CHEMICAL ENGINEERING TRANSACTIONS
VOL. 48, 2016
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Eddy de Rademaeker, Peter Schmelzer

ISBN 978-88-95608-39-6; **ISSN** 2283-9216
DOI: 10.3303/CET1648154

Consequences of Ignoring the Complexity of Human Behaviour for Industrial Safety and Security

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In the field of safety science, the "socio-technical system" (also referred to as man-machine-environment system) has become a general model for considerations on safety. Today it is common practice to use this model in order to analyse, evaluate and design the conditions under which all kinds of safety problems may arise. In many fields, standardized procedures have been established to design the technical components of production plants. These procedures have likewise been adopted in safety strategies and some of them are particularly very successful – when it comes to designing actual technical situations. Based on the man-machine interface, this approach has meanwhile increasingly won recognition in safety strategies concerning the social components of socio-technical systems. The standardized approach is also applied to organisational and behavioural conditions, to humans. Such procedures start from the assumption that humans show a behaviour that is similar to the functional behaviour of machines, computers and robots. Often, psychological and social determining factors are not considered; and of course with that the resultant requirements. This leads to more serious problems. The present paper shows a study, as example, in which we accompanied the final closing of an industrial chemical plant-site for more than one year and analysed it from a safety-scientific point of view. The study shows that management decisions are often based on the assumption that all employees exhibit the same behaviour and can be guided through standardized procedures and rational stimuli – a false conclusion. It can be seen from the study that such a decision has far-reaching consequences on the situation of the company. This course of action is the reason for safety and security problems, such as diseases, accidents and disturbances or intentional damaging actions such as sabotage. The results of the study provide insights into the conditions under which extremely varying problems are developing and, therefore, also present general principles for prevention programmes.

1. Introduction

In the field of safety science, the "socio-technical system" (also referred to as man-machine-environment system) has become a general model for considerations on safety. Today it is common practice to use this model in order to analyse, evaluate and design the conditions under which all sorts of safety problems may arise. In many fields, standardized procedures and model-based approaches have been established to design the technical components of industrial production plants. These procedures have likewise been adopted in safety strategies and some of them are particularly very successful – when it comes to designing actual technical situations. Based on the man-machine interface, this approach has meanwhile increasingly won recognition in safety strategies concerning the social components of socio-technical systems. The standardized approach is also applied to organisational and behavioural conditions, to humans. Such procedures start from the assumption that humans show a behaviour that is similar to the functional behaviour of machines, computers and robots. Often, psychological and social determining factors are not perceived; and of course with that the resultant requirements. This leads to more serious problems.
Under this aspect, we have analysed and evaluated several different real situations in the framework of a series of investigations. A study from this series is presented in more detail in the following; it concerns the final closing of a production-site.

Please cite this article as: Festag S., Hartwig S., 2016, Consequences of ignoring the complexity of human behaviour for industrial safety and security, Chemical Engineering Transactions, 48, 919-924 DOI:10.3303/CET1648154

2. A Case study

2.1 General and method

The present investigation shows a case study, as example, in which we accompanied the final closing of an industrial chemical production-site, which is in Germany located and a part of a corporate group with different sites around the world. For the analysis of the situation, in addition to analysing the accidents, we have also evaluated plant inspections, interviews and announcements appearing on a monthly basis (for the purpose of communication between the site management and the employees) and assigned them to the chronology of the site closure. For the quantitative analysis of the situation, the frequency of accidents and days of absence during the plant-site closure was compared to the previous year, before the official promulgation of the resolution. Among other data, 92 accidents (reportable accidents at work (more than 3 days of incapacity to work), non-reportable work-related accidents (more than 1 and less than 4 days of incapacity to work), accidents at work suffered at the premises of a contractor company and commuting accidents) with 653 calendar days of incapacity were included in the study for evaluation of the safety situation and 88 accidents with 418 calendar days of incapacity for the evaluation during the closure phase.

2.2 The Initial situation and chronology of the phases of the final closing

The site being studied belongs, after several entrepreneurial takeovers and mergers, to a large group of companies. The group of companies possesses a range of sites spread around the world. The site being studied belongs to one of the group's smaller companies. The site's production had at its disposal, two parallel production plants, at which the product to be manufactured could be varied as regards its characteristics. One of the production machines was suitable for trials and technical-developments for the defining of certain product characteristics due to its small dimensions. Until the closure of the site with its two production plants, more than 300 employees worked in the company.

Since the year 2005, the site being studied here was under "special management observation" due to a generally tense market situation, because apart from the market situation the company's profits did not meet the group's expectations. In order to overcome this problematic situation, the analyzed site developed a new product with special characteristics. After a period of adjustment, this product was manufactured with consistent quality and was successfully launched onto the market. Because of this, the workforce became hopeful for the long-term survival of the site and a turnaround in the difficult business situation. Employees of the site in question were called upon to assist in the transferral of the product characteristics to a new sister site being founded abroad at this time, with larger machines and at the same time fewer jobs and indirectly stated high expectations of profitability. During this transferral phase the group management adopted the resolution to close the site being examined here. At first, however, the prospect was still held out that the resolution might be delayed and the employees were kept informed of current developments via regular announcements.

In October 2006, the group management adopted the resolution for the final closure of the site and announced this to the employees and the public. Reasons named for this were: a) "long-term unprofitable results" of the site and b) the "increasing of the company's profitability" and "economic earning power".

Because promises of deliveries had been made to customers for up to the end of 2007, it was not intended to shut down the production immediately but instead not until the end of 2007. In order to ensure production capacity, the management emphasised the necessity of problem-free production, in order to also be able to ensure the payment of wages – in parallel with this, a severance scheme was worked out. Figure 1 shows the chronological sequence of company-policy events and consequences.

2.3 Results and assessment of the situation

As can be seen from the chronology and quantitative analysis of the accidents and absence times, the number of accidents first sinks after the announcement of the plant's closure in comparison to the same period the previous year and then rises beyond its usual proportions over the course of time, see Figure 2.

We interpret the fall in the accident figures at the start of the closure phase as being due to the employees' hope for a turnaround, because after the announcement of the site's closure the delaying of the resolution was left open, depending on the operating result. The increase in the accident parameters over the course of time, on the other hand, is regarded by us as due to resignation and frustration on the part of workforce as the finality of the site's closure became increasingly apparent. The visible effect is actually even greater, because at the end of the period being studied fewer people were employed in the site.

Between the end of 2006 and the end of 2007, the situation as regards the production and sales result fluctuated between record results and substantial losses. During this, there were frequent disruptions and

plant stoppages in production, also including unusually serious interruptions occurring at production points that were difficult to access, which does not rule out sabotage.
As time passed, the situation continued to intensify. Accidents, disruption of production and machine stoppages occurred more frequently. In addition to this, damage to property, insults and assaults took place. The absence rate rose severely and at the end of the closure phase there were no longer enough employees working, so that production had to be prematurely abandoned.

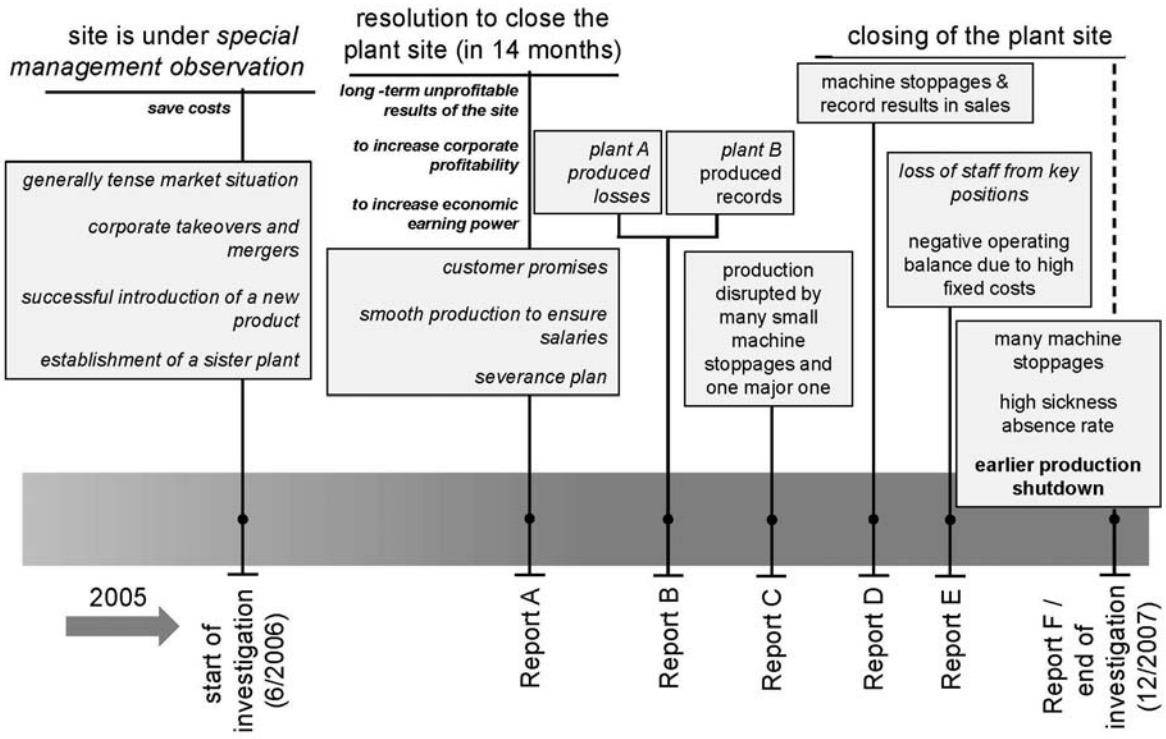

Figure 1: Chronology of the final closing of the analyzed site

3. Summary and conclusion

What can we learn from the presented case study? This case study provides findings for the forming of risk reduction strategies in such and similar situations and more general conclusions can also be drawn (see Festag, 2012, Festag & Hartwig, 1/2013, Festag, 5/2014 and Festag, 5/2015). We can learn from the findings:
i) Collateral damage; at first, the case study made it obvious that the management's resolution caused substantial collateral damage. This damage is not or is only rarely included in cost-benefit analyses of the management resolutions and could under some circumstances lead to a different overall result.
ii) Occurrence of safety and security problems; as we can see on the basis of the case analysis and the events during the closure phase, security-relevant problems also arise here, such as e.g. assaults. In the case of some incidents, the pattern of damage provides evidence of deliberate interference, but it is difficult to find out the exact causes, which can to the same extent also often not be traced.
iii) Breeding grounds for states of failure; regardless of the exact mechanisms causing the individual accidents, absences due to sickness and production stoppages, it is to be assumed that the ruthless nature of the interaction between the management personnel and the employees and the behaviour of the management personnel in general have an influence upon the states of failure. Communication plays an important role in this.
iv) Normal and non-normal operation; it furthermore shows that risk-related measures are now often well established in the normal operation of an industrial production, especially in large groups of companies. As we have seen here, however, there is a great need for risk-related analyses, evaluations and measures outside normal operation and this involves special challenges. This need can far exceed the requirements of "ordinary demand". The situation is made more difficult by the fact that only little attention is devoted to safety work in

such situations, because the management is occupied with itself and the survival of the company at such a time.
v) Insufficient qualification; thus far there has been no training for managers and safety officers on how to deal with such situations and how one is to act in them. Managers may therefore be over-challenged by these situations.
vi) Varying employee behaviour; it also becomes evident that the behaviour of the employees varies greatly. This can be gathered at certain points in time from, among other things, the differing results of the two production plants. These arise despite the technical and organisational boundary conditions being the same.
vii) Unexpected employee behaviour; the behaviour of employees is sometimes unexpected for the management. The measures for employee motivation are strongly oriented towards financial incentives and correspond with the assumption of rational decisions. Emotional driving forces tend to be ignored, which we also see as the explanation for the unexpected behaviour, e.g. assaults, damaging of property and first the decrease and then later the increase in accidents. As one can see, the failure to take into account such ways of behaving and reacting to management decisions leads to inadequate quality of management.

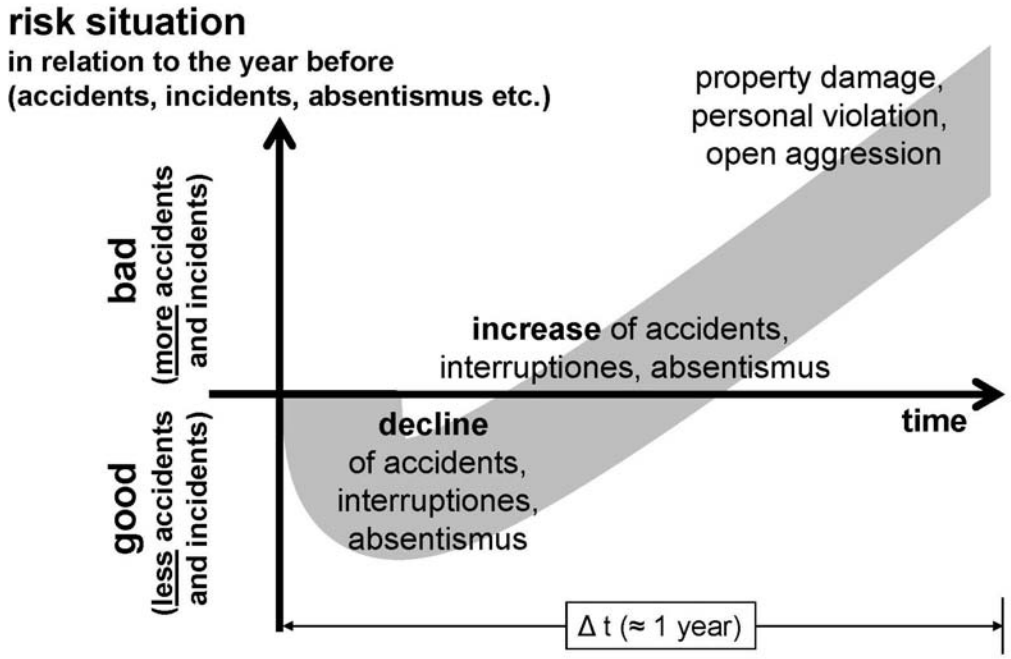

Figure 2: Development of the risk situation during the closure phase

The study findings mean the following for preventive work:
1) There needs to be a detailed (qualitative and quantitative) analysis, evaluation and documentation of the situation for the actual state – and for checking the effectiveness of measures introduced.
2) Additionally there needs to be a comprehensive analysis of the operating situations while taking into account collateral damage and long-term consequences as well as measures adjusted to these.
3) Effectiveness analyses are important when deriving measures.
4) It is necessary to take into account the workers' individual sensitivities and ways of reacting (persons reacts individual).
5) Management behaviour plays an important role in management decisions.
6) Managers are to be qualified in how to deal with employees correctly, which also involves the type of communication.
7) Managers are to be qualified in coping with special operating phases (e.g. closure of a company-site or a department, shutting down of facilities, machines or plants). Situations outside normal operation can be highly demanding. This should be taken into account in resource planning.

8) It is necessary to take into account security-relevant occurrences (e.g. sabotage) and to develop an understanding of such occurrences, because they play a role in the development of the overall situation of companies and necessitate specific counter-measures.

A general statement

By means of the series of investigations, into which the case analysis discussed here is incorporated, it could be ascertained that new safety and security problems could be caused and existing ones exacerbated by the type of action to reduce risks – due to an inadequate understanding of the damage processes, especially in connection with the arising of problems due to human reactions. The situation leads to special consequences if risk reduction measures are introduced and not adapted to the reactions of human beings. Under certain circumstance the measures can have the opposite effect, as shown in Figure 3.

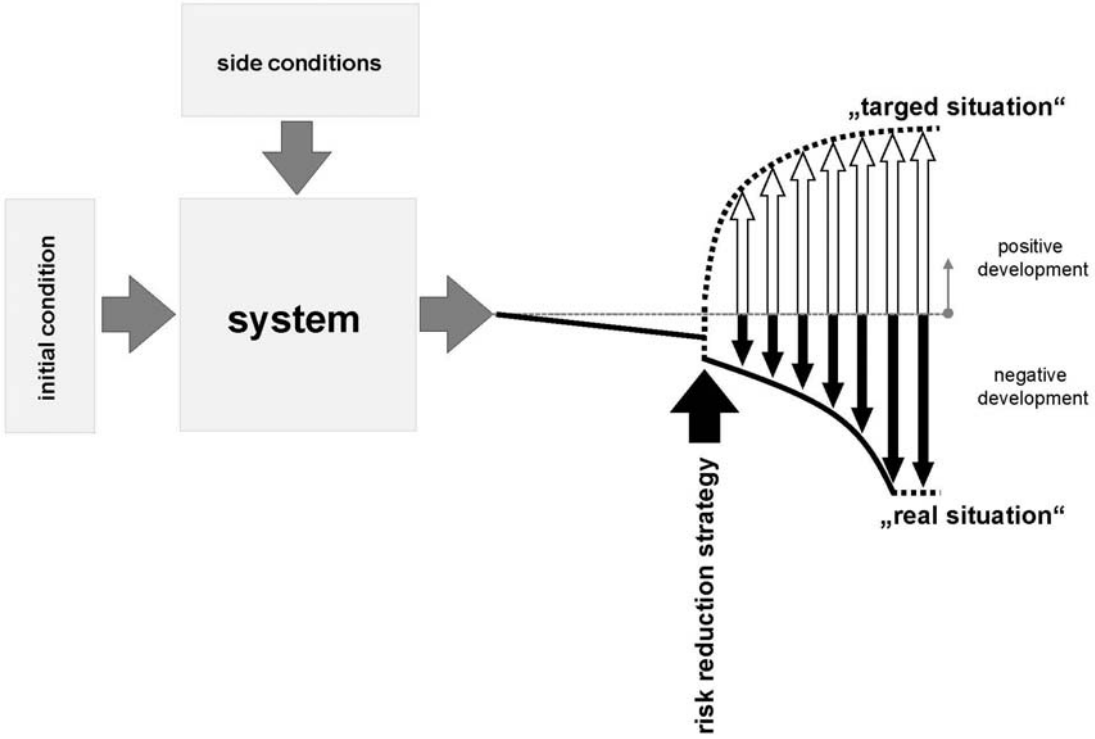

Figure 3: Counter-productive mechanism of risk reduction strategies

The exact cause-effect relationships for the counter-productive mechanism are not known. It must be made clear, by means of further studies, in which cases this situation exists and in which it does not. The influencing variables in this will have to be identified on a case-by-case basis. We see that human behaviours and sensitivities are important within this examination of risks. From this it can be deduced that there is no general and simple solution for this type of safety problem, particularly as it is necessary to react differently to safety risks than to security risks. In both areas, human behaviour plays a prominent role. Various countermeasures are to be derived according to the causes of events. Basically, a problem awareness that is inadequate for the actual safety situation can be ascertained.

In "socio-technical system" new and different strategies need to be developed, especially addressed to the human behaviour, than has been the case thus far. The reactions of those affected must be taken into account as an individual whole and linked to the circumstances of the case.

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