Explosion inside an underground storage of explosives

November 2, 1992

« Steingletscher », Swiss Alps Switzerland

Pyrotechnics
Underground storage
Risk analysis
Waste
Ammunition

THE FACILITIES INVOLVED

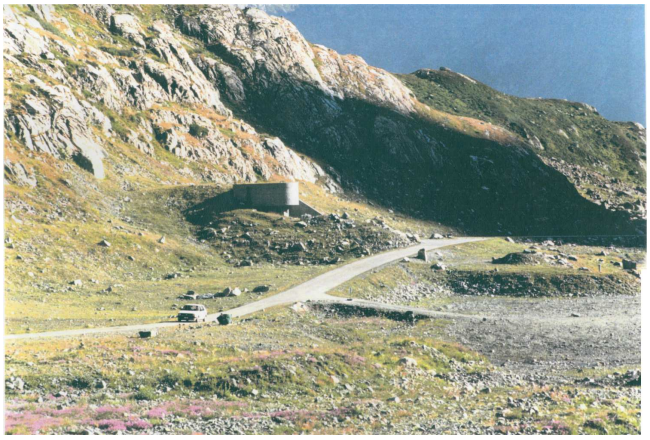
The site:

The magazine was located 2040 m above sea level, right in the centre of Switzerland, in a side valley close to the "Gotthard" valley which is an important north to south road in Europe.

The magazine was built between 1982 and 1984 in a steep mountain slope in order to serve as an intermediate storage of old ammunition and production waste awaiting for destruction. The nearest inhabited building was 1.5 km.

In front of the magazine stood a 0.5 km^2 plateau, surrounded by mountains up to 3000 m high. The plateau consists mostly of rock rubble with some alpine meadows and is covered with snow more than 6 months a year. It was not used for anything, except as a destruction area for old ammunition and explosives as well as occasional military training.

Explosive waste and old ammunitions ready to be destroyed, were delivered to the depot once a week and stored there until autumn when the destruction campaign took place.



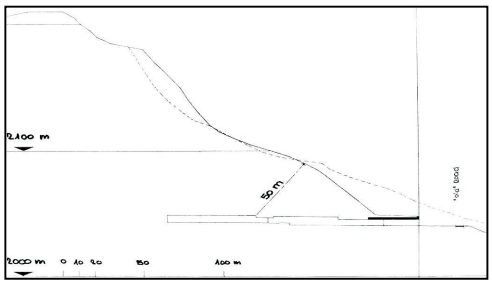
Entrance of the underground storage and destruction area (before the explosion)

The involved unit:

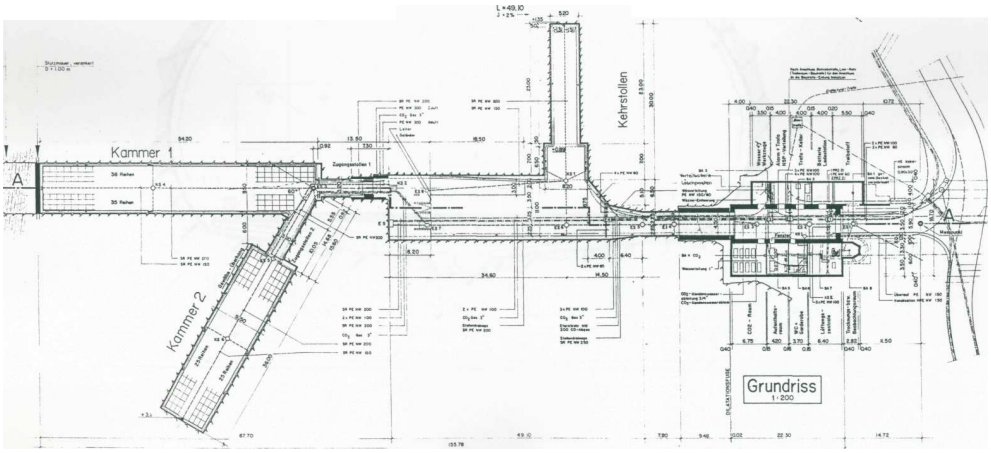
The underground magazine consisted mostly of (see picture below):

- two chambers
- an unloading area, accessible for trucks,
- and the entrance building containing all technical installations (utility building), a recreation room for the personnel and a specially designed room (watch tower) used during destruction operations. This building was actually built in the open and covered with rock rubble.

The rock overburden of the storage chambers was about 50 m.



Longitudinal Section through the Mountain and the Installation before and after the event



General layout of the underground magazine

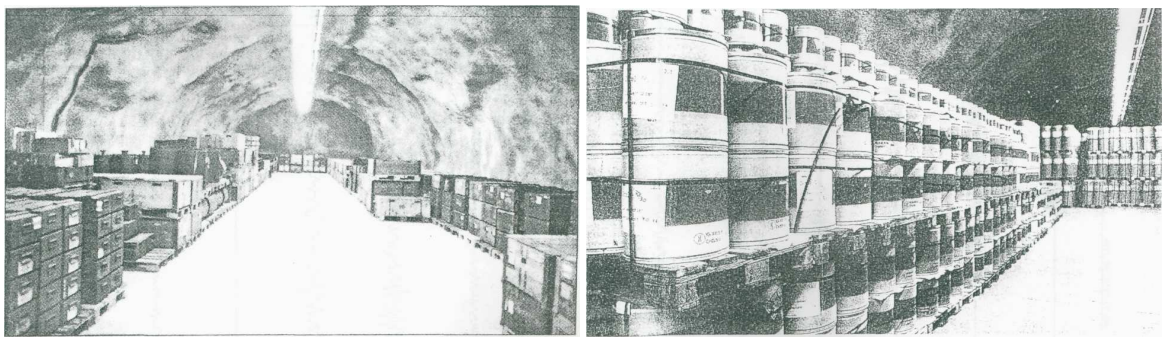
Initially, the storage was supposed to be built as one 90 m-long chamber. During construction however, a geologically “bad zone” was reached after 60 m, which could not be crossed without enormous costs. It was therefore decided to seal the chamber with a concrete wall and to build the remaining part as a side tunnel.

The installation lay in very good rock, mostly granite. Therefore, the access tunnels and the chambers were not lined with reinforced concrete but were secured with shotcrete and rock anchors.

Moreover, the storage was equipped with the following technical installations:

- a ventilation system for the storing chambers and the unloading area
- electrical installations (“explosion proof" where necessary)
- a fire detecting system
- an automatic fire extinguishing system with carbon dioxide (not activated when the personnel was inside the installation)

The day of the explosion, the storing chambers contained several hundred gross tons of material (TNT-flakes in cardboard drums, waste from fabrication, parts from disassembled old ammunition, including parts from illuminating grenades, small to medium calibre rounds…), which TNT-equivalent can be evaluated at 200 tons. The average loading density of the two chambers was around 40 kg/m^3.



Material Stored a few days before the explosion (left: chamber1 ; right: chamber 2).

17 persons worked in the area the day of the explosion : 6 of them inside and 11 outside where normal demolition work was carried out (preparation for blasting).

Among the workers inside the installation, there were probably :

- one person in one of the loading chambers preparing/loading material to be transported to de demolition ground,
- one person doing some repair work on one of the transport vehicles inside the installation, but close to entrance,
- 4 persons inside the recreation room, near the entrance.

One person, had left the installation only a few minutes before the accident, without noticing anything unusual.

As work on the demolition ground was in progress, the access road was closed to the public and no other people (hikers…) were around.

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

The accident:

At 16:13, a ground shock reaching a magnitude of 3.7 on Richter's scale was recorded by all seismological stations in Switzerland and down to Italy. A fire in the chamber was reported 5 to 10 seconds before, thus indicating that the fire turned into a detonation within a very short time.

The blast destroyed part of rock above the chamber ; due to the steep mountain slope, a large quantity of rock material broke loose from the top of the mountain and covered the area where the installation had been located. The bad geological zone recognized during the construction of the installation, worked as a gliding zone for this material.

After the explosion, some explosives material burnt inside the mountain as flames could be seen emerging from cracks in the rock.

Overview of the whole area

Consequences of the accident:

The six persons inside the installation were killed immediately. The 11 persons on the demolition ground were not injured despite falling debris, but severely shocked.

The installation was completely destroyed. Rock material from the overburden was thrown to the surrounding up to a distance of 500 m.

The entrance building was torn to big pieces and dislocated 50 to 100 m from its original place. Some parts, up to 20 tons a pièce, were hurled over the plateau to a distance of up to 600 m and were only stopped by the steep mountain slope on the other side of the plain.

The transport vehicle under repair, inside the access tunnel but near the entrance, was also torn to pieces which were thrown out up to 200 to 400 m as well as other vehicles parked in front of the access tunnel or nearby.

Debris from the entrance building arch, found 370 m away (weight: 15 t).

The European scale of industrial accidents:

By applying the rating rules of the 18 parameters on the scale officially adopted in February 1994 by the Member States' Competent Authority Committee, which oversees application of the "*SEVESO*" directive on handling hazardous substances and in light of available information, this accident can be characterised by the following 4 indices:

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

The level of the "hazardous materials released" index stands at 5 because of the TNT-equivalent (evaluated at 200 t / Q2 parameter).

The level of the "human and social consequences" index reaches 4 due to the death of 6 employees (H3 parameter).

Since no information was available regarding environmental consequences, the corresponding parameter could not be rated.

Since no information was available regarding the costs, the corresponding parameter could not be rated.

Overview of the scene after the explosion

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THE ACCIDENT

The cause of the fire leading to the explosion remains unknown, due to the full destruction of all installations.

Nevertheless, it should be noted that the material stored in the depot was peculiar (TNT-flakes in cardboard drums, waste from fabrication, parts from disassembled old ammunition, including parts from illuminating grenades, small to medium calibre rounds…) and differed from normal ammunition storage conditions. The waste material might have been more reactive than “normal products”, which increased the probability of the event. No information is available concerning that point nor the risk analysis of the installation.

ACTIONS TAKEN

The ruins were not excavated due to the costs and high risks of such operations.

In Switzerland, explosive waste materials are now burned in closed ovens. The planning for such a system was on its way at the time of the accident. The tragedy probably accelerated the transition.

LESSONS LEARNT

Legal and technical investigations were carried out. Unfortunately, snow covered the place three days after the explosion. The inventory of the debris started only in July 1993. The aim of the data collection was to get more basic data about the effects of such explosions and compare the effects with the models used for the risk analysis according to the Swiss regulations at the time of the accident (TLM 75).

The aim of this intermediate storage was a risk-reduction measure at the production site in order to avoid the accumulation of waste and consequently the effects of an accident there. In that sense, the conception of the depot was good, since no third party was injured during the accident.

The gravity of the accident with the death of 6 workers is nevertheless questioning the idea of storing large quantities of explosive waste materials for such a long time. Indeed, the properties of those products are less known and evolve in different ways as “normal productions”.

It is recommended to destroy explosive waste as fast as possible in order to avoid the accumulation of huge quantities and the ageing of already less stable and less “known” products.

REFERENCES (INCLUDING PICTURES)

- √ “The explosion in the underground explosives storage magazine in the swiss alps on november 2, 1992”, report from Bienz, Kummer and Partner AG for the Swiss committee for the safety of the handling of ammunition and explosives by forces and administration and the defence technology and procurement agency; Contribution to the 18th Klotz-Club Meeting, 19-21 October 1993.

- √ http://www.festung-oberland.ch/Infrastruktur/Munition/Explosion%20Steingletscher/Explosion%20Susten.html

- √ Accident investigations at the swiss steingletscher installation, H. Ritz, P. Kurnrner, J. Jenus and K. Bakhtar Air Force Operability Management Office. Available at http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA507023&Location=U2&doc=GetTRDoc.pdf and http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA507020&Location=U2&doc=GetTRDoc.pdf