been developing its own pyrotechnic composition designs, and a product qualification procedure had already been initiated. The sensitivity of these stars to both shock and friction would have caused the accident.

    **ARIA 19122 - 12/07/1999 - 62 - CALONNE-RICOUART**  
 84.11 - Administration publique générale  
 84.11 - General public administration

    During a pyrotechnic assembly operation held in a basement underneath the city hall, a fireworks shell exploded and triggered the release of all the other fireworks (200 kg) stored onsite, while awaiting the Bastille Day show two days hence (14th July). Fire-fighters arrived with 3 small nozzles to control the incident. It appears that the fireworks preparation team had combined the displays inside the storage room, thus transforming the initial event into something more catastrophic. 4 people were present on the premises: 2 pyrotechnicians and 2 city hall employees. One was seriously hurt, the 3 others sustained minor injuries. As a general rule, experts recommend pyrotechnic products not to be stored on a basement level, but instead in adapted spaces allocated for this purpose. The issue was also raised over how best to train city hall personnel in handling pyrotechnic activities.

    **ARIA 17751 - 08/06/2000 - 24 - FOUQUEYROLLES**  
 20.51 - Fabrication de produits explosifs  
 20.51 - Manufacturing of explosive products

    An explosion destroyed a 200-m<sup>2</sup> farm building around 3 am. Some 40 fire-fighters - unaware upon their arrival of the presence of pyrotechnic substances - were able to control the onset of fire initiated by the projection of debris and secured the zone. A wall containing the CD32 unit was destroyed, tiles were torn off the building and window panes were shattered; sprayed debris could be found over 90 m away. A dwelling adjoining the building had been occupied; neighbours experienced real shock, yet no injuries were reported. During the investigation, it was observed that the damaged building, located 1 km from a pyrotechnic facility manufacturing fireworks, was housing pyrotechnic products and accessories (300 kg of fireworks, various types of powders, etc.) and was being used as a workshop (presence of an assembly table, connection wires, tags, etc.). An explosives-defusing team arrived at the scene on 9th June in order to recover and destroy the remaining explosives. A series of judicial and administrative investigations were conducted. Inspections of the authorised installation were also carried out. Subsequent to the December 1999 storm and cancellation of pyrotechnic shows, the operator had stored without a permit the facility's surplus fireworks in a barn it owned. According to the press, the fire would have broken out following a short circuit on a used battery (perhaps associated with the fireworks?). At the beginning of November, the Bergerac court ruled on the matter: the manager was fined 25,000 francs and had equipment confiscated for the permitting failure and noncompliance with regulatory measures.

    **ARIA 22516 - 13/06/2001 - 69 - RILLIEUX-LA-PAPE**  
 20.51 - Fabrication de produits explosifs  
 20.51 - Manufacturing of explosive products

    In a storage facility dedicated to recreational fireworks, a package containing firecrackers (1.4G category, originating in an Asian country) fell during unloading. A firecracker exploded and then, one by one, the remaining firecrackers wrapped in the same package popped, yet without causing any splattering capable of spreading fire. The alarm was sounded and the personnel reacted according to the posted procedure. The burning package was neutralised by the site's fire prevention unit using multi-purpose powder extinguishers. External fire-fighters called to the scene did not need to intervene. Based on an investigation, the products were found to be defective. A poor seal of the fireworks envelope led to the release of a large quantity of pyrotechnics composition, which then ignited subsequent to mechanical aggression during handling. Experts in this field have suggested strengthening quality controls as part of the product acceptance protocol.

    **ARIA 22517 - 20/06/2001 - 69 - RILLIEUX-LA-PAPE**  
 20.51 - Fabrication de produits explosifs  
 20.51 - Manufacturing of explosive products

    During loading, a package of recreational fireworks (1.4S category) containing small detonating peas produced in an Asian country was exposed to a shock: about ten peas popped in succession yet without triggering any splattering of the type that could spread fire. The packaging was not deformed in any way, yet did show signs of blackening. The same kind of accident happened a week prior (ARIA 22616) ; experts in the field have suggested strengthening quality controls as part of the product acceptance protocol, given its influence on subsequent transport potential.

    **ARIA 22518 - 21/06/2001 - 18 - BOURGES**  
 84.22 - Défense  
 84.22 - Defence industry

    In a pyrotechnic storage facility, a photogenic composition decomposed during the preparations of its destruction, thereby causing a small discharge of hydrogen sulphide (H<sub>2</sub>S). The composition, manufactured in 1979 using a base of black powder, aluminium and magnesium powder, was contained in a total of thirty 300-g bags. As part of planning for their destruction, the bags were poured into 2 cans of water placed outside and covered with a lid. A few hours later, a technician noticed a gas release on one of the cans along with a rotten egg smell. A fire nozzle was used to initiate cooling, a step that limited the release of gases. The contents of these cans were then poured from a safe distance into tanks. A laboratory analysis of the composition revealed nothing abnormal. A reaction involving the chemical decomposition of water molecules had taken place during contact with magnesium and aluminium powders. In turn, this reaction triggered the hydrogen sulphide release due to a re-composition of hydrogen with sulphur stemming from the black powder. This incident highlighted the hazardousness of older products, whose alterations over time (stability, sensitivity, etc.) are not always well known. Moreover, during preparation of the product disposal phase, the guideline applied targeted the destruction of black powder, even though the composition corresponded to a mixture. Under these conditions, a preliminary safety analysis would have been necessary to introduce adequate measures.

    **ARIA 22832 - 10/07/2001 - 47 - FRESPECH**  
 20.51 - Fabrication de produits explosifs  
 20.51 - Manufacturing of explosive products

    An explosion followed by a fire occurred inside a pyrotechnic warehouse during the very early morning hours. Fire-fighters arrived onsite, but the fire had already been self-extinguished after 1 hour of burning. The incident only resulted in property damage (notably a destroyed roof). The depot had contained weather flares (1999), Asian

products from a 1998 batch (shells with diam. < 100 mm), miscellaneous stored pyrotechnic equipment on hand for the July 14th celebration fireworks, and a few untraceable pyrotechnic items. This storage unit had not been handled since July 6th (when boxes had been removed). Neighbouring depots did not undergo any deterioration due to extraneous debris from the explosion, thanks to the presence of protective bund walls placed to the north and west of the storage facility. The causes of this accident remained unknown.

        **ARIA 20825 - 24/07/2001 - 44 - PLESSE**

        *20.51 - Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

       In a workshop dedicated to assembling recreational fireworks, the only qualified employee of the 4 on the job was repairing a machine when a short-circuit occurred. A spark ignited the pyrotechnic material located in the vicinity. A fire quickly spread within the premises due to the presence of other pyrotechnic materials, as well as combustibles.

       Among the 4 employees, 3 were able to escape, but the fourth, unable to find his way to exit the facility, died while trying. Another employee was severely burned in attempting a rescue, while a second rescuer sustained more minor injuries. Despite the efforts of the roughly 30-member fire crew for 4 consecutive hours, the workshop could not be saved. An investigation was undertaken to determine the precise causes of the accident. The workshop/depot had not been declared to the local Prefecture, and the business activity had never been addressed in either a workplace safety report or materials safety report.

The installation design and workspace layout did not comply with basic safety rules: absence of an emergency exit, cluttered workshop, no analysis of mutual workstation isolation, no analysis for treating anomalies, uncertified personnel, and the presence of combustibles on the premises. The lack of rigour in managing the workshop had led to dramatic consequences. Inspection authorities requested that all operations be suspended.

        **ARIA 22521 - 01/08/2001 - 69 - RILLIEUX-LA-PAPE**

        *20.51 - Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

       In a workshop devoted to producing filmed cards of plastic caps for a toy gun, a case of caps ignited in the machine loading zone. This ignition was revealed by flames reaching 50 cm to 1 m high with small projectiles of melted plastic over a 2-m radius around the case. Two people sustained slight burns. Friction caused this case of caps to activate.

       The safety analysis conducted at the workstation would be examined to identify more efficient means of protection.

        **ARIA 21010 - 19/08/2001 - 44 - LA BAULE-ESCOUBLAC**

        *84.11 - Administration publique générale*  
84.11 - General public administration

       During a municipal fireworks show, one of the rockets fell amidst the crowd of spectators. 10 people were slightly injured: 7 suffered from hearing disorders, while the other 3 were victims of burns to their skin.



        **ARIA 22532 - 22/08/2001 - 29 - PONT-DE-BUIS-LES-QUIMERCH**

       *20.51 - Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

       During the manufacturing of gunpowder, a portion of the cut powder ignited during its transfer using the worm screw mechanism; combustion spread to the feeding hopper. The automatic quenching system was triggered, and technicians activated the alarm procedure. No injuries were reported. The equipment was shut down and the raw

material onsite was lost. Friction between the protective casing and the output shaft would have caused the fire to break out. It seems that the casing providing support for technicians, especially during maintenance operations, gradually deformed to a point of entering into contact with the mobile parts of the machine. Measures intended to reduce risks were adopted: in the area of prevention, the clearance between the casing and mobile parts was modified and would be verified prior to each operation; while in the area of protection, the efficiency of the quenching device would be improved by attaching nozzles and additional detectors.

        **ARIA 21699 - 14/01/2002 - 93 - LE BOURGET**

        *52.10 - Entreposage et stockage*  
52.10 - Warehousing and storage

       A major fire destroyed 15,000 m<sup>2</sup> of one of the buildings at the Le Bourget Exhibition Centre. The building was housing party fixtures on exhibit. Small quantities of recreational fireworks were also on hand: firecrackers, rockets, birthday candles. The roof collapsed. The gas bottles used to fuel the hall's forklifts exploded. During their battle

against the blaze, 150 fire-fighters experienced problems related to water supply and were forced to connect to distribution pipes from the neighbouring city. 16 fire nozzles proved necessary. One fire-fighter was slightly injured during the emergency response. A national highway and a portion of the local motorway were closed to traffic to allow running the pipes. The accident was brought under control within 3 hours. Among the initial hypotheses of potential causes, a faulty electrical installation was cited. The presence of fireworks, if confirmed, would have provided another potential cause.

        **ARIA 24915 - 22/03/2002 - 89 - MERE**

        *20.51 - Fabrication de produits explosifs*  
20.51 - Manufacturing of explosive products

       In a firm dedicated to destroying pyrotechnic products at the end of their useful life, a flash occurred while disposing of fireworks (class 1.3.G, containing 20-mm candles, shells, full 30-mm strikes). With the oven loaded, technicians perceived a white lightning bolt and felt intense heat. All products present operated successfully. A technician was

burned on his hands, face and torso despite wearing protective gear (gloves, goggles, fire-retardant suit) and another was slightly injured. Several hypotheses were forwarded, the most plausible of which points to friction created on the floor with a friction-sensitive pyrotechnic product. As for feedback from this accident, experts have underlined the attention to be paid to operations involving the destruction of pyrotechnic products (which, by definition, have become degraded and more sensitive). In the case of this incident, the nearby presence of a water tank allowed one of the injured technicians to immerse himself, thus limiting the extent of his burns. Yet the technician was not wearing the anti-static gear and safety shoes recommended in the draft safety report (not yet approved).

          **ARIA 22747 - 18/07/2002 - 38 - ROUSSILLON**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 An explosion and fire occurred inside a 200-m<sup>2</sup> hangar, used to store recreational fireworks, adjoining a residence; 2 men sustained burns and had to be hospitalised in a special burn unit. The building was destroyed. Fire-fighters extinguished the fire using 2 large nozzles. An explosives-defusing team was called to the scene. According to the press, the 2 men (1 of whom was a pyrotechnician) were packaging pyrotechnic products at the time of the explosion.

          **ARIA 23033 - 19/08/2002 - 73 - NOTRE-DAME-DE-BELLECOMBE**  
 90.0 - *Activités créatives, artistiques et de spectacle*  
 90.0 - Creative, artistic and performance-related activities  
 During a village celebration in the Savoy region of France, a fireworks rocket, instead of launching vertically, took off horizontally and burst in the assembled crowd. About 10 members of the public were slightly burned by shattered rocket pieces. Emergency responders accompanied the injured to the closest medical office for diagnosis. Three individuals, including a young girl, had to be hospitalised. According to initial reports, a support box that had shifted position would have modified the rocket's trajectory. The following day, all those injured were allowed to return home; the gendarmerie conducted an investigation.

          **ARIA 24545 - 09/05/2003 - 01 - SAINT-JEAN-DE-THURIGNEUX**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 A fire broke out in a 40-m<sup>2</sup> workshop in a fireworks factory. During the middle of the afternoon, a technician removed an electric igniter on a Roman candle firework (comet effect, 10 strikes, 30-mm calibre) by means of cutting the portion of black fuse carrying the igniter. Scissor action on the distributor cap is what ignited the firework. The candle comets caused the onset of fire of cardboard boxes, either empty or containing wood wool and intended for packaging. The fire released heavy smoke for some 20 minutes. The workshop had been housing pyrotechnic accessories (fuses, delays, igniters) used in production, along with a few assembled fireworks not yet packaged (8 candles split between 2 workstations), packages of wrapped fireworks (Divisions 1.3 and 1.4) and packaging supplies, accounting for a total mass of 65 kg of active material. The site alarm functioned normally and the personnel were evacuated. Internal responders were mobilised with reinforcements provided by external fire-fighters some 20 minutes later. An 80-m safety perimeter was set up. All neighbouring installations were secured and the electrical current was cut onsite. The incident was contained 90 min after the alarm was sounded. Two employees present inside the workshop suffered from a state of shock and required emergency medical care; they would resume their activities at the plant the following Monday. Just a single Roman candle was lost during the accident. Some thirty pieces of fireworks had to be destroyed subsequent to their contact with the fire extinction water. Since the level of property damage was limited, the workshop reopened for production the next week. No damage was observed outside of the workshop. Personnel information campaigns on the risks of untimely ignition had been organised. An operating protocol for igniter disassembly lacking the adequate precision would have caused the accident. The operator modified this protocol and notified the personnel. The outcome of this incident was reported during a site inspection conducted on 10th July, 2003.

          **ARIA 25233 - 03/08/2003 - 74 - ANNECY**  
 90.01 - *Arts du spectacle vivant*  
 90.01 - Live performing arts  
 A pyrotechnic incident occurred during a show held on Lake Annecy. A rocket reached a stand where spectators had gathered. 4 slight injuries were reported. The fire also spread to the pontoons used to stage the rocket launches. The show resumed after a one-hour interruption.

          **ARIA 27249 - 01/06/2004 - 47 - VILLENEUVE-SUR-LOT**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 Around 11:20 am, an explosion ripped through a building of a Seveso classified facility used to manufacture fireworks. Extended by an awning, the building in question contained 2 parts separated by a reinforced wall. According to the facility manager, 2 employees beneath the awning began assembling 60-mm fireworks shells (powder + stars in a plastic shell) in order to subsequently produce several candles. These stored materials, following assembly in the first part of the building, were considered as belonging to Division 1.3 (normally not leading to detonation). The building's second part was where the filling step took place on shafts (composed of an alternation of shells and active material used for their ejection), which were then transported to another building. According to witness testimony, the accident occurred in two stages: an initial explosion followed shortly thereafter with a second, more violent explosion accompanied by thick white smoke. Both employees working in this building at the shell filling / assembly stations were killed; their bodies would be found at distances of 20 m and 25 m from their station. Two other employees were slightly injured (hearing disorders) in nearby buildings. The extent of property damage attests to the violence of this explosion; 14 of the facility's 27 pyrotechnic buildings were either totally or partially destroyed, 9 others damaged, and 5 others had to be razed. The building where detonation struck was totally obliterated, with a crater 3 m x 1.5 m x 0.5 m deep visible in the concrete foundation plate. A 50-kg cart was projected a distance of 150 m, chunks of the wall littered over a 50-m radius. The blockhouses storing the explosive substances were slightly penetrated. No domino effect was observed. Only a few impacts were noticeable outside the facility, with the exception of the nearest residence (broken windows). 2 employees had to be made redundant due to the ensuing shutdown. A judicial and administrative investigation was conducted in order to determine the causes. Upon proposal of the inspection authorities, the Prefect issued an emergency order requesting: shutdown of the site's manufacturing activities, disposal of finished products, restoration of the premises in order to ensure the storage of pyrotechnic substances in accordance with their certification stamping, and the separation of storage spaces between end use and intermediate products.

Given the effects observed, this pyrotechnic material wound up detonating; the TNT equivalent was estimated at 15-30 kg. While the origin of the fire outbreak remained unknown, it could have been exacerbated by configurations prohibited inside the building (the door separating the two premises being left open with a relay effect due to the handling cart?). The risk introduced by products typically stored on these

premises had been poorly evaluated (with the risk of detonation being overlooked, despite the The risk introduced by products typically stored on these premises had been poorly evaluated (with the risk of detonation being overlooked, despite the presence of "bulk" storage within a confined space).

        **ARIA 27575 - 12/07/2004 - 24 - LE FLEIX**

       *20.51 - Fabrication de produits explosifs*

       20.51 - Manufacturing of explosive products

       In an explosives production plant, a deflagration followed by fire broke out at 8:30 am inside a (16-m<sup>2</sup>) building used to assemble and store fireworks, 30 minutes after an employee entered the building looking for electric igniters. The ignition was gradual and extended roughly over 10 minutes. Fire-fighters extinguished the fire in less than 2 hours using 2 small nozzles. The building was destroyed, and a few roof tiles were projected within a 10-m radius. The accident did not result in any injuries. The day before, a "dud" (unfired fireworks) had been returned to inventory. According to the operator, the storage unit contained 78 kg of active material in the form of assembled fireworks shells. Facilities inspectors recorded these facts. An expert was called to the scene to determine the exact causes of the accident. Several hypotheses were forwarded, though none appeared to stand out (lightning, falling objects, a rodent). In light of this accident, the operator initiated an anti-rodent campaign and reassessed product stability.

        **ARIA 27553 - 13/07/2004 - 61 - ALENCON**

       *90.01 - Arts du spectacle vivant*

       90.01 - Live performing arts

       The accidental launch of an entire batch of fireworks while setting up the installation for the July 14th celebration injured 3 pyrotechnicians, who had to be hospitalised. These victims sustained surface burns (hand, abdomen, knee). The accident was caused by poor handling on the part of one employee of the set-up team.

        **ARIA 27557 - 13/07/2004 - 10 - NOGENT-SUR-SEINE**

       *90.01 - Arts du spectacle vivant*

       90.01 - Live performing arts

       The untimely initiation of a fireworks display injured 17 spectators in the crowd gathered for the city's July 14th festivities: 7 of the victims required hospitalisation, while the other 10 were treated onsite by an emergency physician.

        **ARIA 29548 - 10/09/2004 - 31 - SAINTE-FOY-DE-PEYROLIERES**

       *20.51 - Fabrication de produits explosifs*

       20.51 - Manufacturing of explosive products

       During the night, a storm adversely affected a SEVESO-rated pyrotechnic facility. Isolated from the outside world by virtue of downed telephone and electrical lines, the site guardian notified on-call managers as of 6:30 am thanks to an emergency phone installed in the site's reception area. At 7:30 am, an initial diagnostic allowed eliminating all possibility of a high-risk situation that would have necessitated calling for external reinforcements: it was concluded that no physical danger existed for either the site's personnel or neighbouring residences, as well as no risk of soil or atmospheric pollution. An action plan was implemented. The personnel, with support provided by specialised technical units, performed a number of operations, including: transfer of pyrotechnic products to the buildings still intact, repackaging of products exposed to the foul weather event yet still free of damage, separate storage of all degraded products (with the intention of their subsequent destruction), protection of some buildings slightly affected by strong wind gusts through the placement of tarps, service start-up of the site's electrical and phone lines, and backup guardian services retained for the time required to reset building anti-intrusion systems. No redundancies in personnel were anticipated.

        **ARIA 28019 - 15/09/2004 - 59 - MARQUETTE-LEZ-LILLE**

       *17.12 - Fabrication de papier et de carton*

       17.12 - Production of paper and cardboard

       A violent fire erupted around 8 pm on the premises of an 8,000-m<sup>2</sup> packaging company located in an industrial park. This 10-ha site comprised a number of older buildings. The fireworks-related explosions complicated the intervention of emergency responders. In the absence of closures with a fire rating of at least 2h, the accident was able to quickly spread to all buildings in the park. A 100-m safety perimeter was set up. Forty neighbouring residents had to be evacuated. The fire then spread to 7,000 tonnes of scrap car bodies (i.e. a domino effect) at an automobile junkyard located 15 m from the building. These vehicles, despite being cleaned of pollution, still contained hydrocarbons that fed the fire until the following evening. The emergency response teams allocated significant resources to stopping the fire at 8:30 pm; a total of 56 employees were made redundant and over 10,000 m<sup>2</sup> of warehouses destroyed.

         **ARIA 29067 - 01/02/2005 - 78 - SAINT-ARNOULT-EN-YVELINES**

       *20.51 - Fabrication de produits explosifs*

       20.51 - Manufacturing of explosive products

       An explosion occurred in a company that had been illegally storing pyrotechnic materials (fireworks) and whose business activity had been suspended by Prefectural order enacted on 20th December, 2004. The installations consisted of 2 prefabricated buildings, one of which was used for storage and assembly of fireworks components, while the other was exclusively dedicated to storage. On 14th December, 2004, a site inspection had led inspectors to propose suspending the activity and placing the company on notice to comply with administrative regulations. The team of inspectors recorded their findings. Both premises were officially sealed. An explosives removal operation was conducted by Civilian Safety authorities on the morning of 1st February, 2005 for the purpose of removing all pyrotechnic connections between fireworks components, in addition to eliminating from the site all non-transportable fireworks and shipping to an alternative site all packaged items. A rocket lying in one of the prefabricated buildings was activated during this exercise and struck the explosives team's utility van, where a portion of the removed fireworks had already been placed. An explosion occurred inside the van, with the ensuing fire spreading to one of the prefabricated structures. Fire-fighters, already onsite as part of this explosives removal effort, were able to protect the second building, which sustained no damage. The quantity of material in reaction was estimated at 100 kg of the 200 kg total present on the site. The toll of this accident amounted to: 3 slightly burned anti-explosives agents, and a gendarme officer experiencing a slight malaise due to pressure surge effects: all 4 were hospitalised. The

prefabricated structure was destroyed, as was its entire contents. Nonetheless, the onsite crew completed the ongoing task by proceeding with the explosion of all fireworks still left to be destroyed: a 100-m safety perimeter was established, which in turn led to evacuating around 20 single-family homes and a few company offices. By the evening of the 1st, the zone, which had been emptied and cleaned, was considered risk-free.

     **ARIA 29269 - 23/02/2005 - 38 - SAINT-EGREVE**  
 47.78 - *Autre commerce de détail de biens neufs en magasin spécialisé*  
 47.78 - Other retailer selling new goods in a specialised store  
 Around 8 pm, a fire destroyed 500 m<sup>2</sup> of a 2,500-m<sup>2</sup> building housing party objects and items. The fire broke out on the fireworks sales floor. Fire-fighters had the blaze controlled using 5 nozzles and were able to avoid spreading to neighbouring premises; 5 employees were made redundant. The accident was brought under control in 90 minutes, but fire-fighters kept their resources at the site and continued to monitor the zone throughout the night.

     **ARIA 31562 - 24/03/2006 - 63 - BILLOM**  
 46.49 - *Commerce de gros d'autres biens domestiques*  
 46.49 - Wholesaler of other household goods  
 Around 9:50 am, a violent fire followed by heavy explosions broke out inside a fireworks depot. The fire generated a thick smoke cloud. The storage building roof collapsed, and ignited projectiles were responsible for spreading the fire to a lorry strongbox, placed on the ground and used to store pyrotechnic substances, as well as to an adjacent building containing packaging materials and accessories (domino effect). Crews of roughly 20 fire-fighters relayed one another in battling the blaze, which was eventually controlled around 5 pm. Some crew members remained onsite throughout the night in order to monitor for any resumption of fire. A 200-m safety perimeter was established, encompassing departmental highway D212. With approval from explosives disposal authorities, this D212 road was reopened to traffic. The site was secured by the gendarmerie and regular patrols were scheduled. The initial investigation findings pointed to an employee failing to comply with the safety rules applicable to pyrotechnic activities. This employee was performing electrical arc welding inside the storage building when the fire erupted in back of where he was working and then spread. The projection of incandescent debris was the likely source of this incident. The employee was burned on the face and hands, and a fire-fighter sustained a slight hand injury. The storage premises and strongbox were destroyed, and the neighbouring building damaged. On the day of the accident, the company did not hold any of the required permits or certifications to operate a fireworks storage facility. The quantity of stored explosives could not be identified, as all computer records were destroyed in the fire. Invoices submitted by the company nonetheless suggested that the 2-tonne capacity of active materials had been reached and even exceeded. The classified facilities inspectorate issued a report of its findings.

     **ARIA 31614 - 06/04/2006 - 37 - TOURS**  
 52.10 - *Entreposage et stockage*  
 52.10 - Warehousing and storage  
 A fire broke out in a 800-m<sup>2</sup> warehouse containing theatre stage sets, fireworks and 3 gas bottles. The warehouse was sandwiched between 2 buildings. Fire-fighters removed the gas bottles and deployed 3 nozzles, 1 of which was mounted on a pivoting ladder.

     **ARIA 32159 - 29/08/2006 - 13 - MARSEILLE**  
 46.69 - *Commerce de gros d'autres machines et équipements*  
 46.69 - Wholesaler of other machines and equipment  
 Shortly after midnight, a fire followed by heavy smoke erupted in a 2,000-m<sup>2</sup> warehouse storing fireworks and pressurised volumes. An explosion ensued. Fire-fighters deployed 1 water cannon and 4 nozzles, 1 of which was mounted on a ladder, yet they experienced difficulties in advancing inside the building.

     **ARIA 35168 - 07/08/2007 - 21 - VIELVERGE**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 Fire broke out around 2 pm in a 100-m<sup>2</sup> building rented to a pyrotechnician by a non-pyrotechnic company. The site manager and one of his friends (a 55-year-old retiree working on an occasional basis), who were both K4-certified pyrotechnicians, were preparing a fireworks show. They were using, among other things, pieces that had not been launched during previous shows. Due to poor handling, an igniter caught on fire; the blaze then quickly spread to all fireworks contained in the unit (approx. 25 kg), and then to the building. The premises were not equipped with a fire extinguisher; the only extinguisher present was located in a distant office.

The retiree, who was not wearing any protective gear, was burned to 2nd and 3rd degrees over 30% of his body. He had to be evacuated by helicopter to a hospital with a burn unit.  
 Fire-fighters established a safety perimeter and had the fire extinguished by around 4 pm; 30 m<sup>2</sup> of premises and the roof were destroyed. The manager forwarded 2 hypotheses: the victim had walked on an igniter that was not fitted with its protective envelope and/or he had cut the fuse connected to a candle too short, thus triggering its launch.  
 An investigation jointly conducted by the labour office and classified facilities inspectorate revealed that neither the employee nor the fireworks depot had been officially approved by authorities (lack of a technical certification, the operator failed to respond to the comments and observations issued the DRIRE Regional Office for Industrial Affairs regarding the permit application, which had been refused on the grounds of insufficient safety measures). The investigation highlighted not only the absence of risk evaluation, workplace safety report, protective devices, training, adopted safety guidelines, input/output log and onsite fire-fighting resources, but also the presence inside the depot of combustibles, electrical equipment and unpacked fireworks.

-   □ □ □ □ □ **ARIA 35012 - 04/08/2008 - 36 - DEOLS**  
 47.78 - *Autre commerce de détail de biens neufs en magasin spécialisé*  
  □ □ □ □ □ 47.78 - Other retailer selling new goods in a specialised store  
 □ □ □ □ □ In a garden of a single-family dwelling in a residential district, a fire broke out around 9:45 am inside a 150-m<sup>2</sup> hangar containing pyrotechnic equipment. Neighbours notified local emergency services, in indicating that several explosions had occurred. Fire-fighters set up a 50-m safety perimeter around the depot. First responders had the blaze under control within 1 hour of their arrival by deploying 4 nozzles. They body of the homeowner, who as a K4-certified pyrotechnician was in the process of handling fireworks (preparation of a fireworks display for neighbouring municipalities) when the incident struck, was found under the rubble. Explosives disposal experts secured the site and recovered 50 kg of various fireworks, which they properly destroyed. The quantity of fireworks found in the hangar was evaluated at between 100 and 400 kg: this storage depot had not been certified for such a use. The cause of the accident was not known.
-  □ □ □ □ □ **ARIA 36734 - 23/06/2009 - 01 - VILLEMOTIER**  
 49.41 - *Transports routiers de fret*  
  □ □ □ □ □ 49.41 - Road freight transport  
 □ □ □ □ □ The technological risks unit of the fire-fighting department was called to the scene of an accident on the A39 motorway subsequent to a malaise suffered by the driver of a lorry carrying one pallet of soda and another of fireworks. The victim was rushed to hospital; the unit's recordings onsite revealed no leaks.
-   □ □ □ □ □ **ARIA 37949 - 30/07/2009 - 33 - AILLAS**  
 20.51 - *Fabrication de produits explosifs*  
 20.51 - Manufacturing of explosive products  
 □ □ □ □ □ In a fireworks production plant, an untimely trigger went off during replacement of an igniter on a "Bengal flame" firework. Instead of discarding it outside the building, the technician left the spent firework inside the building; combustion spread to other products present in the workshop: pyrotechnic delays, fuse under ducts, and five 75-mm shells, i.e. nearly 8 kg of active material. Plant personnel applied the action guidelines and extinguished the fire. No injuries were reported, but the building was destroyed. The fire did not spread to the other buildings located a sufficient distance away. In noncompliance with the protocol calling for this procedure to be performed on an external workstation, the technician-trainee was located inside the building. The foreman responsible for trainee supervision failed to correct the mistake and was subsequently fired for negligence.
-   □ □ □ □ □ **ARIA 40102 - 12/04/2011 - 13 - ISTRES**  
 38.21 - *Traitement et élimination des déchets non dangereux*  
 38.21 - Treatment and elimination of non-hazardous wastes  
 □ □ □ □ □ A fire broke out around 1 pm on a 500-m<sup>3</sup> pile of green wastes (compost) at a household waste recycling and storage centre. A violent gust fanned the flames, which threatened the 20,000-m<sup>3</sup> capacity sorting building and the site's vicinity (which included a school and a designated NATURA 2000 zone). A thick black plume of smoke was visible for tens of kilometres around. A response involving 92 fire-fighters and 17 tanker lorries, backed up by teams from the nearby air force base, protected the sorting building and extinguished the blaze by around 6 pm. Upon instruction of emergency services, neighbours (including a school) were confined indoors because the smoke was considered to be more unpleasant than it was actually toxic (burning vegetation). Nonetheless, the army decided to evacuate one of its facilities in the area. The next day, the operator proceeded by clearing the mound of waste that had burned. Responders continued to monitor throughout the night and performed reconnaissance missions every 4 hours over the next 5 days, as the waste was capable of burning for several more weeks, as demonstrated during a previous fire several years prior. One employee and 1 fire-fighter were slightly injured during the response. Over 100,000 m<sup>3</sup> of waste were burned, and 2 ha of undergrowth and pine forest were destroyed. The shock of a backhoe on an abandoned maritime distress flare left by accident in the pile of green waste caused the outbreak of this fire.
-   □ □ □ □ □ **ARIA 40241 - 23/04/2011 - 59 - LE QUESNOY**  
 90.01 - *Arts du spectacle vivant*  
 90.01 - Live performing arts  
 □ □ □ □ □ During the reconstitution of a historical battle, a cannon firing incident injured 2 extras, one suffering damage to his eardrum, the other (a 58 year-old) severely burned on his face and arm. Emergency responders transported both victims to the hospital. According to press accounts, both men were handling black powder in preparation for the cannon firing demonstrations.
-   □ □ □ □ □ **ARIA 40398 - 21/05/2011 - 45 - COULLONS**  
 00.00 - *Particuliers*  
 00.00 - Individual activity  
 □ □ □ □ □ In the garage of his home at around 11:15 am, a pyrotechnician caused the explosion of a 3-kg stockpile of type K3 fireworks while performing welding work nearby. The victim, who had sustained serious burns on 30% of his body, was airlifted by helicopter to the Tours Hospital. Emergency responders, one of whom held a K4 certification, defused the previously bundled fireworks and submerged them in water-filled tanks. A specialised subcontractor was requisitioned to discharge the ensuing pyrotechnic waste. The 50 year-old victim was an authorised pyrotechnics dealer.
-   □ □ □ □ □ **ARIA 40621 - 13/07/2011 - 63 - CEBAZAT**  
 84.11 - *Administration publique générale*  
 84.11 - General public administration  
 □ □ □ □ □ Around 11 pm, a fireworks show started in the Cébazat city park in the presence of some 1,000 spectators. Shortly after the first rockets were fired, between 5 and 10 projectiles were propelled horizontally and exploded adjacent to where the public had congregated in back of the barricades just tens of metres away, creating crowd panic and jostling. Nine spectators, including four children, were slightly injured; they were transferred to 2 hospital facilities in the Clermont area and released during the night to return home, only sustaining slight superficial burns and hearing discomfort. The origin of these defective firings remains unknown. The extremely high humidity following rainfall over the previous days might offer one

explanation; the humidity would have softened the cardboard mortars that are used to propel fireworks. According to other sources, the mortars had been fastened to a barrier that swung after the first firework was shot since a second barrier, which served to secure the entire batch, would have been shifted after its installation by the team of pyrotechnicians. A police investigation was ordered.

        **ARIA 40909 - 09/09/2011 - 33 - AILLAS**

*20.51 - Fabrication de produits explosifs*

       In a fireworks-producing firm subject to administrative approval, a series of explosions followed by fire occurred around 11:15 am within a fireworks facility dedicated to preparing and storing assembled fireworks. The 160-m<sup>2</sup> building used for this purpose housed 25 kg of fireworks, cardboard boxes and tables. All 5 employees present evacuated the site; first responders installed a 100-m safety perimeter. Fire-fighters deployed 3 water nozzles at the

scene. The building was on the verge of collapse; a backhoe tore a hole into one side of the building wall to allow extinguishing secondary ignition sources.

Patrols were conducted at night. No neighbouring structures had been compromised and no injuries reported. The operator eliminated the waste from this accident in accordance with current regulation.

"Misfired" fireworks, which were waste awaiting disposal, are thought to be the source of the explosion. Due to delays experienced in disposing of fireworks waste, the items had been stored in a building that was not designated for this purpose. The inspectorate also pointed out that the waste destruction zone did not provide for secure operations, i.e.: a damaged metal-frame structure, vegetation not removed, waste found in scattered places, ashes left outdoors. Site operations (outside of the depot) were suspended until refurbishment of both the damaged building and waste incineration zone. The operator was required to allocate a dedicated spot within the pyrotechnic zone for storing "misfired fireworks" safely (i.e. away from the other buildings, in accordance with storage rules).

        **ARIA 41467 - 14/12/2011 - 18 - SAINT-SATUR**

*84.11 - Administration publique générale*

       An explosion followed by fire occurred around 2 pm inside an 800-m<sup>2</sup> stone building housing a number of municipal workshops; 1 employee was killed on the spot and 4 others injured, 3 of whom seriously. Fire-fighters set up a 100-m safety perimeter and extinguished the blaze using 2 nozzles.

       The building, intended for storing and maintaining tools, sustained considerable damage: walls collapsed and a portion of the roof was blown off. In the rubble, emergency response crews discovered bottles of acetylene, LPG and individual fireworks (bombs). The next day, the land mine removal squad recorded their observations and assumed responsibility for fireworks disposal.

The press suggested the hypothesis of a fireworks explosion triggered by sparks from a grinder. The presence of fireworks at this spot of the building and at this particular time went unexplained; the gendarmerie carried out an investigation for manslaughter.