Lecture PT3

Risk analysis by ZHA (Zurich Hazard Analysis) for an Explosives Plant

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Abstract:

The contribution contains a critereon of the risks of a facility for the production of emulsion and ANFO-explosives following the Zurich Hazard Analysis (ZHA). That analysis is comparing a potential extent of damage with an estimated probability of occurrence during possible malfunctions. The risk in section out of these two quantities is shown on a grid (matrix). Putting a limit is determining whether the residual risk is accepted or if further steps have to be taken.

With several examples for a site for production of emulsion and ANFO-explosives the evaluation of potential risks is advised which might cause an incident and means to prevent incidents respectively to limit their consequences. The handling is orientated towards the Council Directive 96/82/EC (Seveso-II-Directive). The results of determination are then compared with the consequences supposed in the matrix described, and the result can be read.

This method is taken as an example for the risk of running dry and dead heading of pumps for conveying emulsion, or transport equipment and storage conditions for ammonium nitrate when producing ANFO.

This principle can be used for both any production equipment and for calculating any risks not arising from inside the facility but from outside (external risk evaluation).

1. Introduction

Systematic risk management has been carried out since the fifties, especially in nuclear facilities. Since the eighties the risk examinations of process technologies in industrial facilities have also been increased. Recurred major incidents sensitized the public and increased the use of risk examinations in the industrial states.

Risk examinations have not only been autonomously introduced by the (chemical) big business, but have also resulted in relevant regulations. Risk management today is mainly carried out by scientists and engineers of various fields as a technical solution is expected first. How engineers understand risks and safety is therefore, responsible for our safety and our risks effective. The essential parts of the risk management are the systematic and preventive determination of risks, appraisal of risks, and the fixing of protective arrangements.

2. Technical risk management

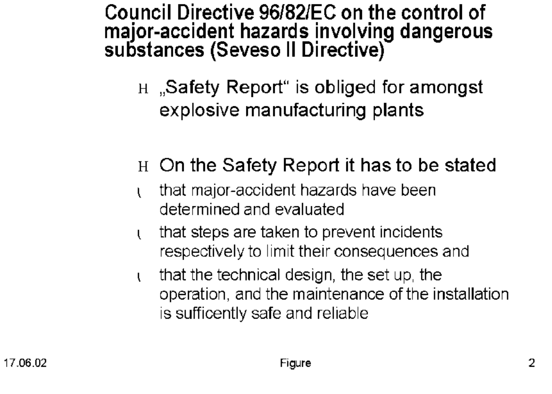
Process technology-facilities might either be interferred by technical malfunction of parts of the installation or by an operator's mistake, or by risks caused by nature or surroundings. The potential risk of the installation depends on the intensive state variable (e.g. pressure, temperature, sensitiveness of products, and substances), and the extensive variables (e.g. volume, mass). The design of the installation including its error sensitiveness is an important step for safety. In this connection concept errors and failures must be considered to prevent the installation from becoming dangerous. One of the methods for risk analysis and risk evaluation is dealt with on this lecture. The methods are part of the system for risk management mentioned below.

<Figure 1>

3. Norms of the Seveso-II-guidelines (StörfallVO [= German legislation in accordance with European legislation])

Under European law the Council Directive 96/82/EC "on the control of major-accident hazards involving dangerous substances" abbreviated as "Seveso-II-Directive" following a chemical accident at the Italian town Seveso which contributed to the formulation of the first directive on this matter. This formulation especially fixes what kind of installations a safety report has to be issued for. Usually installations for the production of explosives are included. On this safety report it has to be explained that:

- the risks of possible serious accidents have to be determined and analysed and steps are taken to avoid them or to limit possible effects and
- the technical design, the set up, the operation, and the maintenance of the installation is sufficiently safe and reliable.



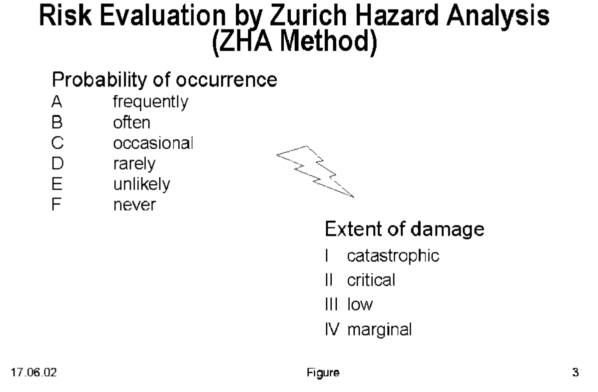
<Figure 2>

These critereons comprise the terms "determination of risks" and "risk evaluation".

4. Risk evaluation in accordance with the Zurich-method

The Zurich Hazard Analysis (ZHA) belongs to the inductive methods of analysis, i. e. the potential risk is based upon the occasion, and it is inferred to the extent of damage expected. It is based upon the US Military Standard 882. The ZHA was developped and perfected on the risk engineering of the "Zurich" insurance company who systematically and quickly showed their customers risks and threats and offered them sensible measures to cope with the risks.

The actual analysis starts with the systematic identification of the risks and their individual causes. Each risk is measured in accordance with its extent of damage and its probability. The extent of damages is divided into four categories:



<Figure 3>

I = catastrophic, II = critical, III = low, IV=marginal

The company itself has to define the category for any injury to persons, for operational damage, or for environmental damage.

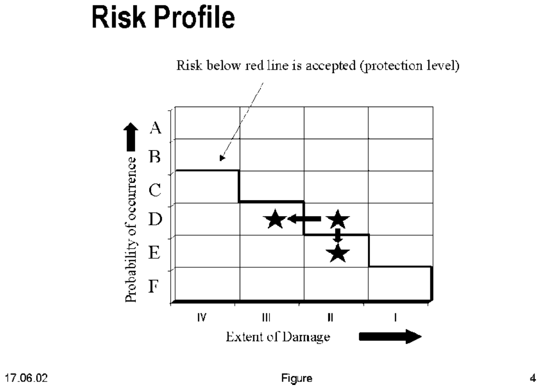
A relative scale is also used for the probability as definite figures are almost not available.

A = frequently, B = often, C = occasional

D = rarely, E = unlikely, F = never

All risks realized are entered in a list of risks, and they are numbered continuously.

The risk profile to be made out is a grid with the axles "Probability" and "Extent of damage". A protection level defined before is shown as a stepped curve, and the risks measured are entered in.



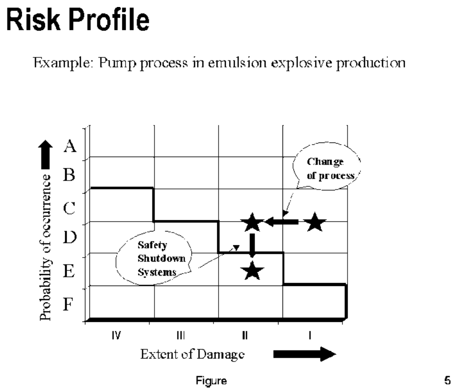
<Figure 4>

Risks below the protection level are accepted by definition. Risks above the protection level have to be decreased in accordance with the extent of damages and/or probability until they are below the protection level.

Two examples for manufacturing of emulsion explosives and ANFO explosives show how to get from the “unsafe” area to the area of the defined protection level.

5. Example: Pumping of emulsions

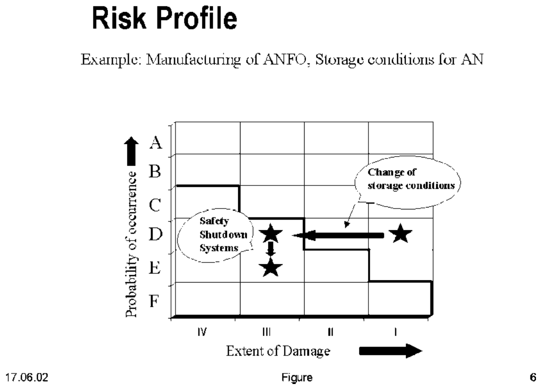
Pumping is the most critical process when handling emulsions respectively emulsion explosives as the matrix is mechanically and thermally quite stressed during dry running and dead heading. Just imagine a stationary installation which is batch processed. There is a tank containing emulsion explosives sensitized by glass bubbles and a pump installed behind which runs to a cartridging machine. Without additional safety shutdown and control systems the probability of a dead heading or dry running were just occasional (C) or rarely (D), the effects were catastrophic (I) if there are still explosives in the tank which might react, see coordinate C/D I on our grid „risk profile“. When changing the batch process to a continuous flowing process with small amounts of matrix and chemical sensitization right before being cartridged, the extent of damage (X-axle) makes us move left to number II (critical). The probability is decreasing to unlikely (E) if a pressure control, a rupture disk, and a temperature control with maximum/minimum cut-off is installed. We are now on coordinate E II in the area of the defined protection level on the grid.



<Figure 5>

6. Example production of ANFO-explosives

The main raw material for the production of ANFO-explosives is prilled ammonium nitrate. Just a few years ago raw material was stored in two metal silos of up to 25 tons each which were located right beside the production building. An auger conveyed the material to the production line. It cannot be excluded that an incident in the production line is transmitted into the silos, and the material stored inside the metal silos (confinement conditions) might react with catastrophic effects, see coordinate D I on our grid. Today WESTSPRENG GmbH stores its raw material in two silos with flexible walls and an additional rupture disk. The silos are located some 25 m away from the building. The ammonium nitrate is pneumatically conveyed into a small silo (7 tons, with flexible walls, too) for the daily output. Silos with flexible walls avoid confinement conditions. Furthermore, it heats up less in summer and condensation water is prevented. The material is still delivered from the small silo. The driving motor is controlled by a frequency converter which cuts off when it is overstressed. Furthermore, the bearing of the motor shaft has a temperature control with maximum cut-off. The different storing in our matrix makes us move from I to III, and the additional control devices make us move from D to E. Thus, our new coordinate is E III, and we are now within the area of the defined protection level (residual risk accepted).



<Figure 6>

1. Conclusions

- The standardized form of the ZHA-method makes it a method which is both easy to handle and economic to determinate and to appraise risks.
- The grid can either be increased (detailled representation) or decreased.
- Similar installations can be compared with each other (in case they have got the same protection level)
- The ZHA-method can be used for both complete installations and for parts of them or for single products.