12.1 THE REASONS

In the late 1940s, four catastrophic accidents occurred in ammunition storage magazines in Switzerland, killing several people and causing more than CHF 100 million (Swiss francs) of damage in the surroundings and to the installations. In addition, roughly 10,000 tons of ammunition were lost. As a consequence, the government established an Ammunition Storage Board uniting military and civilian logistic leaders and safety experts. After the investigation of the accidents, one of the first tasks of this board was to review and tighten the safety regulations. In essence, these regulations were deterministic and relied mainly on measures: they followed the traditional and widely accepted principles of safety distances to inhabited buildings and of various hazard categories for different types of ammunition. As another consequence, the construction and manufacture of the ammunition were improved, less dangerous materials were used, and the quality of the stored ammunition was continually controlled.

However, after only a few years, these regulations proved to be too inflexible to respond properly to the new problems which evolved. The amount of ammunition to be stored and its explosive content steadily increased. Military readiness requirements called for additional storage space closer to populated areas. At the same time, a great number of residential, public, and industrial buildings, leisure installations, and roads were built closer and closer to the existing storage installations. And finally, the financial funds were limited as always and everywhere.

The Ammunition Storage Board did not want to bury its head in the sand and increase the number of waivers. It therefore decided to investigate the problem thoroughly and in all its dimensions in order to find the correct answers to the actual questions and, based on
them, work out new regulations that would really help. The general direction was shown by the first experimental risk analyses, performed in 1970 for a few existing underground magazines, the capacity of which was actually limited by the former safety regulations and not for reasons of space. With the risk/filling relationship calculated individually for every magazine, taking into account the actual human activities in the surroundings, it was shown distinctly which magazines could be filled beyond the limit given by the regulation without a bad conscience and which could not (Fig. 12.1).

**12.2 THE COURSE OF ACTION**

For the program in mind, the Ammunition Storage Board looked for external expertise. It founded a subcommittee for conceptual decisions, study groups with military and civilian officials as well as experts, and obtained the necessary funds. In essence, the resulting organization still exists today.

The problem was tackled along the whole front, the questions arising being numerous and contrary. There were the military requirements such as readiness and protection against enemy weapon effects, the cost, and, of course, the safety aspects. Obviously all these aspects should have been met at the same time, and solutions could be found not by setting absolute requirements but instead by weighing up the three aspects and uniting them in an optimum solution.

Concerning safety, there was no better way than to introduce the quantitative risk concept and risk/cost criteria. This was a completely new method that was possible because the civilian laws and guidelines did not focus on the safety of ammunition and explosives in the military area at that time. The Swiss Explosives Law [1] released (and still releases) the military from its substantive contents but commits the government to issuing its own regulations.
Many methodological, technical, and political questions arose, such as risk calculation procedures or data on spreading of hazardous effects, effects on humans, probabilities of explosions, representative explosive quantities, etc., and safety criteria. Much technical data came out of literature studies. Other data were gained through model or even full-scale tests. The safety criteria were discussed thoroughly and issued by the responsible authorities.

Of course, not all questions were anticipated in the very beginning and, due to the limited funds, capacity and capability, they had to be answered one after the other and little by little. The priorities were given by the practical needs: new magazines had to be built, i.e. they had to be designed according to the requirements and sited safely.

The basic work on methodology and data and the conceptual decisions were applied immediately to actual examples. Thus, the storage regulations [2], which were written and established rather quickly (1975), had already been successfully tested in practice when they came into force.

Initiated by a project of a new assembly plant in one of the ammunition factories of the Department of Defence, risk analysis was also applied to ammunition and explosives handling in factories. This activity also lacked adequate regulations and criteria that would have allowed safe and economical installations and operations. A study group was founded in the mid-1970s, and a concept study for safety assessment in ammunition factories was worked out [3]. A risk analysis of all the working places of one of the factories underlined the feasibility of the quantitative approach in this field of activities [4]. The findings of this study were applied to the assembly plant project. The missing technical data for constructions and risk analysis were acquired through model tests.

A couple of years later, the concept study was adapted to technical regulations [5], and the safety criteria were harmonized with those of the storage activity. On the upper level the risk based concept (RSCAE—Risk based Safety assessment Concept for Ammunition and Explosives) was enacted in a directive of the Chief of General Staff that covered the whole range of handling of ammunition and explosives in the Department of Defence [6].

Today, the RSCAE has been carried out in storage, manufacture/demilitarization, and testing/passing as well as in special problems. Because of financial priorities, it has not been introduced in transport and in the armed forces, where safety is dependent on a very dense net of detailed deterministic regulations. At the moment, a study of the transport is ongoing and should show how to proceed in carrying out the RSCAE.

In addition, models, data, and criteria in the existing technical regulations have to be revised and adjusted periodically according to the advancing state of knowledge.

### 12.3 THE METHODOLOGICAL CONCEPT

#### 12.3.1 The Three Main Points of View

As many discussions show, the term of safety is not always understood definitely and clearly. Current deterministic safety concepts leave open which safety they are good for. But three important points of view can be distinguished and have to be considered according to the Swiss RSCAE (Fig. 12.2):

- **The first viewpoint** is that of the endangered *individual*. His primary interest is on his own hazard, which he judges based upon his own standard, regardless of how many other people are endangered and how.
- **The second viewpoint** is that of the anonymous *society* at large, which is first of all interested in the total extent of a hazard, e.g., as it appears in accident statistics.
- **Apart from this, the people responsible** for the dangerous activity are interested in limiting hazards in such a way that public opinion does not question the specific dangerous activity.
The Department of Defence feels generally more exposed to the public response and is much more afraid of catastrophic accidents that cause a great deal of discussion than of smaller but more frequent accidents creating less stir.

12.3.2 Dichotomy of the Safety Assessment

The RSCAE distinguishes distinctly between the objective, factual part of the safety question and the subjective part, which is determined by social values (Fig. 12.3). Very often, conventional deterministic concepts mix these aspects and cause numerous misunderstandings. Corresponding to the structure of the safety question, the risk analysis and the risk appraisal are separate tasks.

12.3.3 Quantification of the Hazard

A very important element is the quantitative description of the hazard using the terms of risk. Only if hazards are expressed quantitatively can they be compared with other hazards of the same or other activities, and only in this way can the benefit of safety measures be shown reasonably.
Simply said, the risk is given by the product of the probability or frequency and the expected damages or consequences of the event concerned (Fig. 12.4). The hazards of explosions would usually be described with sufficient accuracy as a fatal risk.

Corresponding to the above-mentioned three aspects of the safety problem, individual risk, real collective risk, and perceived collective risk are identified. The real collective risk of an event—a statistical expected value—is given by the sum of all individual risks caused by the event. The perceived collective risk is the real collective risk increased by an aversion function that takes into account that the reaction of the public is much more violent to rare events with large consequences than to more frequent events with fewer consequences per accident.

12.3.4 Methodical Procedure of the Risk Analysis

The aim of a risk analysis is to calculate these risks. The risk analysis is a systematic procedure of four steps (Fig. 12.5):

1. **Event analysis**: Possible events are identified and described concerning location, type of reaction, probability, and size (quantity of explosives).
2. **Effect analysis**: The dangerous effects of the possible events to persons in the surroundings such as fragments, debris, airblast, etc. are determined.
3. **Exposure analysis**: Places, protection, and history of possibly exposed persons in the hazardous areas are investigated.
4. **Risk calculation**: The parameters deduced from the previous steps are connected mathematically.

12.3.5 Levels of Risk Appraisal

While the risk analysis aims at identifying the characteristics of a particular case in question, risk appraisal has to be seen from a wider perspective (Fig. 12.6). Methodologically, it is
necessary to distinguish between the establishment of long-term safety criteria by the responsible persons and the proof of safety in practical cases when the safety analyst has to prove that the remaining risks do not exceed the limits.

### 12.3.6 Differentiation of the Risk Bearers

The RSCAE considers that the acceptance of risks depends on the relationship of the exposed person to the hazardous activity and to what extent the person is able to influence his risk (Fig. 12.7).

For example, risks voluntarily taken are considered acceptable on a much higher level than those risks unintentionally run. The difference may be about a factor of 1,000.

The Swiss safety criteria are based on a simplified model that distinguishes four categories of risks: (1) voluntary, (2) high self-determination, (3) low self-determination, and (4) involuntary. Two of them (3 and 4) are relevant in the field of safety of explosives and ammunition. The risk of third persons in the surroundings of a storage or a factory belongs to category 4. The risks of people earning their money by working with dangerous goods with a low ability to influence and a low degree of self-determination, but a certain perceived benefit (directly and indirectly involved persons), are assigned to 3.
12.3.7 Types of Safety Criteria

The main aspect under which individual risk has to be appraised is equity: nobody should bear a higher risk than any other person in the same situation. So the adequate safety criteria for individual risks are upper limiting values (Fig. 12.8).

In the case of the collective risk, however, upper limits are no longer reasonably applicable. It can be shown that upper limits would prevent from producing the minimum risk for a given investment for safety measures. In addition, there is no common basis for risks from different sources of hazard. Being aware that at the very end safety is a function of financial means, it seems plausible to rely on how much society is (and should be) willing to pay for the safety of its members. There is no question that financial means for safety measures are definitely limited, and everybody agrees that the resources available should be spent so as to achieve the maximum safety (or the minimum risk) overall. Thus, limiting collective risks is a typical optimization problem. When appraising the collective risk of an activity, the investment for safety has to be related to the achieved risk reduction, as it is shown in the risk/cost diagram in Fig. 12.9. One has to go on with safety measures until a
certain risk/cost ratio is attained that has to be respected by everyone. So the basic principle in limiting the collective risk is the willingness-to-pay-approach, and the quantitative safety criterion limiting the collective risk is actually a marginal-cost value.

It has to be emphasized that the willingness-to-pay principle differs completely from attempts to use the monetary value of a human life or even life years as a safety criterion. There will never be a reasonable and ethically indisputable answer to that question. Ten different people who would be willing to quantify the values of the lives of 10 different persons might give 100 different answers. But even people who would refuse to answer this question for ethical reasons will find it necessary to spend money to prevent people from becoming victims. But, with regard to the value and object of the dangerous activity as well as the limited funds, they would not spend an infinite amount and would want to realize the minimum risk with the money spent.

The marginal-cost approach is also totally different from the attempts to limit the collective risk (expressed in a frequency/consequence value couple) in a frequency/consequence diagram that gives the quantitative safety criteria by two lines enclosing an ALARP (As Low As Reasonably Practicable) area, separating “safe” from “unsafe” (Fig. 12.10). These lines marking off what is obviously considered tolerable and obviously not acceptable usually lie rather far apart. However, the actual cases usually lie in between (i.e., in the ALARP area), still leaving the safety analyst or the responsible authority without clear instructions for deciding on “safe” or “unsafe.” On the other hand, the marginal-cost principle really helps, independent of the level of the system (i.e., factory or pressing machine), quantifying the notions “appropriate” and “reasonable,” which the judge would apply after an accident,
clearly and in advance. It has to be added that the frequency/consequence-method can be outwitted by suitably modeling the hazardous system in the risk analysis [7].

### 12.3.8 Quantitative Safety Criteria

The quantitative safety criteria for the handling of ammunition and explosives in the military field in Switzerland that were laid down by the responsible authority are shown in Fig. 12.11:

- The maximum acceptable individual fatal risks are:
  - $10^{-4}$/year for directly involved persons\(^1\)
  - $5 \cdot 10^{-5}$/year for indirectly involved persons\(^2\)
  - $10^{-5}$/year for not involved third persons\(^3\)
- The marginal costs for preventing one fatality are:
  - CHF 4 million \(= \text{€ 2.7 million or US$ 2.4 million in 2001}\) for directly involved persons
  - CHF 8 million \(= \text{€ 5.3 million or US$ 4.7 million in 2001}\) for indirectly involved persons
  - CHF 20 million \(= \text{€ 13.3 million or US$ 11.8 million in 2001}\) for third persons
- The aversion function weighing up the actual consequences to the perceived consequences is \(\varphi(C) = 2^C/5\), where \(\varphi_{\text{max}} = 16\).

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1 Such as the worker at the high-explosive pressing machine.
2 Such as the secretary in an ammunition factory.
3 Such as the car driver driving along an ammunition magazine.
12.4  THE REGULATIONS AND ORGANIZATION

The development of the regulations did not take the ordinary course from top to bottom. The urgent needs came from the practical side. Real needs could not wait for the judicial and administrative background to be set up.

On the highest level there is the Swiss Explosives Law [1], including rather traditional deterministic decrees concerned with limited explosive quantities, safety distances, and qualitative catalogues of safety measures. This law releases the military forces and the military administration from the substantive contents of the law and decrees but commits the government to issuing its own concepts and regulations for this area. The government assigned this duty to the Department of Defence, which designated the Chief of General Staff as the person responsible for the safety of the handling of ammunition and explosives by the forces and the administration.

The Chief of General Staff enacted the Directives Concerning the Safety of the Handling of Ammunition and Explosives by the Military Forces and the Military Administration (WSUME) [6]. These directives lay down:

- The general safety goal (e.g., the protection of human life and prevention of injury)
- The safety assessment concept and planning mode based on quantitative risk analysis
- The quantitative safety criteria
- Duties and responsibilities of the subordinate spheres
- The policy on information to the public

The Technical Regulations for the Storage of Ammunition (TLM 75) are the regulations for ammunition and explosives storage in peacetime, an activity with which several agencies of the Department of Defence are concerned. TLM 75 consists of five parts:

- Part 1: General Principles
- Part 2: Safety Assessment
- Part 3: Planning and Construction of Magazines
- Part 4: Storing of Ammunition
- Part 5: Storing of Ammunition by the Troops

Part 2 [8] contains the detailed methodology, data, and criteria for the risk analysis and risk appraisal due at different stages of planning and operating magazines.

These parts are renewed periodically with regard to the improvements of methodology, models, data, and criteria as well as with respect to new needs, developments in the civilian branch of safety and public opinion.

For the safe handling of ammunition and explosives in the ammunition and propellant factories, the chief of the agency concerned enacted the Directives for Safety in Federal Armament Factories with Explosives Hazards (WAE) [5]. It consists of two parts: Part I: General Principles and Responsibilities, and Part II: Guidelines to Perform Safety Assessments. With respect to methodology and criteria, the WAE is also applicable in the field of testing/passing and other special problems.

For transport, the third large-scale activity with ammunition and explosives, the concepts and the regulations have not yet been worked out, mainly for reasons of financial support and capacity. Transport was given second priority because there are many civilian regulations that apparently must and can be followed without severe problems. A preliminary step will soon be taken to investigate whether transport is safe regarding the quantitative safety concept.

Because many different military and civilian government agencies are involved with ammunition and explosives handling, coordination is necessary for economical management
with maximum safety benefit. For this purpose, several permanent bodies have been founded over the years. The top level committee is the Committee for the Safety of Handling Ammunition and Explosives by Forces and Administration (the former Ammunition Storage Board). This committee advises the Chief of General Staff concerning storage and ammunition and explosives safety. It leads and coordinates the management of storage, development and revisions of regulations, and basic research in this field. There is also a Safety Deputy and a Project Committee with advisory functions.

The decisions are supported by a number of study groups. The main technical (permanent) body is the Working Group for Basics, which is concerned with methodology, models, data, and criteria for safety assessment and risk management on several levels of ammunition and explosives handling. It is the oldest study group, having performed the first risk analyses nearly 30 years ago. In addition, there are nonpermanent working groups who are responsible for the regulations, as well as a couple of management teams.

12.5 ILLUSTRATING APPLICATIONS

12.5.1 Transport of Dangerous Goods

This is a classic example from the early 1970s. A state-owned Swiss ammunition factory used (and still uses) an outside storage installation for its explosives products (Fig. 12.12). They were transported on a public road by trucks and by railway on an industrial track along the same road. This road and the track crossed a main road that was, at that time, one of the most important transit routes from southern to northern Europe! Some 20 trucks and about 25 railway wagons met several thousand vehicles every day at this crossing. Thus, it seemed only matter of time before a crash between a vehicle and an explosives transport occurred that could lead to a catastrophic explosion.

In the Department of Defence, people were aware of the problem, saw the solution in building an underground passage for the main road, and made a corresponding agreement with the state government. However, in the process of planning the underpass, they became aware that it would cost at least CHF 7 million (equivalent to about U.S. $5 million). Therefore it was decided to perform a risk analysis of the situation and study cheaper alternatives [9].

The investigation of the situation without any safety measurements showed that all individual risks were far smaller than the accepted limits. As for the collective risk (Fig. 12.13),
the crossing with the main road caused only about 40% of the total risk to transport. About 50% of the risk was due to the traffic along the road used by the transport vehicles, and the remaining 10% was caused by the access road intersections leading to the neighboring factories. When the underpass had been considered the best solution, nobody would have imagined that the crossing represented less than half of the real problem.

Subsequently, a great number of safety measures were studied, their risk reduction calculated, and their cost estimated. Figure 12.14 shows the principal measures represented in a risk/cost diagram. The most interesting measures are those with the best risk/cost ratio. It is readily apparent that the underpass is ill advised due to the high cost and the limited risk-reduction effect.

This risk/cost diagram convinced not only the responsible members of the Department of Defence but also the Minister of the state government, who was persuaded that the constructing of the underground passage would represent a considerable waste of money. Con-
sequently, this plan was dropped and the proposed alternative measures were taken instead. They have proved their effectiveness over the last 25 years. Thus, the investigation finally resulted in an increase of safety by a factor of about 7.5 and savings of several millions of CHF.

With their decision, the representatives of the Department of Defence and the state government implicitly determined the level of accepted risk of this activity. This decision was not a very difficult one, as a package of safety measures was chosen that was better and at the same time less expensive. Experience shows that politicians are well able to read and interpret a risk/cost diagram in a sensible way.

12.5.2 Prevention of Artillery Shell Duds

This example also shows that the RSCAE can prevent the squandering of money on ineffective safety measures. In Switzerland, which is a small country, the artillery training of the troops cannot be conducted in absolutely isolated shooting ranges. It has to take place in normally utilized and populated areas, not without a number of precautions, of course. Consequently, there are a few hundred duds a year, which normally are blown up immediately by the troops themselves or by special dud-disposal teams of the defense administration. As the duds sometimes cannot be found immediately, especially those in snow, from time to time accidents have occurred resulting in personal injuries or even fatalities.

The Department of Defence was offered a device that, once fitted into artillery fuses, would make the duds ineffective a few minutes after impact. The appropriate agency assessed the device positively on the technical level but was in doubt as to the safety gain. A risk analysis was performed [10] and the risk reduction was compared to the cost. It showed that the risk reduction would not justify the cost (Fig. 12.15); it would need to be seven times higher or the cost seven times lower. As a result, the dud-safety device was not procured.

12.5.3 Propellant Supply System

As a consequence of the disastrous accident in Lapua, Finland, in 1976 [11], where an explosion in a cartridge loading facility killed 40 and injured more than 70 persons, the safety of similar installations in Swiss ammunition factories was examined. After some immediate safety measures had been taken—derived from a purely qualitative analysis—the question remained whether the present manual supply should be replaced by a pneumatic system similar to the new one in Lapua.

![FIGURE 12.15 Risk/cost diagram for dud-safety device in artillery fuses (THP = third persons).]
The related cost was estimated to be almost CHF 2 million. Since this investment could not be justified from an operational point of view, and since the production of this particular item was planned to be given up in the foreseeable future, the problem boiled down to the question of whether the gain in safety would justify this investment.

The results of the quantitative risk analysis [12] are shown in a risk/cost diagram in Fig. 12.16: The pneumatic system with an estimated cost of about CHF 2 million decreased the risk by about 80%. Assuming a lifetime of 25 years for this new system, a mean expected value of about 1.3 human lives could have been saved with this safety measure in this period.

Applying the above-mentioned willingness-to-pay criterion, the risk reduction would have justified this investment. But the question remained whether the safety could be improved more effectively by other safety measures. In order to answer this question, the contributing factors to the collective risk of the manual supply system were analyzed. It was demonstrably the case that:

- Safety measures are required to reduce the risks caused by the manual supply system.
- The costs for the originally planned pneumatic supply system are not justifiable.
- Safety can be enhanced more effectively and at lower cost if the powder drums and the hoppers above the loading machines are modified so that fire hazards cannot turn into detonations.

Both safety measures were put into practice.

### 12.5.4 Explosives Magazine for an Ammunition Factory

According to the RSCAE, explosives magazines are not standardized as, for example, NATO principles [13] or U.K. ESTC (Explosive Safety Transport Committee) [14] call for. Instead, construction regulation TLM 75 Part 3 defines a range of solutions for a few typical sizes and construction types, out of which the magazine in question can be optimized taking into account the actual readiness and capacity requirements as well as the actual conditions of the location.

Thus, at the end of the planning of a shallowly buried magazine for explosives of an ammunition factory, the problem came down to the question of whether one or two (propagation safe) chambers with the same total capacity should be built and whether they required automatic fire extinguishing installations. The risk/cost diagram (Fig. 12.17) clearly showed that the optimum solution was one chamber with a fire extinguishing installation [15].
12.5.5 Fire Extinguishing Systems in Artillery Bunkers

In Switzerland, a number of artillery bunkers are used for training with live ammunition. The question arose whether ultra-high-speed fire extinguishing systems should be installed to increase the safety of the troops. A fire hazard from the considerable amount of propellant in the closed area cannot be excluded completely but would have catastrophic consequences for the shooting crew (up to more than 20 victims) as the accident in a Swedish coast artillery bunker in 1984 [16] or the catastrophe in the guntower of the U.S.S. Iowa in 1987 [17] demonstrated. The investigation clearly showed (Fig. 12.18) that such installations have to be planned to meet the safety criteria.

12.5.6 Ammunition Storage

Over the last two decades, all under- and above-ground magazines in Switzerland have been investigated according to the RSCAE. The hazards are evident. For example, the difference between the highest and the lowest risk turned out to be about a factor of 1,000! Based on these investigations, safety improvement programs were developed and put into practice.
The quantitative approach for safety assessment allowed purposeful investments to achieve an optimum solution reflecting safety gain, investment, and a problem-oriented realization procedure. A comparison of an actual situation covering 20 existing above-ground magazines assessed according to the RSCAE and according to NATO Safety Principles [13] (or roughly, a modern version of the former Swiss regulation) made the savings of the Swiss approach clear (Fig. 12.19). According to the RSCAE, 19 of the 20 magazines were approved and covered the required capacity completely. By comparison, NATO principles approved only 7 of the existing magazines. For the remaining 75% of the required capacity, 23 new magazines would have been needed, resulting in costs of about CHF 10 million.

Transferred to the whole storage system, the savings would be many times higher. In this context it is interesting to note that the first underground storage built according to the new concept in the early 1970s cost about CHF 10 million less than the version according to the former regulation.

12.5.7 Planning of New Manufacturing Facilities

The RSCAE has also proven flexible and useful for the planning of new facilities for ammunition manufacturing. The main safety problems in ammunition and explosives manufacturing are connected with the personnel working with explosive items and the range of potential hazardous effects of numerous concentrations of such goods. In addition, persons in the surroundings of factories can be endangered. The flexibility of the RSCAE allows an optimum solution to be found, reflecting operational requirements, technical installations, and building structures as well as safety and cost.

[Diagram of comparison between TLM 75 and NATO safety principles]

**FIGURE 12.19** Comparison of the Swiss concept versus NATO principles.
12.6 BENEFIT

Three main advantages of the concept, regulation, and organization presented, which have been achieved over the years:

1. The methodological concept of quantitative safety assessment makes the hazards of ammunition and explosives handling comprehensibly and intelligibly visible and comparable. The responsible people know the responsibilities they actually take.

2. There are regulations that can actually be applied. There are distinctly fewer waivers compared to previous experience.

3. The necessary safety level can be achieved economically, e.g., so far the flexible assessment concept has allowed solutions resulting in savings of millions and millions of CHF.

12.7 REFERENCES

1. Bundesgesetz über explosionsgefährliche Stoffe (Sprengstoffgesetz)
   Die Bundesversammlung der Schweizerischen Eidgenossenschaft
   Bundesgesetz 941.41, 25.03.77.
2. Technische Vorschriften für die Lagerung von Munition (TLM 75)
   Teil 1 (Rev 86): Allgemeine Grundsätze
   Teil 2 (Rev 90): Sicherheitsbeurteilung von Munitionslagern
   Teil 3 (Rev 86): Planung und Projektierung von Munitionslagern
   Teil 4 (Rev 93): Friedensmäßige Belegung von Munitionslagern
   Teil 5: Sicherheitstechnische Vorschriften für den Umgang mit Munition bei der Truppe
   Eidgenössisches Militärdepartement
   01.01.87
3. Konzept für die Sicherheitsbeurteilung in explosivstoffverarbeitenden Betrieben
   Gruppe für Rüstungsdienste, Direktion der Abteilung der Militärwerksätten
   Basler & Hofmann AG, Zürich
   B 670-3, 01.03.76
4. Grobrisikoanalyse Beispiel M+FA
   (im Rahmen des Konzeptes für die Sicherheitsbeurteilung in explosivstoffverarbeitenden Betrieben)
   Gruppe für Rüstungsdienste, Arbeitsgruppe Sicherheitskonzept/CH
   Basler & Hofmann AG, Zürich
   Leimer, P.; Cruchaud, M.; Moser, F.; Senn, J-P.; Pulfer, Ch.; Schneider, Th.; Bienz, A.
   B 670-4, 01.03.76
5. Weisungen betreffend die Arbeitssicherheit in R+B mit Explosionsgefahr
   Teil I (WAE) Weisung Nr. 5/10: Allgemeine Grundsätze und Verantwortlichkeiten
   Teil II (RSB) Weisung Nr. 5/11: Richtlinien für die Durchführung von Sicherheitsbeurteilungen
   Gruppe für Rüstungsdienste/Bundesamt für Rüstungsbetriebe
   15.12.86
6. Weisungen über das Sicherheitskonzept für den Umgang mit Munition und Explosivstoffen in Armee und Militärverwaltung (WSUME)
   Generalstabschef Schweizer Armee
   25.03.91
7. What is Wrong with Criterion FN-Lines for Judging the Tolerability of Risk
   Evans, Andrew W.; Verlander, Neville Q.
8. Technische Vorschriften für die Lagerung von Munition (TLM 75)  
Teil 2 (Rev 90): Sicherheitsbeurteilung von Munitionslagern  
Schweizerische Armee  
01.07.92

9. Sicherheitsmässige Beurteilung des Explosivstofftransportes zwischen der M+FA und der Anlage Rynaécht  
Gruppe für Rüstungsdienste, Abteilung für Militärwerkstätten  
Basler & Hofmann AG, Zürich  
Bohnenblust, Hans; Bienz, Andreas  
I 986-1, 06.02.79

10. Blindgängersichere Zündern für Artilleriegeschosse  
Beurteilung der sicherheitsmässigen Notwendigkeit  
Gruppe für Rüstungsdienste - Rüstungsamt 2/CH  
Bienz, Kummer & Partner AG  
Bienz, A.  
I 121-1, 26.02.92

Ministry of Defence, Finland  
Karahulahti, Jorma  
01.01.79

12. Sicherheitsmässige Beurteilung der geplanten pneumatischen Pulverzuführung bei der GP 11  
Eidg. Munitionsfabrik Thun/CH  
Ernst Basler & Partner AG  
Janser, Paul; Bienz, Andreas; Willi, Walter  
I 1131.70-1, 01.02.82

13. Allied Ammunition Storage and Transport Publication 1 (AASTP-1)  
Manual of NATO Safety Principles for the Storage of Military Ammunition and Explosives  
NATO Headquarters, Brussels/Belgium  
AASTP-1 01.05.1992

14. Quantity-Distances for Military Explosives  
Explosive Safety Transport Committee (ESTC)/UK  
ESTC/220/Leaflet No. 5-Part 2 // File No. ESTC/226/16, 06.1979

15. Eidgenössische Munitionsfabrik Thun  
Unterfluhranlage Glütschbachtal  
Generelles Sicherheitskonzept  
Amt für Bundesbauten, Abteilung Ingenieurwesen  
Ernst Basler & Partner AG  
AB/KP/ms  
TM 3163-1, 01.07.1982

16. Explosion in a Swedish Coast Artillery Bunker  
Personal Communication  
Newspaper Reports, 01.01.84

17. U.S.S. IOWA Explosion  
Sandia National Laboratories’ Final Technical Report  
US Department of Energy  
Sandia National Laboratories, Albuquerque/NM, Livermore,/CA  
Diverse  
GAO/NSIAD-91-4S, 01.08.1991