

The role of economic, social and psychological factors in safety in chemical process engineering



Why this information booklet?

- The field of process engineering/chemical process engineering is constantly working on improving the levels of safety and limiting the effects of accidents wherever possible. Investigations into the underlying causes of incidents pay specific attention to organisational and technical factors. The relevant economic, social and psychological aspects remain largely underexposed, despite the fact that they can also play a role in the occurrence of incidents or near-incidents.
- Economic factors mainly concern cost control and the optimisation of the company's economic performance, which could have a negative impact on the organisation's level of safety.
- Social and psychological factors relate to the employees' attitude towards safety risks and the conduct of workers (in groups or individually) within a hazardous environment.
- The Ministry of Social Affairs and Employment has commissioned an analysis of the potential factors as well as the measures that can be taken to guarantee safety. The main conclusions of this study have been summarised in this booklet.

The full research report can be downloaded (in Dutch) from:
www.arboportaal.nl/arbeidsveiligheid.

Which factors are concerned?

A. Organisation and workforce:

Producing the same output with fewer staff, workload, changes to tasks and responsibilities, staff complement, automation of operations.

B. Company stability and continuity:

The company's adaptability to growth, deferment of investment, reducing actions to core activities/outsourcing.

C. Equipment and maintenance:

The age and condition of the equipment, other maintenance management systems.

D. Organising the work:

Interpreting managers' signals, minimum staffing for shift work, good housekeeping, bystander apathy (responsibility for safety).

E. Personal circumstances:

Personal ability to cope with change, safety culture, personal circumstances, risk-prone personality, dedicated worker problem, macho behaviour/flaunting own expertise and experience.

F. Communication and knowledge transfer:

Communication between employees, level of education, capacity for comprehending and following instructions, language and cultural differences.

How do I use this information booklet?

- You can use this booklet as a quick test to ascertain whether safety at your company is under pressure due to economic, social or psychological influences. The booklet also offers suggestions for reducing the negative consequences for safety within your organisation.
- You can use this booklet to launch a discussion about the themes that are relevant to your company. Together, you and your staff can bring safety within your company another step further!

Action plan for taking the test:

- Form a multidisciplinary team of representatives from all departments. Ensure that all levels of the company are represented. The team members need to be well informed about the actual daily procedures (i.e. not only the procedures on paper).
- Discuss each theme and its score questions and assess the current situation within the company.
- Determine whether the proposals for 'solutions' to the observed bottlenecks are applicable to your situation. If not, look for alternative solutions.
- Implement the solutions.
- After some time, check whether the problems have in fact been resolved. Study the contents of the report and this booklet as a guideline for the regular assessment of the actual situation within your company and the implementation of the relevant corrections.

Management mechanisms with respect to safety

- The lowest standard of the 'boss' is the highest standard of the employees.
- It is vital to be consistent in setting a good example. A single wrong signal from management and the standard drops immediately (and almost always permanently).
- 90%-95% of the people want to do their best and be appreciated. The 5%-10% unwilling to do their best must 'shape up or ship out'.
- The principles that apply to raising children are also relevant at the factory and workplace: rest, regularity and cleanliness (physically in the factory but also mentally and behaviourally). A fourth principle is also important: room for the individual, for participation and personal innovation.
- Employees' attitude towards their work is largely the result of their manager's behaviour. Management decisions (both good and bad) are followed by an 'incubation period' before the situation worsens or improves. How long this incubation period will last will depend on the self-cleansing and learning capacity of the company and the efficiency of its management.

Never underestimate the points put forward by the team!

Theme A Organisation and workforce

A.1 Producing the same output with fewer staff

The production is carried out by a smaller number of people. This does not necessarily mean that safety will decline. In fact, if the organisation adapts properly to the new procedures, safety can increase. On the other hand, fewer people producing the same output can also have a negative impact on safety. If workers are absent, for example due to illness, the capacity can prove insufficient for ensuring that production can be continued in a responsible manner. Any malfunctions at this time would certainly increase the risk of incident.

A.2 Workload

A decline in the number of employees or a rise in the production can cause the workload to increase. A high workload can have an effect on safety, as employees are more likely to make mistakes if they are put under too much pressure. That is why it is important to prevent needless escalations of the workload. Determine whether tasks and responsibilities need to be changed if staff numbers drop or production increases.

A.3 Changes to tasks and responsibilities

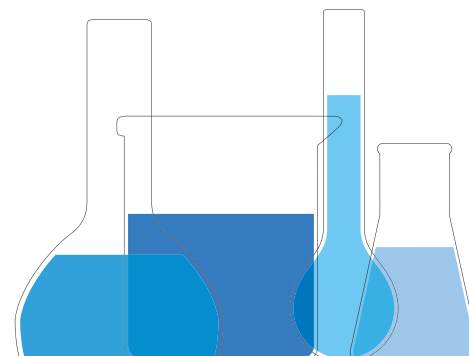
Companies adapt the tasks and responsibilities of their employees for the sake of more efficient production. Specialisation helps employees build up their own expertise. Simplification can help reduce the risk of errors and increase the level of safety. Job enlargement means that employees are deployed in a more flexible manner and are given more responsibility to boost their job commitment. This can have a positive effect on safety.

A.4 Staff complement

The structure of the staff complement is closely linked to developments in the labour market. There is little influx and efflux at companies, and the challenge in the coming years will be to transfer the knowledge and experience of the older employees to their new colleagues. This also holds true for the knowledge needed for safe working conditions. Safety levels could decline if this knowledge disappears along with the older employees.

A.5 Automation of operations

Automation can help improve safety, but does come with the risk of losing the human element. Older employees might also find it difficult to cope with the new - often more automated - equipment. For that reason, it is vital to devote sufficient attention to the training and education of all staff members, so that they become fully capable of using the new automated equipment and systems.



A Organisation and workforce

Theme A Organisation and workforce

Theme A Factores	Score 0	Score 1	Score 3	Score 9	Enter Score
A1 Staff reduction	Effects in the field of HSE are not taken into account at all.	Effects in the field of HSE are not taken into account sufficiently.	An HSE risk analysis is created beforehand.	An HSE risk analysis is created beforehand, with active participation from HSE-critical positions.	
A2 Workload	There is no insight into the workload.	There is insufficient insight into the workload per department.	Workload surveys are carried out in a systematic and integrated manner.	Validated workload surveys are carried out in a systematic and integrated manner. Management takes the results into account.	
A3 Organisation of tasks and responsibilities	There are no systematic assessments to determine whether tasks and responsibilities are adequate and up-to-date.	Systematic assessments are not always carried out to determine whether tasks and responsibilities are adequate and up-to-date.	Systematic assessments are carried out to determine whether tasks and responsibilities are adequate and up-to-date.	Tasks and responsibilities have been identified and defined and incorporated into the operations.	
A4 Staff complement	Staff policy fails to take demographics and knowledge level into account.	When drafting the staff policy, the demographics and knowledge level are not taken into account sufficiently.	Demographics and knowledge level receive adequate attention, but lack correlation with the staff policy.	When drafting the staff policy, the demographics and knowledge level are taken into account sufficiently. There are indications of a balanced staff complement.	
A5 Automation of operations	Automation is carried out without employee participation.	Automation is carried out with employee participation.	Automation forms part of the MoC process, whereby employees' capacities and wishes are taken into account.	Automated operations receive constant attention. Effects are assessed in an integrated manner across all departments and employees receive adequate training and support.	

Total score for theme **A**

A Organisation and workforce

Theme B Company stability and continuity

B1. The company's adaptability to growth

A company's growth can have an effect on its safety. This can be the case if, for example, production increases before enough newly trained employees can set to work, or if the working environment has not yet been adapted sufficiently (in the physical sense or otherwise). In practice, adapting the organisation to keep up with the rapid growth will seldom run parallel with this growth, and if the mismatch is too great it could place safety under serious pressure.

B2. Deferment of investment

Sometimes investments are postponed or a freeze on investment is introduced. Deferment of investment can have consequences with respect to safety. It is important to note that most companies try to avoid to not further invest in issues that are clearly safety related. A freeze on investment could however have an indirect effect on safety, as it might lead to a greater prevalence of malfunctions. This could create a situation where production has to be halted while the repairs are carried out. Such a situation in particular poses even greater risks in the field of chemical process engineering. People can furthermore come to believe that safety is on the decline, for example if they notice that the factory premises are being neglected.

B3. Reducing actions to core activities/outsourcing

One of the business operations that is increasingly 'farmed out' is systems maintenance. This outsourcing trend could lead to an increased risk of incidents. This is especially true if there are no clear agreements with the contractor or if communication between the client and the contractor is poor.

B Company stability and continuity

Theme B Company stability and continuity

Theme B Factors	Score 0	Score 1	Score 3	Score 9	Enter Score
B1 Company's adaptability to growth	The expansion plans (projects) fail to assess the impact on employees.	The expansion plans only take the impact on employee numbers into account.	The expansion plans take employee numbers and staff requirements into account.	The expansion plans include a thorough analysis of the effects of the expansion on all the business operations, including the working environment (physical or otherwise) and the time needed to implement the changes.	
B2 Deferment of investment	Deferment of investment does not take the potential effects in the HSE field into account.	Deferment of investment includes a brief analysis of the potential effects in the HSE field.	An analysis of the short-term effects in the HSE field forms part of the analysis of deferment of investment.	The 'incubation period' of the potential effects in the HSE field are taken into careful consideration during deferment of investment. This incubation period can take up to 5 years.	
B3 Reducing actions to core activities/ outsourcing	Maintenance outsourcing is only done for the sake of cost savings, whereas the contractor's competency and capacity are left out of consideration.	The outsourcing takes the contractor's capacity and competency into account.	The outsourcing includes a careful assessment of the work processes between own employees and contractor's staff, and organisational and management processes are adapted accordingly.	All the short and long-term effects of outsourcing are analysed, including the potential effects in the field of HSE, knowledge management, alignment with safety regulations, commitment and communication and safeguarding of knowledge with regard to specific maintenance strategies.	

Total score for theme **B**

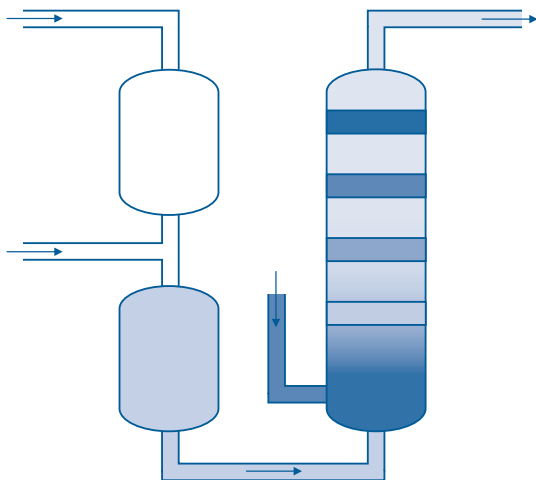
B Company stability and continuity

Theme C Equipment and maintenance

C1. Age and condition of the equipment

Many systems used in the field of chemical process engineering remain in production beyond their useful life. This could lead to a decline in the safety of such equipment. Regular maintenance can of course keep older machines going safely for years to come. This maintenance must however apply to all parts of the system; components made to last the entire useful life of the piece of equipment should not be neglected.

A poor technical condition of machinery and equipment increases the safety risks. This does not imply that incidents are inevitable. Experienced employees are sometimes able to operate older machines without any great risks. This does however make greater demands on those supervising new employees who are not yet familiar with the specific and non-documented qualities of the machines.



C2. Other maintenance management systems

Optimal maintenance can help limit the time that the system is out of use. That is why preventative maintenance is gaining ground over corrective maintenance. The risks are very high during maintenance activities in particular. Incidents are more likely to occur in the case of unscheduled corrective maintenance rather than preventative maintenance and regular production activities.

A good maintenance management system is essential. An example of this is Risk Based Inspections (RBI), which is used to determine how frequently each component of the system should be serviced. The frequency depends on how likely the component is to become defective within this period.

Traditional inspections are not always sufficiently geared towards the actual need for inspection. RBI makes for a more flexible planning and implementation of the inspections, resulting in a more efficient utilisation of manpower and resources.

C Equipment and maintenance

Theme C Equipment and maintenance

Theme C Factors	Score 0	Score 1	Score 3	Score 9	Enter Score
C1 Age and condition of the equipment	There is no maintenance and replacement strategy in place.	A maintenance and replacement strategy is in place, but is not applied consistently.	The maintenance and replacement strategy is already clear at the time of purchasing new equipment. The risk analysis fails to take the maintenance-related HSE risks properly into account.	The maintenance and replacement strategy is already clear at the time of purchasing new equipment. HSE risks are taken into account in the risk analysis.	
C2 Other maintenance management systems	No RBI (Risk Based Inspection) is carried out.	RBI methods and analysis are used, but lack a professional approach.	RBI methods are set up adequately once only, but fail to form part of a secure system.	The maintenance and replacement strategy is already clear at the time of purchasing new equipment. HSE risks are taken into account in the risk analysis.	

Total score for theme C

C Equipment and maintenance

Theme D Organising the work

D1. Interpreting managers' signals

One of the important aspects of communication relates to the way people interpret the signals from managers on the shop floor. A manager who asks if the work has been done while looking at his watch sends out a different signal than the one who asks in a neutral way how things are going. The former could make employees feel pressed for time so they start to take risks to get the work done sooner.

D2. Minimum staffing for shift work

If a reorganisation leads to fewer people being deployed in the operations (e.g. when the shift work teams are reduced), it could give employees the impression that their work is becoming less safe. Proper implementation of the management of change principle and clear agreements on the minimum staffing for shift work (calculated for emergency situations) are vital.

D3. Selective blindness

People who have been with a company for years and always deal with the same processes can become blind to the potential risks. People's perception of risks change when they are confronted with them on a regular basis, so they start believing that a certain level of risk is acceptable. The danger is that they then underestimated the actual risk, especially if they have never experienced an incident first-hand.

D4. Good housekeeping (behavioural influence)

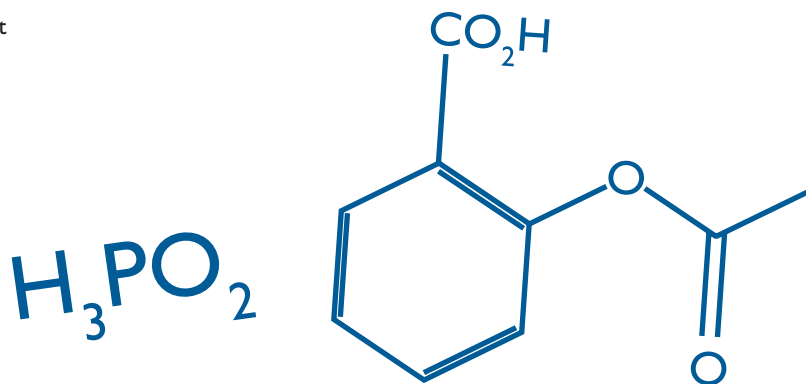
Good housekeeping is a precondition for safety. Good housekeeping influences people's behaviour on the shop floor. A company investing in visual aspects, such as a fresh coat of paint on the walls or a tidy work area, is likely to notice an improvement in safety as a whole. Attention to such aspects have a ripple effect on the perception of safety and the relevant safety culture within a company. Remember, example is better than precept.

D5. Bystander apathy

The phenomenon of *bystander apathy* can be summarised as follows: the more people you have looking at a problem, the smaller the chance of anyone taking the initiative to resolve it.

In terms of safety, this means: the larger the number of people who are aware of an unsafe situation, the smaller the chance that anyone will assume responsibility for setting it right.

Management needs to make it clear who is responsible and accountable in this regard. Regular checks are needed to ensure that this is understood and put into practice.



D Organising the work

Theme D Organising the work

Theme D Factors	Score 0	Score 1	Score 3	Score 9	Enter Score
D1 Interpreting managers' signals	Management has little or no visibility.	Management is visible, but fails to introduce measures.	Sufficient scope is created for safe working practices in busy periods and unsafe situations are resolved before work is resumed.	Management continues to emphasise safe working conditions and sets a good example.	
D2 Minimum staffing for shift work	No replacement takes place.	Replacement is arranged on a makeshift basis.	Agreements for replacements are made, but are not always implemented.	Safety-critical jobs have been identified and replacements arranged.	
D3 Selective blindness	People carry out the same activities for years.	Alternative tasks can be discussed at the employee's initiative.	Regular training takes place on job-related dangers and lessons learnt from incidents.	Career and development meetings form part of the performance interview. Sufficient scope is given for job changes or training programmes.	
D4 Good housekeeping	No agreements have been made with regard to a clean and safe workplace.	The area is tidied from time to time.	Agreements have been made with regard to a clean and tidy workplace, but these are seldom implemented in practice.	Work does not commence until the workplace is sufficiently clean and tidy.	
D5 Bystander apathy	HSE tasks are unclear.	It is clear who is in charge, but this only concerns the actual tasks.	Responsibilities for HSE work processes have been defined, but are ignored in practice.	All roles and responsibilities that are vital to safe working conditions have been defined and implemented.	

Total score for theme **D**

D Organising the work

Theme E Personal circumstances

E1. Personal ability to cope with change

Older staff members or employees who have been working at a company for years sometimes find it difficult to adapt to change. They have become accustomed to specific procedures, which means they struggle to keep up with changes in the approach to safety. As a result, this group might choose to ignore any renewals in the safety culture.

This could happen, for example, if a company introduces a sudden transformation in its approach to safety. Middle management, where employees often remain with the company for long, could find it difficult to adapt to the new programme.

E2. Safety culture

The link between the existence of an unambiguous safety culture at a company and the issue of safety is widely endorsed. Both literature and practice have shown that it is of the utmost importance for a company to develop a culture where safety takes centre stage. This trend has become particularly evident among companies in recent years. Objectives are formulated and action programmes established. Assessment, exemplary conduct and supervision by management for HSE culture-related aspects often have a motivating effect on the individual and the team.

E3. Personal circumstances

Personal circumstances (e.g. problems at home, alcohol/drugs and stress) can lead to a decline in work performance and an increase in unsafe operations. This risk is influenced by the level of solidarity (mutual support) and the extent to which first-line management and supervision are able to recognise the signals and take action.

E4. Risk-prone personality

Some people have a greater desire to take risks, because of their personality type. This is called a risk-prone personality and is common among people who are attracted to dangerous jobs. People with this personality type are strongly action-oriented ('don't think, just act'), quick to take risks and always strive for perfection.

E5. Dedicated worker problem

A *dedicated worker problem* describes the situation when dedicated employees ignore safety regulations when they are in a hurry to complete an assignment. This happens when the safety regulations hamper the speed at which employees would like to work.

If a company is suffering financially, its employees sometimes try to improve the situation by increasing their own production rate. This could prompt workers to repair malfunctions through improvisation, which can lead to safety risks.

E6. Macho behaviour/flaunting own expertise and experience

Workers sometimes act in an unsafe manner to impress their colleagues or show off their expertise and experience. Employees might refrain from asking for assistance if something is unclear to them, because the solution is seen as part of their own expertise. Another example is that 'macho' employees might pressure the group (consciously or otherwise) to carry out the work in an unsafe manner. This could lead to the belief that those who do observe the safety regulations are 'not man enough' for the job'.

E Personal circumstances

Theme E Personal circumstances

Theme E Factors	Score 0	Score 1	Score 3	Score 9	Enter Score
E1 Personal ability to cope with change	Employees are never involved in policy changes.	Only the higher middle management is involved in policy changes.	'User participation' is encouraged when important changes are made within the company. In practice however there is still too little coordination with the shop floor on the safety policy and its implementation.	Employees from all levels are involved in the policy changes at an early stage. After implementation, the changes are assessed on their effect and effectiveness and revised where needed.	
E2 Safety culture	Safety is a government task; we just do the minimum to avoid a penalty.	We have a safety system, but are too busy to pay it any real attention.	We have a safety system, which usually receives attention after a serious incident. There is no real consistency in the implementation of the safety policy.	Our safety system has become ingrained in every part of our company. It is part of our culture. We can count on the fact that management will always give the same priority to HSE than it does to production and costs.	
E3 Personal circumstances	There are no support programmes available to assist employees with a personal problem.	Support programmes are available, but personal problems are identified too late if at all.	Managers are trained to identify dysfunctions in time. The company has a range of programmes in place to assist employees with problems, but these do not correspond with the needs.	Various programmes are available to assist employees with problems. The employees are aware of these programmes, communicate any problems and also make use of these programmes where needed.	
E4/E5 Risk-prone personality	Incident assessments fail to devote attention to the 'dedicated worker' and 'risk-prone personality'.	Only when investigating serious incidents are the terms 'dedicated worker' and 'risk-prone personality' taken into consideration.	The terms 'dedicated worker' and 'risk-prone personality' are taken into consideration when investigating incidents, but not enough is being done to limit this risk.	The terms 'dedicated worker' and 'risk-prone personality' are always taken into consideration when investigating incidents. Support is available for those who need it. Colleagues call one another to account on unsafe actions. 'Dedicated workers' and 'risk-prone personalities' are identified in time and offered support.	
E6 Macho behaviour/ flaunting own expertise and experience	You are rewarded for using unsafe behaviour to speed up your work pace.	Irresponsible risk-taking forms part of the assessment system.	Irresponsible risk-taking forms part of the assessment system. Sanctions have also been defined, but management does little to correct this behaviour.	Irresponsible risk-taking forms part of the assessment system. Sanctions have also been defined and are used to address and correct macho behaviour.	

Total score for theme E

E Personal circumstances

Theme F Communication en knowledge transfer

F1. Communication between employees

Interaction between employees has a major influence on safety. Take the Piper Alfa disaster, for example, which was partially due to inadequate communication between the crews. Communication has many facets, such as communication between crews during a shift handover, or how managers' signals are interpreted. An overload of information forces the recipient to absorb only certain parts of the message and could lead to the loss of relevant information. Too little information, on the other hand, could prevent the recipient from receiving any relevant information about a component important to his crew or shift. The manner in which the information is conveyed also plays an important role. Information provided in writing and explained verbally is said to provide the best guarantee for safety. Finally, the transfer of information carries the risk of safety being jeopardised by the messenger's or recipient's routine. An experienced recipient might think that a word is enough to the wise, thereby missing the key message, for example about a change that does not usually occur in the process.

F2. Level of education

Employee's level of education determines the manner in which they should be given instructions. If the instructions are too complicated, the employee might fail to understand and observe the regulations. The manner in which knowledge is transferred should correspond with the level of education of each individual employee.

F3. Capacity for comprehending and following instructions

The development of safety management systems is nothing new. Growing numbers of manuals and procedures are being produced. The number and nature of the procedures differ strongly from one company to the next. In fact, some companies have so many procedures in place that employees are no longer able to keep track of them all. In theory, the procedures are meant to describe the safest possible approach, but they become counterproductive when their contents and scope exceed the employees' capacity for absorption. This could lead to the dedicated worker problem (see theme E). On the other hand, employees might also start ignoring the procedures in principle because they find them too theoretical. This gives rise to safety on paper which has no bearing on the actual situation in the factory.

F4. Language and cultural differences

Language and cultural differences can have direct consequences for safety. Language problems occur when people who speak different languages and are unable to understand one another properly are working together on the same systems. This could be the case during maintenance, for example, or when activities carried out by subcontractors. Cultural differences relate to people's different views with regard to hierarchical relations.



F Communication en knowledge transfer

Theme F Communication en knowledge transfer

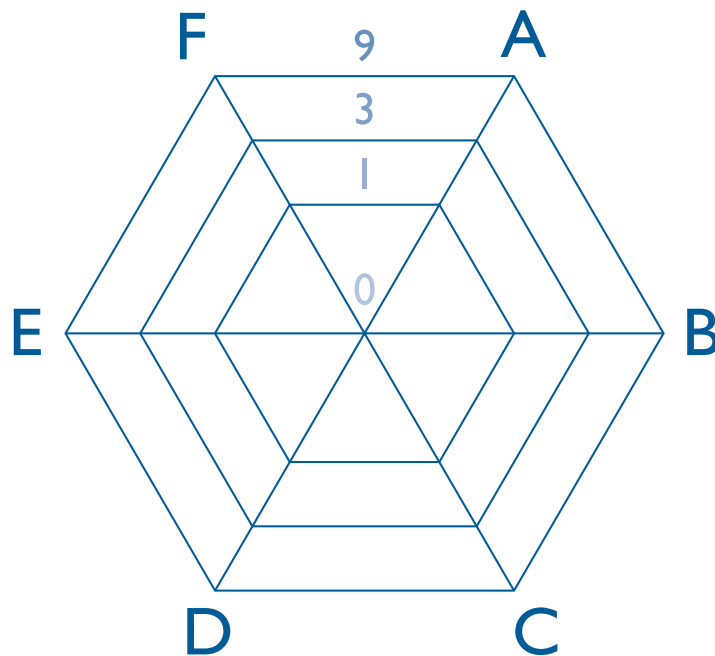
Theme F Factors	Score 0	Score 1	Score 3	Score 9	Enter Score
F1 Communication between employees	No official rules or systems are in place for communication (important information/ shift orders; work orders and work/shift transfer etc.).	Agreements have been made but have not been put on record officially.	Systems are in place for the main communication processes, but these are not checked and have not been integrated into the training programmes.	All important communication moments and processes have been identified and officially included in training and checks.	
F2 Level of education	Employees' different levels of education are not taken into account during training and communication.	The target groups' different levels of education are occasionally taken into account during training and instruction.	The target groups' different levels of education are taken into account during training and instruction, but miscommunication still frequently causes employees to miss out on information.	All training and instruction materials and all communication flows are consciously and systematically tailored to the target group's level of education.	
F3 Capacity for comprehending and following instructions	We never ask employees if they are able to follow procedures. It just needs to be done automatically.	We sometimes use the incident system to analyse whether employees are realistically able to follow procedures.	We screen all existing regulations and procedures for applicability and relevance.	We have a permanent 'user committee' in place for every field to systematically test every procedure and instruction for applicability and topicality. Staff are responsible for the training and testing with respect to revised procedures.	
F4 Language and cultural differences	Our operations do not in any way take the various languages and cultures in our company into consideration.	The different nationalities work separately and most of the communication is done via the foreman.	The most important procedures, instructions and training programmes are available in various languages.	All operations and communication tools are fully geared towards the various languages and cultures in the company .	

Total score for theme F

F Communication en knowledge transfer

Analysis diamond

The analysis diamond is quick and simple to complete and provides you with a clear overview of the status of the work processes within your company!



Credits

This publication is a joint initiative of representatives from the process engineering/chemical process engineering sector and the Ministry of Social Affairs and Employment.

The publication is based on the report entitled '*De rol van economische en sociaal-psychologische factoren bij veiligheid in de chemische procesindustrie*' (The role of economic and socio-psychological factors in safety in chemical process engineering) by Bureau Bartels B.V. (15 August 2008). The full report is available (in Dutch) from the health and safety portal of the Ministry of Social Affairs and Employment:
www.arboportaal.nl/arbeidsveiligheid.

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