

Dominant underlying factors of work related accidents

3rd International Conference ' Working on Safety'
September 2006
workingonsafety.net

C.M. Pietersen Msc
TNO Safety Solutions Consultants BV¹
General Manager
www.safety-sc.com
pietersen@safety-sc.com

Introduction

A distinction can be made between different types of accidents and even unwanted events during the different life cycle phases of an operation.

In this paper the focus will be on work related incidents during construction and maintenance work.

We have found remarkable resemblances between the underlying factors in our accident analysis studies for completely different sectors and activities.

It is therefore important to share these factors with the industry. It will enable a safety improvement in these work related activities in different sectors.

The accidents/ incidents that have been investigated are different in nature: fall from height, high voltage contact and electrocution, damaging underground pipelines, fire and more. The accidents differ, but the nature of the underlying factors that caused the accidents show remarkable resemblances.

The analyses of the incidents/ accidents have been performed with different methods, but mainly the Tripod method is used. In this paper, the results are shown in a condensed form to show the commonalities between the way these type of accidents are caused.

The following important (basic) aspects will be discussed:

- The quality of the Work permit system
- The effectiveness of the (Dutch) requirement of a Safety and Health plan
- The performance of an analysis of the risks of the work

The three aspects are basically important instruments (Lines Of Defence - LOD) to prevent accidents to occur. These LOD's nevertheless do not always get the necessary attention. It will be shown that improving a few aspects of the preparation of the work activities can lead to a significant lower chance of occurrence of these accidents and/or the adverse consequences, knowing the common underlying aspects.

¹ TNO Safety Solutions Consultants BV (TNO SSC) gives advise to the (process) industry about all aspects of safety. These imply aspects in relation to design, construction and operation of processes installations.

Working safely

Despite all good efforts, accidents continue to occur. Why? We have taken the necessary safety measures, we comply with the regulations etc. So what is the problem? Part of the answer is given here for work related incidents/ accidents, that occur during construction, maintenance and demolition activities for installations in the process industry. This on the basis of a number of thorough accident analysis studies.

Normally, for the mentioned activities a workpermit is required. In that framework and in the framework of the labour safety requirements, a risk analysis is required. On that basis sufficient measures should be taken and documented to be able to work safely. Also internal company procedures and instructions play a role.

In theory, safety is simple:

1. Think about all possible hazards of the activity.
2. Determine whether sufficient measures are in place or need additionally to be taken to reduce the risks of the hazards to an acceptably low level (e.g. with the use of a Risk Matrix).
3. Make sure that the measures are applied correctly. This means also that someone needs to be responsible for it and someone else need to supervise it.
4. Monitor the practice of the actual work and the effectiveness of the measures
5. Learn lessons from (near) incidents and accidents and improve the system.

These steps need to be implemented in a Safety Management System.

Like always, the practice is not so simple as the theory wants us to believe. There are many threats that make the above mentioned steps ineffective. In accident/ incident analysis, we are trying to identify the circumstances where those threats managed to be successful. These also can and need to be identified from audits en investigations of near misses and even unwanted situations. The threats are basically the same.

Some companies only perform thorough accident analysis studies (searching for the underlying factors) for the accidents/incidents with a more severe outcome. Given the same nature of the underlying factors for all accidents/ incidents, this can not be justified. Accident prevention by learning from previous incidents needs to include all (near) incidents and accidents.

Safety Measures

The type of Safety Measures obviously depends on the type of activities and the type of hazards. For the purpose of this paper we have chosen four 'standard' measures for the mentioned construction and maintenance activities in the (process) industry):

- The performance of a Risk Inventarisation for the specific work activities. This is a general work safety requirement (by law). This can have the form of an Job Safety Analysis and/or Task Risk Analysis. For larger projects, a Safety and Health Plan need to be made, including the risk inventarisation and measures taken.
- The assurance of a safe workplace by means of safe constructions and/or by removing the hazard from the installation (e.g. high voltage, hazardous material under pressure in a pipe).
- Workpermit: Before the work can start, often a workpermit is necessary to make sure that also the hazards for the rest of the installations are taken into account and to record who is at work where in the plant.
- The use of the relevant Personal Protection Equipment (PPE).

Results of the accident analysis studies²

In recent years, TNO SSC assisted companies to perform incident/ accident analysis studies which needed to (also) address the underlying factors. Some of these accidents were severe (even fatalities) and some of them were near misses and/or incidents with high potential for damage.

From the analysis studies that concerned the mentioned work related activities, it became clear that some underlying factors were common to a number of accidents. Some insight in it will be given below. We mention here already the main underlying factor: The risks of the *specific* activities are not, or not well enough, identified. The nature of the risk analysis studies is often too generic.

Figure 1 shows a Tripod accident analysis structure ('Tripod tree') constructed from common elements from several accident analysis studies. This Tripod tree is therefore a useful 'checklist' and starting point for the type of activities that we are discussing here: working at height, working with high voltage, working on pipes with hazardous material etc.

The figure contains the four mentioned Safety Measures. These are shown as 'broken' barriers³. Correct application and implementation of these barriers should have been able to prevent the accidents to occur. It should be realized that these barriers are for the purpose of this paper somewhat generalized. In practice, the broken barrier will be more specific showing the problem area. We will not discuss the PPE barrier here, it is shown that this barrier was effective (which of course is not always the case). The failure of the other three barriers is discussed below.

Failure of the barriers

Procedure to make sure that the installation is safe

This concerns to make sure that the electrical power is removed, that the pipes are free of pressure and inert, etc. In a company, normally standard procedures exist for this. The immediate cause of failure of this barrier is trivial: it is just the fact that these procedures are not always completely followed. Or are not complete or not (completely) understood.

Risk Inventarisaton, Job Safety Aanalysis and Safety and Health Plan (Dutch: RI&E, V& G plan)

The immediate cause failure of this barrier is that fact that the quality of this obligatory barrier is often too low. The main problem is that the seemingly generic nature of the work ('working at height') has induced generic risk analysis results (e.g. a TRA for working at height in general). In using these, this barrier is ineffective and in fact counter productive to its purpose: to take specific safety measures for the specific job.

Workpermit

The problem with the functioning of this barrier can be compared with the one discussed above. The risk studies required are not present or are of a too generic nature.

² Performed with the use of the Tripod beta method. Description : www.safety-sc.com

³ The barrier concept more and more became the standard in thinking about safety and safety measures. In the framework of the Post Seveso (BRZO) regulations, the Dutch regulator use the concept of Lines of Defence (LOD), internationally also the name of Layer of Protection (in LOPA) is used. SIL Classified Safety instrumentation also need to be seen as a barrier.

Analysis of the underlying factors

Figure 1 shows the underlying factors for the barrier failures.

Tripod makes a distinction to two levels of underlying factors:

- Preconditions: The context which did encourage the immediate failure of the barrier.
- Latent Failures: these are the problems on organisational/ system level which create the Preconditions.

Learning lessons and improvements on these levels will lead to important progress towards higher safety levels. Below we mention some representative preconditions and latent failures which have been found in our accident analysis studies. See figure 1.

Preconditions

- Job not seen as risky, seen as a routine job.
- Work permit not sufficiently focused on work related risks.
- Risk analysis too generic.
- Work preparation activities not adequate.
- Creating a safe installation to work on: not done by the right (experienced) people.
- Project organisation not clear enough.
- Importance and role of the procedure not well understood or procedure not complete/correct.

Latent Failures

- Safety perception and behavior different at different levels in the company (Safety culture problem).
- Practice and procedures: 2 worlds.
- Not enough personnel with required knowledge/ experience.
- Almost continuous company reorganizations, creating blind spots in SHE.
- Project management in the company is not focused enough (or too late) at work safety.
- System for responsibility and supervision is not clear.

Conclusions

From analysis of construction and maintenance work related accidents it has been shown that several common underlying factors do exist. The accidents that have been investigated are different in nature: fall from height, high voltage contact and electrocution, damaging underground pipelines, fire and more. The accidents differ, but the nature of the underlying factors that caused the accidents show remarkable resemblances. These underlying factors (most important factors) are described in this paper.

Main underlying factor:

The risks of the *specific* activities are not, or not well enough, identified. The nature of the risk analysis studies is too generic. It means that more attention needs to be paid to the risks of the actual job (location, specific circumstances etc.) The use of generic TRA tables only is not sufficient.

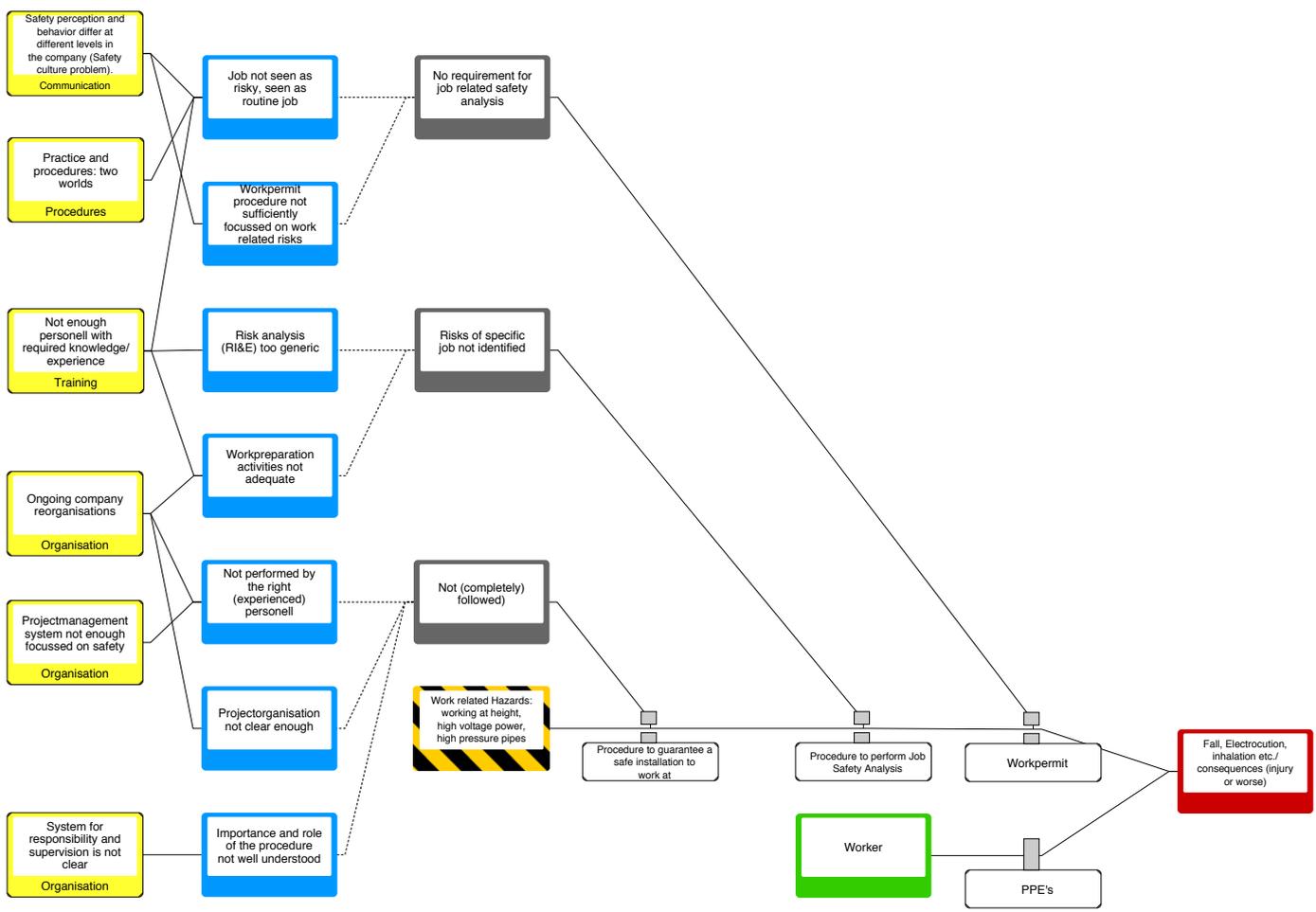


Figure 1 Generic (underlying) factors of work related accidents, shown in a Tripod tree format