

Fire and explosions at a fireworks storage depot

6 march 2002

Carmel

Western australia

Fireworks
 Container
 Mass explosion / confinement
 Procedures
 Safety distances
 Risk analysis

THE FACILITIES INVOLVED

The site:

The storage facility has been operating since 1986. It is located on a 10.35 hectares orchard property. Four relocatable steel explosives magazines were located at the facility (M1 to M4 on the diagram below), secured inside metal chain-link fenced compounds. Two metal-clad sheds (shed 1 and 2) and 4 general purpose freight containers (FC1 to 4) were also on site.



View of the storage facility - FC3 is located inside shed n2 [1]

Fireworks are imported in freight containers from overseas and are stored inside the steel magazines. In order to prepare a firework display, firework pieces are collected from the respective magazines, sorted and assembled in the sheds.



Relocatable steel magazine [1]



General purpose 6 m (20') ISO freight container [1]

The involved unit:

The operator did not keep a detailed inventory of the types and quantities of fireworks that were stored inside each of the magazines and shipping containers. Thus, the quantities could only be estimated based on witness recollection [1].

Unit	Storing...	Quantities (NQE : Net Explosives Quantities)
M1	Ground-level fireworks (packs)	700 kg (steel container less than half full)
M2	Ground packs (230 cartons)	725 kg
M3	Aerial shells (75-300 mm) and salutes (maroons)	300 kg (less than 1/3 full)
M4	Aerial shells (75-400 mm)	1 626 kg
FC1	Roman candles	3-4 cartons (25 units / carton)
FC 2	Daytime smoke, plastic crates and cardboards mortars	3-4 cartons
FC 3	Confetti bombs, portfires, lances, partial rolls of quickmatch, fountains and electric fuseheads	2 000 units of electric fuseheads.
FC 4	Temporary storage of fireworks before preparation in shed 2.	empty
Shed 1 (15x10m)	Mortars, tubes, racks, wood	
Shed 2 (12x8m)	Unfired ground pack, rolls of quickmatch, lances and portfires	

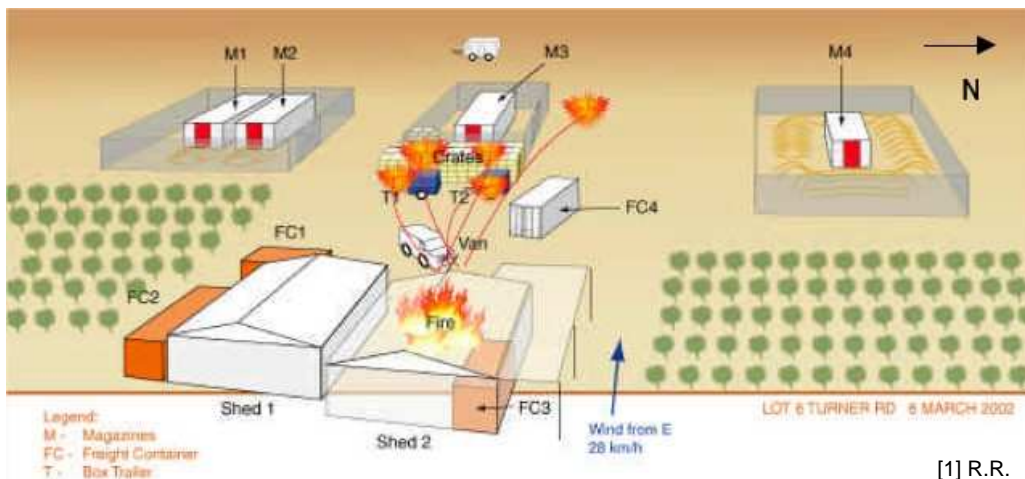
On the day of the accident, 2 operators were on site, working in shed n°2. The first one was removing fuseheads from misfired ground packs from a display; the second one was sorting out the ground packs boxes (less fusehead) in order to prepare them for a forthcoming display.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

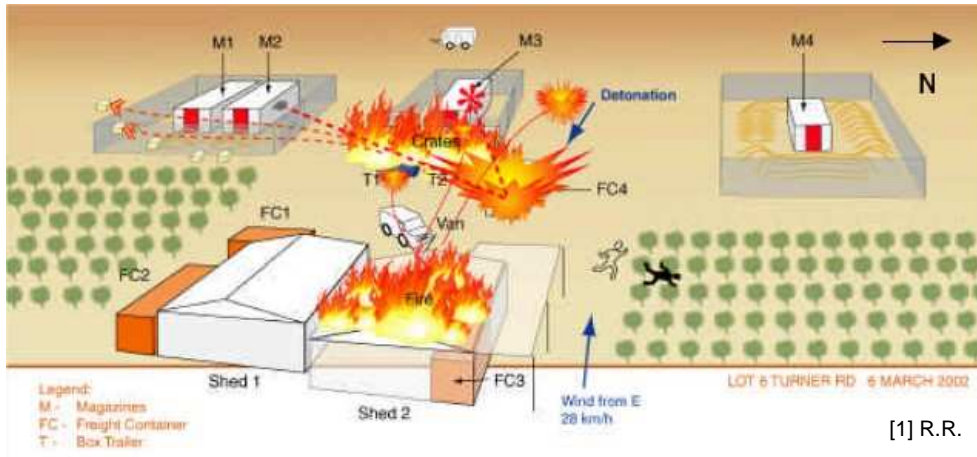
At 8h45, an operator placed a ground pack on one wooden work bench and the firework piece ignited ; the first shot initiated the 25 shots in the entire pack. Burning stars hit the roof and walls of the shed and fired in all directions, initiating other fireworks inside shed 2.

The operators ran outside for shelter, thick grey smoke could be seen emanating from shed 2 and the fire spread to FC4, box trailers, bushes...

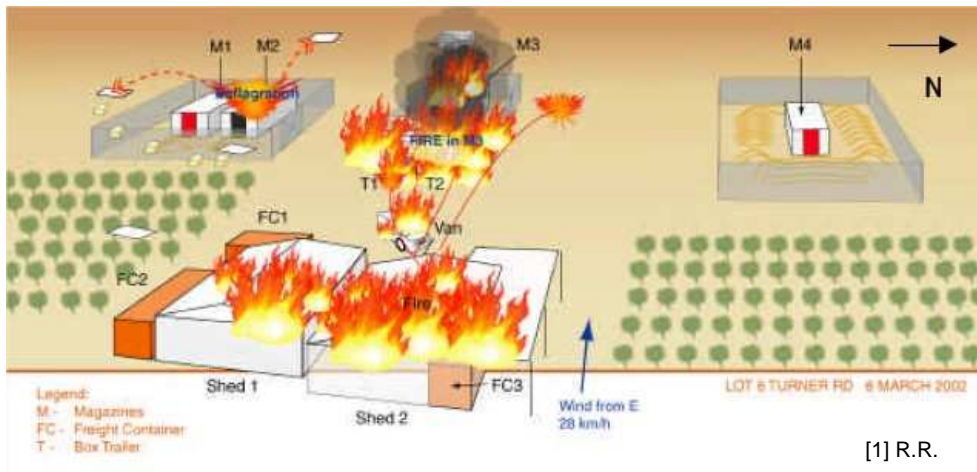


[1] R.R.

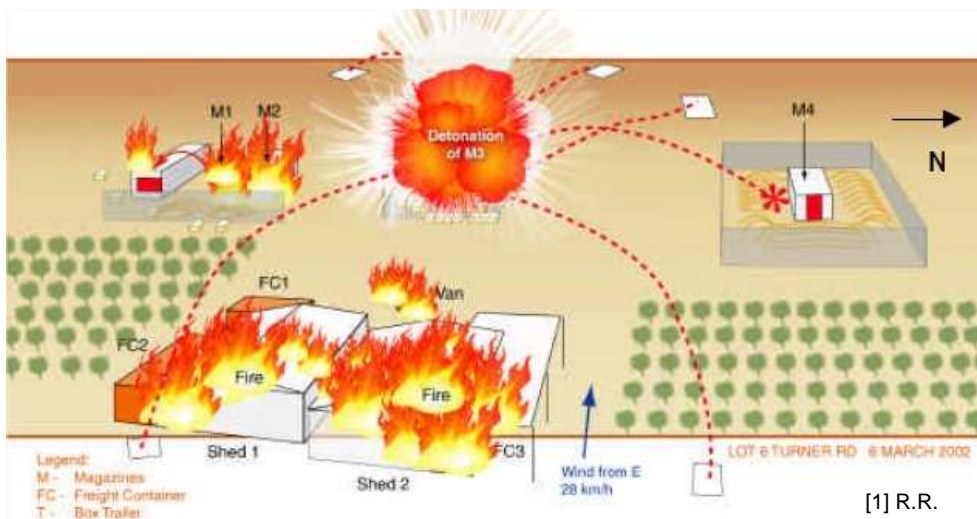
At 8h52, FC 4 exploded, knocking one of the employee to the ground (not injured). Pieces of the container pierced the walls of M2 and M3, causing fires.



At 8h56, Magazine M2 “opened”, Shed 1 and M3 started burning.



Finally, at 9h06, the M3 storage exploded violently with a 100 m fireball, spreading pieces of metal up to 510 m. The door of M3 (170 kg) was found 370 m away, the roof (380 kg) 295 m away in the opposite direction.



M1 burned entirely but did not explode. It fell on the side when M3 blast. M4 was surrounded by an earth mound that protected the magazine from flying debris. It was saved from fires.

The fire at the facility was brought under control at 15h25 on march 7th.

Consequences of the accident:

Fortunately, no-one was hurt.

The site is destroyed and several vehicles were burned.

40 properties were damaged by the air blast within a 4.5 km radius from M3. Damages included scattered windows, damaged ceilings, displaced doors...

40 ha of bushland was burnt.



Accident site after the explosion [1] R.R



[1] R.R.

crates in front of the M1/M2 fence.

The European scale of industrial accidents

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

Dangerous materials released		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Human and social consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Environmental consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Economic consequences		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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

The most violent explosion is estimated at 400 kg TNT equivalent. Thus, the dangerous material released index is rated at 2 (parameter Q2 < 1 t TNT eq.)

No one was injured or confined more than 2 h; the human and social consequences index equals 0.

The environmental consequences index equals 0 (none of the environmental parameter of the scale is concerned in this accident)

Due to a lack of information, the economic parameter is not rated.



[1] R.R.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

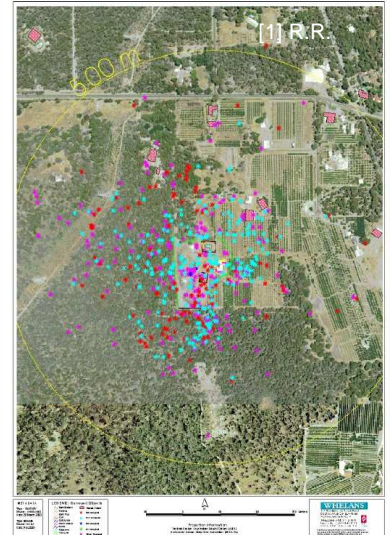
Electrostatic discharge was not considered a likely as the technician had already handled two ground packs and would have dissipated any electric charge on his body. Radio frequencies have been ruled out as both the technicians had their mobile phones switched off.

The operator described tilting the box by 45° too read the inscription to determine the colour of the firework. Some of the firework composition may have fallen out of a pierced firework and been trapped between the paper and the box casing. The impact of the box on the bench might have been sufficient to ignite the composition.

FC 4 was 16 m from the open door of shed 2 and it is possible that one of the door might have been left open. FC 4 contained aerial shells (75-100 mm in diameter) in 4 or 5 boxes. These fireworks were an assortment of shells ready for the coming displays. There were no longer in their original packaging but closed packed (108 shells instead of 72 shells per box) and more energetic. There might have been 1 or 2 salutes that could also have reinforced the mass explosion.

The mass explosion of M3 can be explained by its content : 200-300 mm shells, cartons of 75 mm salutes... that are nowadays classified as UN 1.1 exhibiting a mass explosion behaviour.

survey of the shrapnel from FC4 (light blue), M2 (dark blue) and M3 (red)



ACTIONS TAKEN

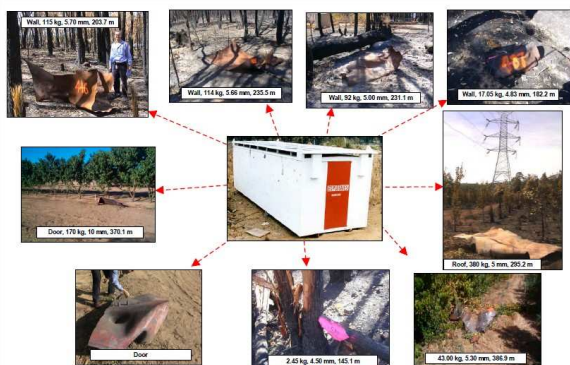
The Australian government recognized the potential for a mass explosion in firework storage under specific conditions and invited the industry to conduct risk assessments in their storages. The legislation regarding explosives and fireworks was modified accordingly. Especially, fireworks for the purpose of a display will only be permitted on the display site, up to 14 days before the fire.

LESSONS LEARNT

The enquiry and subsequent report underlined the importance of :

- the identification of the mass detonation hazards for fireworks,
- the respect of storing conditions (only in licensed magazines, special attention to temporary storages such as FC4...)
- the respect of safety distances between magazines and the risk of “relay” effect, (e.g. FC4, presence of a caravan and trailers...)
- the removal of flammable and combustible material from the magazine storage (e. g. 1000 plastic crates and wooden stakes where stored at less than 8 m from M3...)
- preparation areas outside of -and at a safe distance from- magazine storage (organisation in shed 2 which was partially used for storage...)

REFERENCES (INCLUDING ALL PICTURES)



[1] Report of the investigation into the fireworks accident at Carmel, western Australia – Australian government / department of mineral and petroleum resources, that can be downloaded at :

http://www.dmp.wa.gov.au/documents/Reports/DGS_R_CarmelExplosion.pdf

Left : metal scrap from M3 that mass detonated [1] - R.R