

# **Series of mass explosions in a fireworks plant 25th July 2013 - Città Sant'Angelo (Italy)**

**Eng. Fausta DELLI QUADRI**

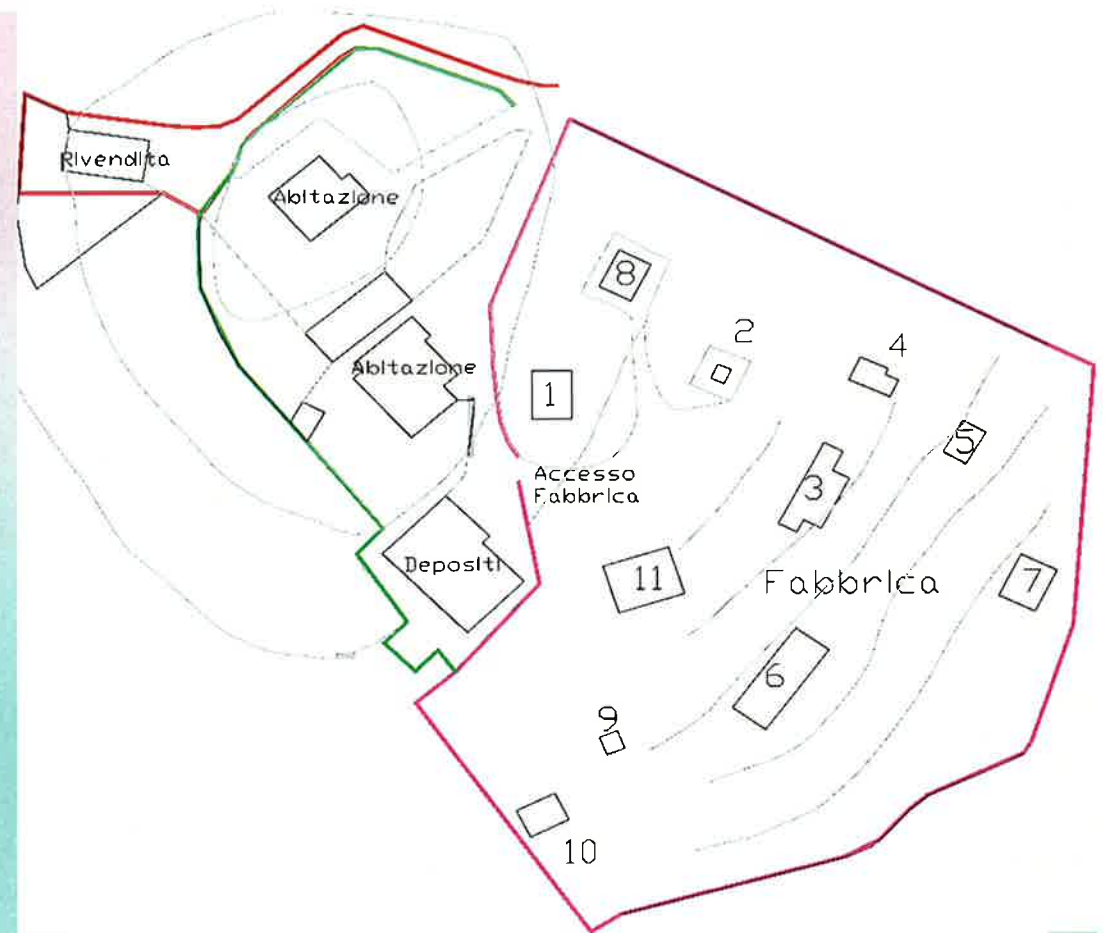
**ISPRA – Italian National Institute for Environmental Protection and  
Research Industrial Risk Service**

## THE FACILITIES INVOLVED

- Fireworks plant located in Città Sant'Angelo (province of Pescara, Italy)
- Surface of 30.000 m<sup>2</sup>
- Composed of 11 small buildings, used for storage or production
- 2 residential buildings (houses of the facility's operator and watchman) close to the plant + other small buildings (trucks garages, offices, depots)



1. Non-pyrotechnic products storage
2. Black powder storage (max 500 kg)
3. Fireworks laboratory
4. Products storage (max 4 t)
5. Products storage (max 9,6 t)
6. Mixing
7. Colours and various material storage
8. Products storage (max 9,6 t)
9. Engines installation
10. Coal crushing
11. Semi-finished products storage (max 7 t) – not yet authorised



**Plant classified as "lower tier"  
establishment under the Seveso II  
Directive**

## **THE ACCIDENT : 25th July 2013, at 10:15 am**

- 3 workers (the operator and two technicians) are transferring fireworks from the storage buildings 4 and 5 to a “pick-up” truck used for internal transfer, parked in front of the buildings.
- Suddenly, a sequence of 3 explosions occurs in the buildings 4 and 5.
- The total amount of explosives stored in the buildings exploded almost instantaneously : “mass explosion”
- Deaths of the 3 workers
- Buildings 4 and 5 + pick-up truck entirely destroyed



- 40 minutes later : a 4th mass explosion occurs in storage building 8, due to a delayed domino effect
- Building 8:
  - already damaged by the blast wave of the first explosions
  - then hit by debris and flying sparks generated by minor blasts following the main explosions
- On the whole : **almost the total amount of pyrotechnic substances stored in the plant involved in the explosions**

## The firefighters intervention

- Internal emergency procedure not properly activated by the company
- Firefighters called by inhabitants who heard the explosions - not by the company
- Employees should have evacuated the plant after the first explosions and reached the safety meeting point located outside the premises but :
  - Evacuation signal not given → employees remained on site
  - One worker, the operator's son, walked inside the damaged buildings to look for his missing father and got killed.



- From 10:20 am to 7:30 pm : 8 firefighters teams involved in the emergency operations
- Use of equipments such as fire-trucks, water pumps, helicopters, fire-planes
- Difficulties encountered due to the layout of access ways and of the plant itself:
  - space area outside the entrance of the plant too small
  - only one access
  - set-up of the plant not suitable for easy moving of fire trucks and management of fire systems
- Emergency considered concluded after 9 hours
- Local Authorities and prosecuting Authority on site
  - seizure of the whole area

# CONSEQUENCES OF THE ACCIDENT

## Human consequences

- Total of 5 fatalities:
  - 3 workers involved in the transfer operations
  - 4th employee hit by a piece of roof projected by the explosion of building 8
  - 1 firefighter, hit by a projection from the same explosion, died 3 months later in the hospital
- Total of 8 injured:
  - 3 workers
  - 5 firefightersinjured during emergency operations and hospitalised



## Material consequences

- Inside: total destruction of almost all buildings of the establishment
- Outside:
  - damages to several civil buildings (houses, church, factories,...) within a 500 m radius.
  - debris projected within a radius of 1 km
- Preliminary evaluation : financial loss of about 1.5 millions euros:
  - 600.000 euros for structural internal losses (equipments and structures destructions) and production loss
  - 900.000 euros for structural external damages.



Remains of the  
pick-up truck

Remains of the plant  
after the accident







Piece of concrete found more than 900 m away from the plant

Debris projected by the explosions



## Environmental consequences

- Sequence of fires in the rural/natural area surrounding the plant (in a 500 m radius), which were extinguished by the firefighters
- Around 8 tonnes of chemical products (flammable and oxidizing substances) used to prepare the fireworks spread on the ground outside the plant
- Big cloud of gaseous products (including toxic substances) observed after the explosions
- Amounts of dangerous substances involved and human/material/environmental consequences exceed the thresholds defined in Annex VI of the Seveso II Directive  
→ **accident classified as “major accident”**





Toxic cloud emitted to the atmosphere

## **THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT**

- Accident still under investigation by the local prosecuting Authority.
- Area still under seizure
- Elements available based on information and data provided so far by local firefighters and the State Police



## Presence of non-authorized products

- After the accident, discovery of fireworks already “armed” with an inflammator within the remains of the plant and in the trucks parked just outside of the premises.
- According to Italian regulation, fireworks should always be assembled directly at the location of the pyrotechnical performance, and never in the production or storage facility.
- **Because of the dangerousness of assembled fireworks, there is not doubt that the transfer operations in front of buildings 4 and 5 were the trigger of the explosions.**

Complete desintegration of the storage buildings and their protection walls :

- evidence of a “mass explosion”
- further proof of the presence of dangerous assembled explosive products at the moment of the accident



Assembled fireworks



Damages caused to the buildings and their protection walls



## Storage of excessive quantities

- Real accident effects (distances of 100 to 500 m from the plant) > theoretical estimated effects (distances within radius of 100 m) based on maximum authorised amounts of products.
- After the first explosions, occurrence of a domino effect in building 8 :
  - Respect of safety distances among buildings should allow to avoid domino effects
  - Safety distances only valid if maximum quantities and authorized typologies of explosives products are respected
  - The occurrence of a domino effect leads to conclude that there have been **violations in terms of qualities and quantities of explosives stored in the plant**
- 20 days after the accident : discovery of a non-authorized amount of black powder (0,2 t) in a small disused building outside the establishment.

## Productive pressure led to risk taking by the technicians

- 25th July : period of peak activity (preparation of several scheduled pyrotechnic shows)
- Circumstances induced time pressure on the technicians, in a rush to perform their tasks
- **Time constraints + possible excess of confidence** of the technicians (long time experience in managing explosives) → **work in unsafe operative conditions**
- Productive pressure probably led the operator to overpass authorised quantities and to assemble fireworks within the plant



## **Defaults in plant design and emergency procedures led to increased consequences**

- Defaults in internal emergency procedure : failure to call to the firefighters and to activate the evacuation plan after the first explosions
- Inadequate layout of the plant in terms of emergency access
- Inadequate location and layout of the civil houses (operator's and watchman's houses) which suffered important damages
- Inadequate material for the roof of the depots : debris coming from the roof of building 8 caused the death of a technician

**→ Incorrect application of regulatory requirements**

**→ Incomplete risks identification**

## **Warning signals insufficiently taken into account by the administrative control authority**

- **7 months before the accident : detailed Safety Management System inspection** conducted by the Regional Environmental Agency
- Several defaults pointed out during the inspection (need to : provide detailed operational procedures explaining the safe way of managing fireworks storage/production, improve emergency procedures, involve personnel in risks analysis, guarantee a safe arrangement of explosives packages...)
- **Some of the issues raised can be related to the causes of the accident**
- Question of the effectiveness of inspection activities:
  - effective inspection strategy should include a follow-up of the corrective actions taken by an operator
  - implementation of article 20.7 of Directive Seveso 2012/18 UE could help Member States to enhance the safety of inspected establishments



## **Lessons learnt** (“vigilance points” in fireworks plants)

- respect of safety regulation and procedures, in terms of quality (compatibility) and quantity of explosive products managed/stored
- safe operative conditions and adequate behaviour/competence of operators, especially during peaks of activity
- adequate internal emergency procedure (activation of the emergency and personnel evacuation)
- adequate layout of the plant (emergency access for external firefighters)
- respect of security distances between civil buildings and plant
- use of adequate construction materials to avoid increased human consequences in case of an accident
- importance of a rigorous follow-up by control authorities of the corrective actions taken to target breakdowns/regulatory breaches put in evidence during inspections

# **Seveso explosives establishments: SMS inspection outcomes**

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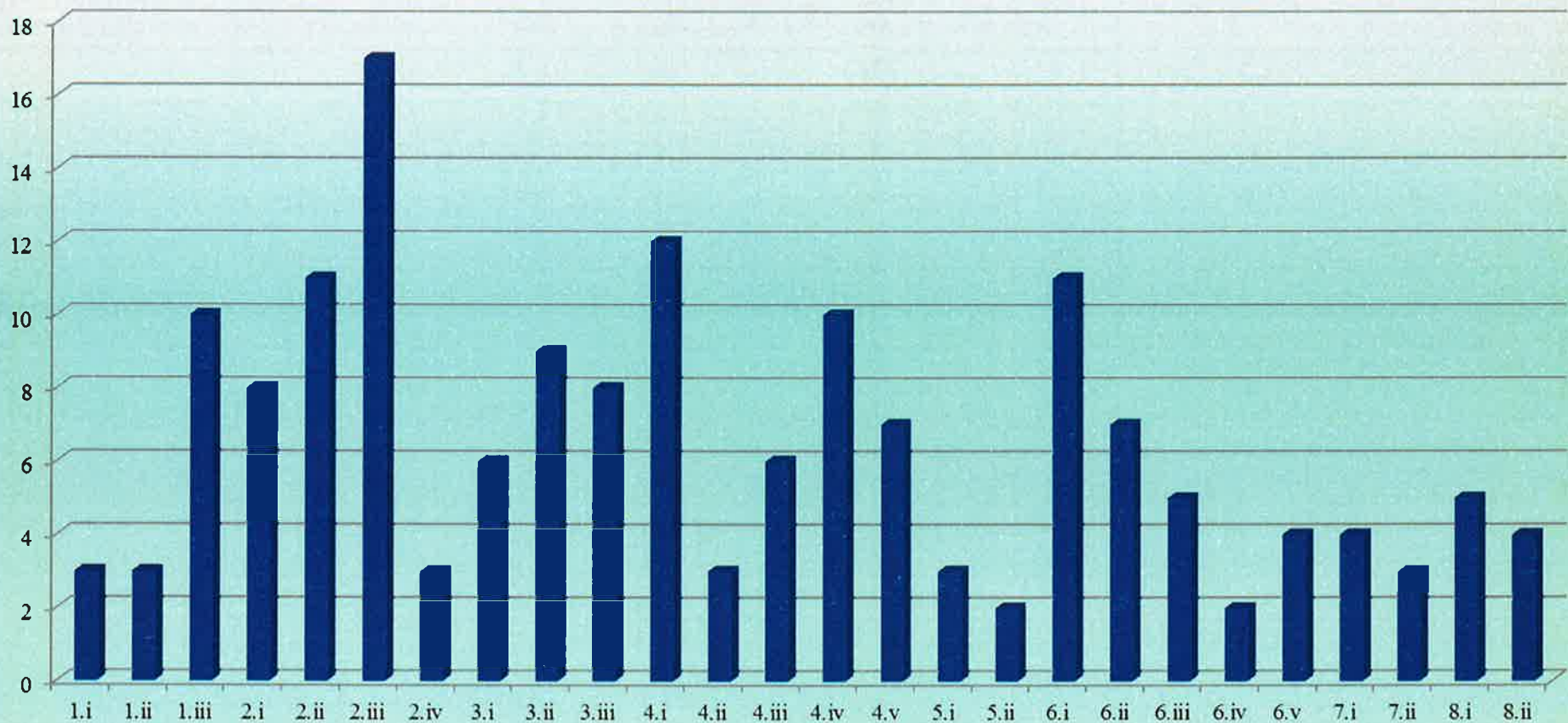


## SMS INSPECTION OUTCOMES: GENERALITY

- critical issues linked to the management elements reported in the checklist (used for the inspections) which leads to different SMS elements (8 macro-points and 26 specific points), as defined in Directive Annex III
- point 1: concerns the Major Accidents Prevention Policy Document (which should include not only the operator statements/aims, but also a description of how he has implemented and continually improves the SMS, according with the Italian legislation); it is mandatory for all types of Seveso establishments, both upper or lower tier
- the MAPP Document is the main operator's tool to organize and communicate his safety management; it contains the objectives and the strategies to be pursued, the resources and actions adopted; in this sense, the Document is Identity Card of the SMS implemented

# SMS INSPECTION OUTCOMES: SEVESO EXPLOSIVES ESTABLISHMENTS

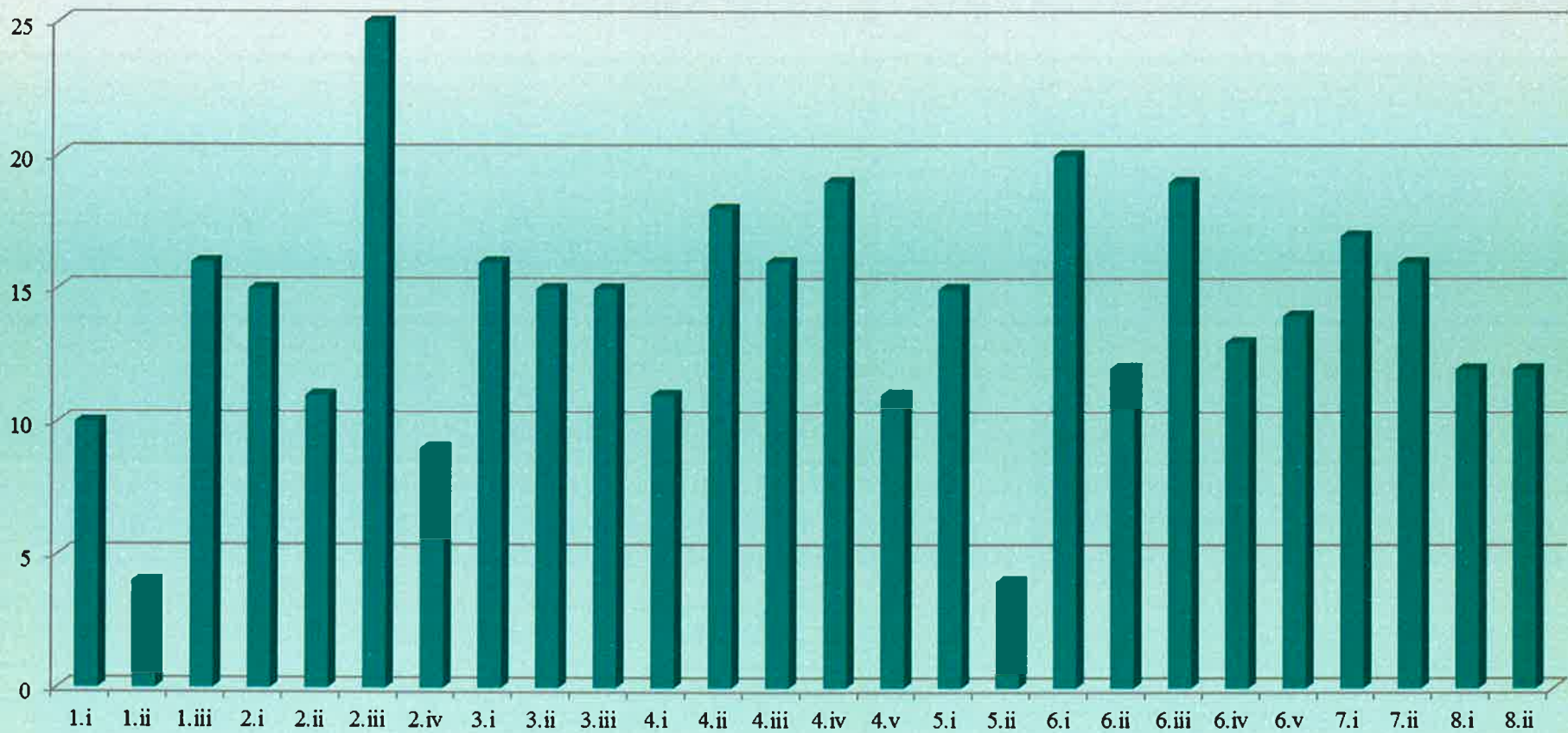
## Major non-compliances



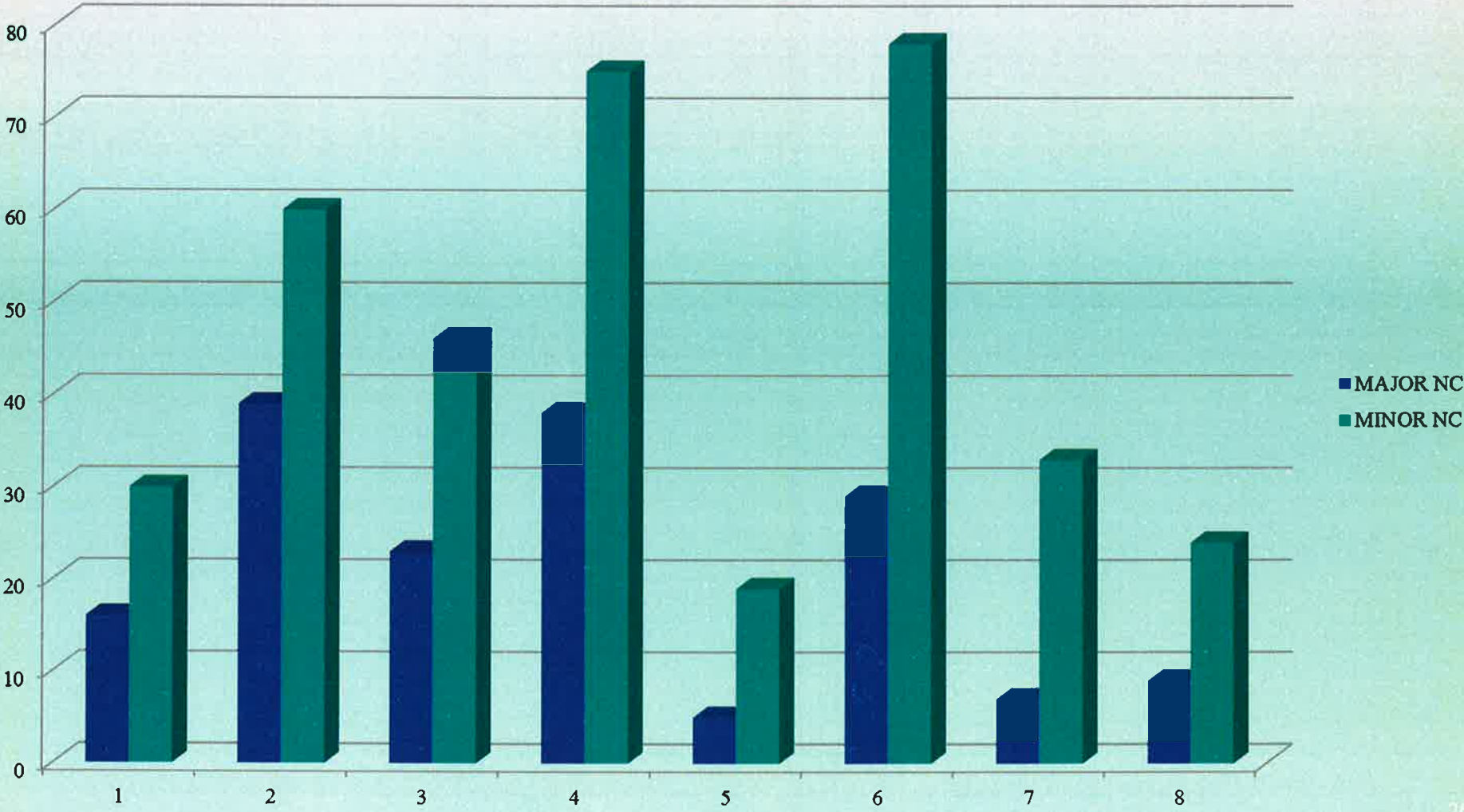


# SMS INSPECTION OUTCOMES: SEVESO EXPLOSIVES ESTABLISHMENTS

## Minor non-compliances



# SMS INSPECTION OUTCOMES: SEVESO EXPLOSIVES ESTABLISHMENTS





## SMS inspection outcomes

- personnel "training" must be improved in many points (especially for family business), starting from the activities plan for internal workers, contractors and visitors, to the evaluation of the results achieved, including a more extensive use of learning tests (points 2.ii and 2.iii)
- need of a full compliance of the planned frequencies for equipments inspection and maintenance. As far as concerning the permit to work procedures, in some cases it has been recommended the improvement of its structure, in terms of the flow of authorizations and the specific definition of its scope and use (point 4.iv)
- during emergency exercises a not complete congruency between the procedures and the real exercise performed was carried out, in terms of use of specific PPE required by emergency situations, as well as in the reporting of the exercise outcomings, and in the analysis and developing of adequate corrective actions (point 6.iii)