# MJV 2016

## Inspections under Seveso III Directive

*Workshop on Explosives and Pyrotechnics*

**Explosives/Pyrotechnics plants safety: SEVESO-TULPS requirements interface and case studies**

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# Introduction – Aim

- analysis of interface between Seveso III - TULPS requirements: integration - completion process to point out important elements (not evident from TULPS) introduced by risk analysis and SMS

- consideration of Inspections and accident analysis outcomes carried out in explosives plants

- in addiction: flash on toxic gases coming from explosion; analysis of gas behaviour and gas toxicity to identify possible effects to the surrounding population

# TULPS: Italian explosive products Regulation



- explosives are controlled by specific regulations concerning their management about production, classification, possession, delivery, etc. In Italy they are regulated by T.U.L.P.S. (Consolidated Act of Public Safety Laws)
- rule prohibits the manufacturing and placing on the market of explosives not classified by the Ministry of the Interior and not bearing the CE marking. Registration in Annex A to the Regulation implementing the Consolidated Law of Public Security (TULPS) of all the explosives for civil use on the market, coupled with checks carried out at the depots and factories holding the required permit set the framework for the current surveillance activity
- inspection of the establishments by the Provincial Technical Committees

# Context of interest

- plants and depots of explosives products, as defined by the Italian Decree (D.Lgs.105/15) on application of Seveso III Directive; products classified in 2 categories:
  - P1a
    - unstable explosives, or explosives Division 1.1, 1.2, 1.3, 1.5 or 1.6, or substances/mixtures having explosive properties according to method A.14 of Regulation (EC) No 440/2008 (see note 9) and do not belong to the hazard classes Organic peroxides or Self-reactive substances and mixtures
  - P1b
    - explosives, Division 1.4 (see note 10)
- according with TULPS categories:
  - pirotechnics (cat. 4–5 TULPS)
  - explosives for civil/military use (cat. 1–3 TULPS)

# Context of interest

- establishments classified into two main tipologies (based on inetrnal complexity of process):
  - factories (explosives producing-packaging)
  - depots (explosives storage-handling)
- different levels of risk connected, different safety measures
- manifacture process based on simple phisical steps: handling, mixing, phase changing (no chemical reactions)

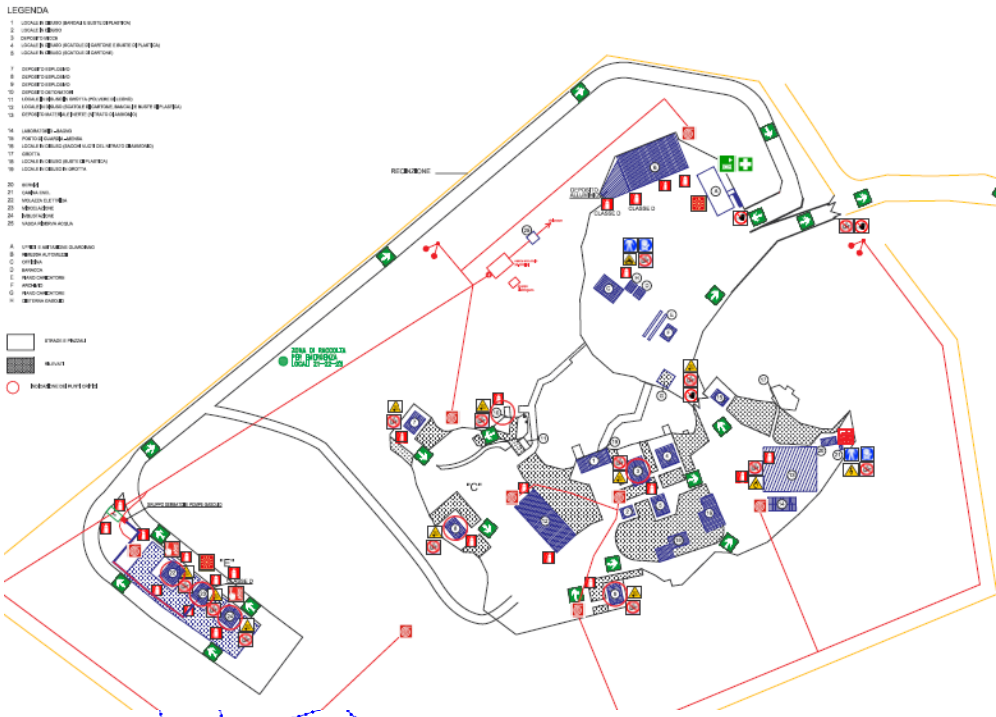
# Explosives factories-depots: possible plant units

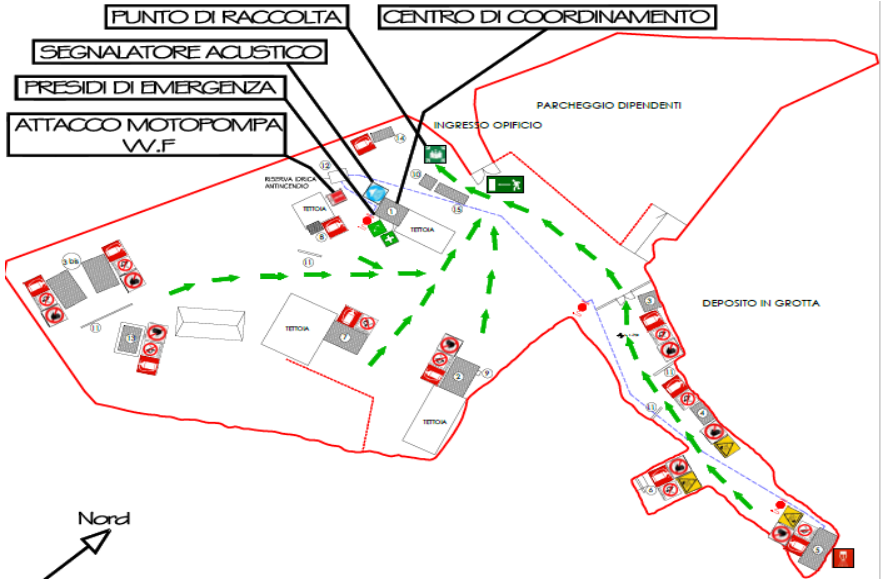


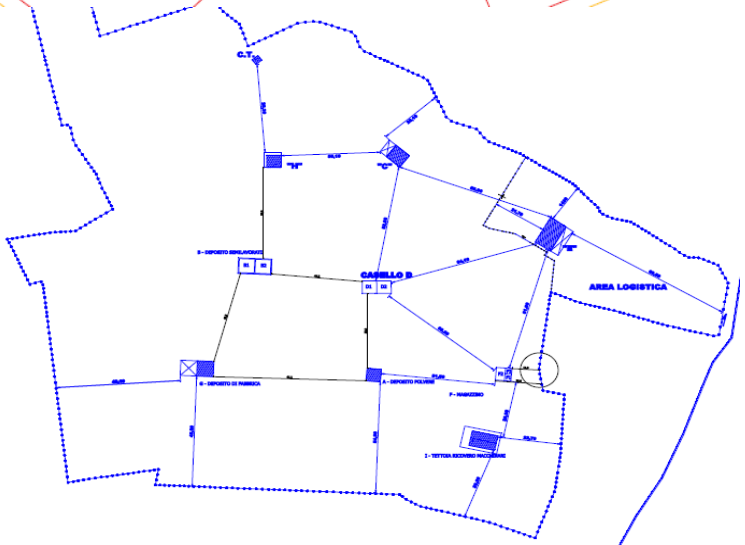
a. Raw materials storage unit
b. Black powder storage unit
c. Mixing-emulsions manufacturing unit
d. Grinding unit (by using grinder)
e. Mixing unit (by using concrete mixer)
f. Pressing unit
g. Drying unit
h. Semifinished products preparing unit
i. Special explosives manufacturing unit (defence-military use, space use)
j. Semifinished products storage unit
k. Finished products packing unit
*l. Finished products storage unit*
m. Test-control unit
n. LPG/flammable liquids storage unit
o. Chemical products warehouse unit
*p. Loading/unloading raw materials and products (from/to external trucks) unit*
*q. Materials/semifinished/Products transferring area*

# Explosives factories-depots : lay-out examples



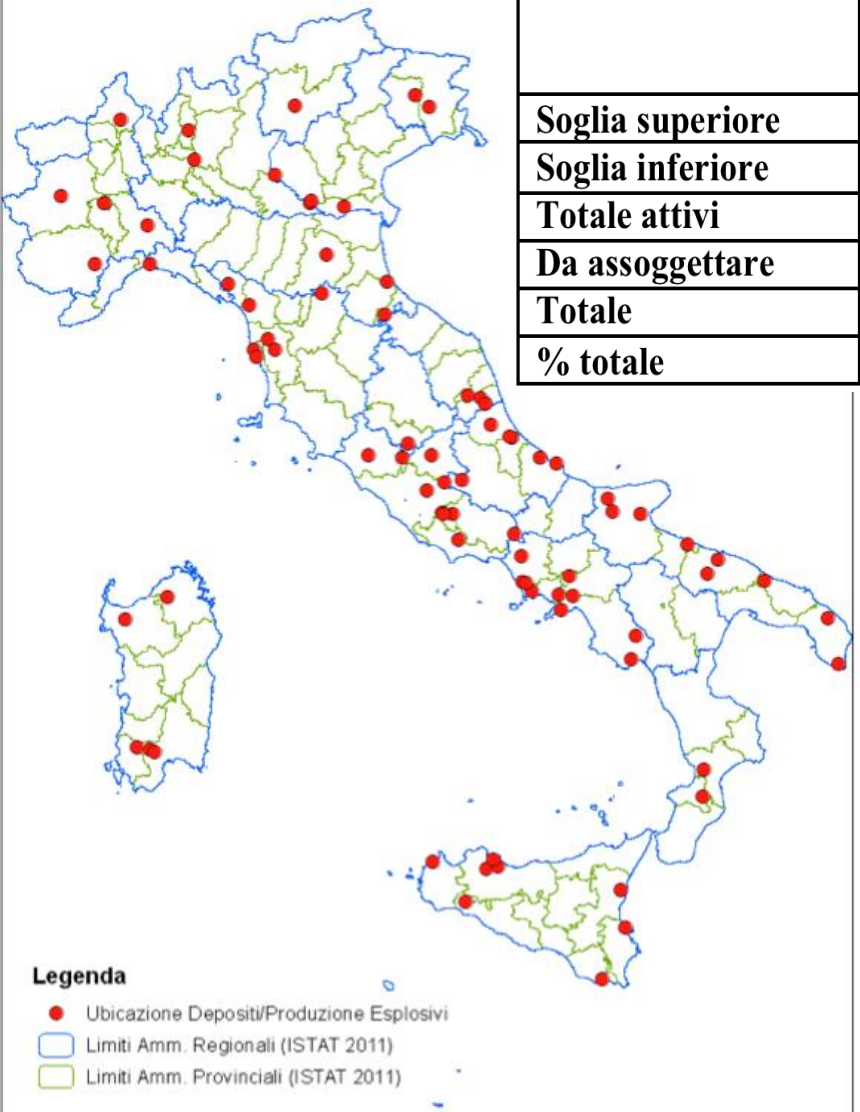



# Plants distribution in national area (source: ISPRA Seveso establishments database - 2015)

| | Pirotecnici | Stabilimenti che trattano esplosivi civili/militari | Totale |
|---|---|---|---|
| **Soglia superiore** | 6 | 21 | 27 |
| **Soglia inferiore** | 19 | 29 | 48 |
| **Totale attivi** | 25 | 50 | 75 |
| **Da assoggettare** | 2 | 5 | 7 |
| **Totale** | 27 | 55 | **82** |
| **% totale** | 33% | 67% | 100% |




- Strong prevalence of military/civil explosives plants respect of pirothecnic ones
- Major deficiencies (resulting from case histories and from SMS inspections) in pirotechnic plants

# Accidents analysis: preliminary considerations

- 35 accidents analyzed (major and not), occurred during the last 15 years in explosives plants over national area; critical elements pointed out in relation with plant units mainly involved
- in spite of TULPS application, it appears necessary to use SMS tools to examine in depht critical elements coming from accidents analysis, and to formulate addictional safety measures where TULPS seems to be not focused/detailed/completed
- not homogeneous situation among the plant units: of critical points concentration in raw materials mixing unit, product packing unit, internal tranferring and irregular products storage unit
- possible safety measures suggested, using SMS tools, in consideration of critical points highlighted

# Accidents analysis: critical points

- **Raw materials compatibility and stability**
  - quality/pureness contamination risk
  - oxidizing, incompatible, water reaction substances reaction risk
  - spontaneus overheating risk (autoreaction mixtures, organic peroxides)
  - spontaneous polimerization risk
- **Electrostatic charges prevenction and control**
  - ignition risk in powders storage unit and manufacturing areas
  - flammable powders dispersion risk; powders provided with explosive feature due to the small particles dimensions
  - charges generation risk by using installations, equipments, clothing not antistatic (handmade process, aged manufacturing procedure)

# Accidents analysis: critical points

- **Semifinished products quality control in manufacturing unit**
  - products accumulation inside the manufacturing unit or/and in proximity, or inside the pick-up trucks used for internal transferring ➔ risk of quantities exceeding TULPS-limits
- **Remote control of the process steps**
  - remote control of high risk operations (es. batch powders handling/manipulation) and/or operations involving toxic materials
- **Products quantities control in packing unit**
  - inside the unit and in proximity, or inside the pick-up trucks
  - adequate criteria for packing and traceability of products

# Accidents analysis: critical points

- **Products handling/manipulation**
  - risk of inadequate handling safety criteria, due to uncomplete respecting of the materials and products safety sheets
  - risk of presence of explosives traces after maintenace or change operations
  - risk of hit/collision of pression sensitive explosives
- **Irregular products storage**
  - risk of decomposition of irregular/not good products (expired, not good, damaged, sequestered by judicial authority) with possible risk of explosion trigger
- **Products test-control management**
  - risk of test of defective/irregular products, leading to explosion with possible domino effect on other plant units
  - need to provide reserved unit, at adequate distance from the other ones

# Accidents analysis: critical points

- **Storage of final products**
  - loss of stability and decomposition risk for high T and inadequate humidity inside the storage units; not adequate time and criteria for storage, not adequate input-output flow from the storage units
  - undesired reaction of metal combustible (present inside the products) with water
  - products damaged by hit/collision/friction due to not adequate arrangement of packages
  - early assembly of products with detonators (made inside the depot instead at the performance location); risk of elettromagnetic ray by using electric detonators close to explosive material

# Accidents analysis: critical points

- **Transport/transferring of products**
  - inadequate pick-up trucks for internal trasferring, inadequate internal routes to prevent possible domino effect on the other units
  - risk of hit/collision of the pick-up trucks or vehicle against the units
- **Equipments/devices ageing**
  - use of ageing and rudimental equipments/devices not provided with legal standards, or not undergoing the right maintenance cicles/frequencies;
  - equipments/devices not provided with right control instrumentation
- **Fragments/debris projection, sympathetic detonation**
  - domino effect caused by fragments projection from roofs and/or walls of plants buildings

# SMS approach and TULPS integration need

- critical points lead to formulate addictional safety measures following SMS approach, in particular risk assessment
- TULPS criteria: to be considered as “basic”, not linked to the specific establishment context (lay-out, site, policy, …), taken instead in consideration by SMS
- small pirothecnic establishments (not subject to Seveso), althought controlled by TULPS, seem to be the more frequent origin of accidents ➔ this confirms the importance to integrate SMS tools with TULPS

# TULPS-SGS integration: focal SMS elements



- clear definition of main roles-responsabilities for safety
- adequate risk analysis in every process-manufacturing-storage steps, identifying technical and management safety measures to apply in order to prevent-mitigate accidents
- definition of adequate training procedures and plans for all the employees; they have to be trained mainly in identifying possible accidents root causes for each step of process, and in emergency response-management for them
- definition of operative procedures containing operative criteria in normal, abnormal and emergency conditions for all the process steps
- definition of maintenance procedures and plans for installations, equipments, devices; provide efficiency test/control of safety systems, in particular of protection barriers
- definition of emergency procedures and maintenance plans for emergency/fire devices

# TULPS-SGS integration: safety measures proposed

- **Raw materials/products compatibility and stability**
  - materials separation in different areas; substances incompatibility control
  - control of input-output flow from the storage units
  - materials specifications standards definition respecting of the safety sheets

*(TULPS controls materials flow on base of quantity, without consideration of stability; absence od specific criteria for materials/products storage in terms of T, umidity, … in relation with safety sheets)*

  - packing and traceability criteria for products; adequate arrangement of packages (organized, fixed), with adequate passing ways (condition, dimension) inside the unit

*(TULPS doesn't consider criteria for adequate passing way)*

# TULPS-SGS integration: safety measures proposed

- **Ignition/trigger/explosion prevention**
  - risk analysis implementation, with reference to specific context of the plant

  *(TULPS adopts rigid/static approach without consideration of specific context of plant and site)*
- **Irregular products storage**
  - management of irregular/not good products stock (expired, not good, damaged, sequestered by judicial authority) providing specific procedure, and possible reserved unit at adequate distance from the other ones

  (*not considered in TULPS)*

# TULPS-SGS integration: safety measures proposed

- **Transport/transferring of products (inside of establishment)**
  - prevention of explosion risk during products transferring; consideration of possible internal map of routes (for explosives and also for persons) adequate for the specific lay-out, which provide for passing ways far from the plant units
  - materials should be picked-up by one truck at a time; limited quantities transferred in the routes
  - use ADR homologated truck/vehicle also for internal transportation; use of road sign, speed limits, safety driving procedure …

  *(not considered in TULPS)*

# TULPS-SGS integration: safety measures proposed

- **Safety requirements for equipments and process**
  - safety requirements list for critical equipments/devices used, constantly updated to the technical and regulation evolution, and periodically verified
  - sistematic presence of documentation and certification showing qualification of devices used for handling explosives
  - remote control

  *(not detailed in TULPS)*
- **Building design and planning**
  - *regulated by TULPS, but the operator can do further more to increase the safety level, in relation with the specific plant*
  - steel buildings, compliant with structural standards to resist at heartquake
  - reinforced concrete barriers/walls to protect the buildings/units

# TULPS-SGS integration: safety measures proposed

- **Explosives quantity control**
  - *regulated by TULPS, but the operator can do further more to increase the safety level, in relation with the specific plant*
  - further limitation of explosives quantities inside the buildings: strong mitigative effect in case of explosion, especially to avoid domino effect
  - quantities control not only inside the units: products accumulation inside the manufacturing unit or/and in proximity, or inside the pick-up trucks used for internal transferring
  - split the production cycle in many simple steps to be realized in different and separed units; simple processes hand made and in small doses
  - need of congruence between explosives authorized quantities storaged inside the units, explosives quantities notified, explosives quantities really used or handled
  - need of congruence between explosives quantities storaged inside the units and explosives quantities registered in the external transport vehicles (coming from the establishment)

# TULPS-SGS integration: safety measures proposed

- **Fragments/debris projection, sympathetic detonation**:
  - possible variation of distance among the units and of the quantities handled/stored inside the units (in relation with the specific context of the plant)
  - use of adequate materials for barriers/walls, building, roof; roof should be made of light materials but breaking up into little pieces (not metallic)
  - use of possible steel reticulum on the top of the unit for double protection: to allow preferential vent for the blast wave, and to block major fragments (more dangerous)

*(marginally considered by TULPS)*

# TULPS-SGS integration: safety measures proposed

- **Internal distance among the plant units**
  - regulated by TULPS, but the operator can do further more to increase the safety level, in relation with the specific plant
  - further longer distances and further higher barriers can be adopted to reduce strongly domino effect
- **Carico – scarico di materiale da/a mezzi esterni**
  - provide for specific areas reserved for loading-unloading materials/products from/to external transport vehicols (separated from parking area and far from manufacturing/storage units) to define in relation with the specific plant and context

*(no TULPS indications)*

# TULPS-SGS integration: safety measures proposed

- **Personnel/employees presence in working areas, custodian**
  - minimize number of employees in working areas
  - minimize number of custodian's hauses; provide for training on emergency response to all the custodian's family and all of mployees
- **Fire system and escape ways**
  - adequate fire devices (for quantities and qualities)
  - provide for (if possible) a 2° access way to the plant, to simplify the firefighters access and personnel escape after accident;
- **Toxicity risk of explosion**
  - consideration of risk of toxicity related to the manipulation of unexploded products
  - consideration of possible toxic gas produced after explosion

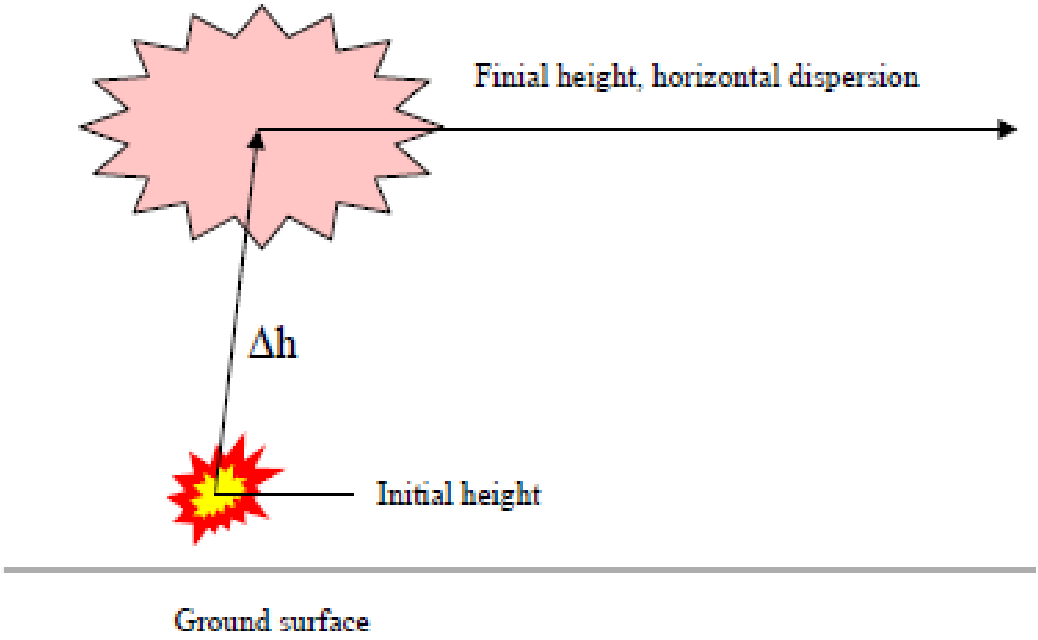
*(no TULPS indication)*

# Analysis of gas behavior after explosion

- TULPS-SMS integration: focus on behavior of toxic gas produced after explosion (es. $NO_x$ e $CO/CO_2$)
- quantities-composition of toxic gas cloud depend on type-quantity of explosive, anyway always presence of $No_x$ and CO
- toxic effect: less importance, but considered in national/international scientific literature and in some safety reports
- toxic gas cloud behavior analysis made by ISPRA: after fixing source terms, use of simplified calculation model (plume and cloud) found in scientific literature, carry out a scenario simulation with PHAST 6.7
- scenario analized: combination of 2 consecutive events: explosion of entire depot (20 t explosives), plume production and toxic cloud dispersion

# Analysis of gas behavior  after explosion





# Analysis of gas behavior after explosion

- plume height H: representative of explosion energy of the explosive mass involved (wich results in movement in height of burnt gases)
- toxic cloud: instantaneous release of CO/NO2 cloud, after cathastrofic rupture of vessel, located at H of height
- considering PHAST limits (which shows results variation only up to max 100m of height), it is possible to conclude that:
  - CO dispersion: low risk; no significative effects; insufficient time of exposition at significative concentration
  - $No_x$ dispersion: more critical results: cloud reaches the soil, but still not enough exposition to cause human health impact