

KNOWLEDGE MANAGEMENT IN **SHUTDOWNS** & TURNAROUNDS

SCOPE MANAGEMENT,
INFLUENCES AND STRATEGIES



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KNOWLEDGE MANAGEMENT IN SHUTDOWNS AND TURNAROUNDS

Scope management, Influences and
Strategies

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FOREWORD

It is a pleasure to present to you an expert view on Shutdown Management.

Asset owners more often look at their assets in a holistic way, from a strategic, organizational and financial perspective. During the lifecycle an asset needs regular shutdowns to allow relevant modifications and maintenance and repair work. This maintenance obviously has to be realized within time and budget and has to meet relevant quality requirements. Integrity, predictability and reliability of asset performance after starting-up have to be secured as they directly link to the asset goals.

Scoping a shutdown is a complex task as it is influenced by a variety of business drivers and as each scoping item has to be challenged against asset management strategy, costs and risk management system, from a total cost of ownership perspective.

This book combines field-proven expertise of several leading asset owners and services providers on their shutdown management strategies. It delivers latest insights and inspiration to bridge asset strategy to execution in the domain of shutdown management.

Stork Technical Services, project leader in this study, will continue to develop knowledge to support asset owners on this important topic.

Femke de Jager
Vice President Asset Management Consultancy
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FOREWORD

Our bodies cannot shut down or stop when in need of maintenance. Apart from a good night's rest, we just have to keep on going. And maintenance work has to take place 'in service' – a dream come true for many industries.

A shutdown is seen as a costly and unwelcome interruption of regular business. However, if an installation breaks down, production comes to a standstill - and with it the income it generates. Shutdowns present an additional challenge insofar as they do not constitute routine activities and, to an extent, are unpredictable in terms of cost and duration. The extent of some of the maintenance work will, after all, only become clear when the equipment has been stopped and disassembled.

A significant amount of knowledge has been developed with regard to the preparation, execution and evaluation of shutdowns. Scoping, however, is in need of more attention: this long-term plant maintenance strategy is based on a wide variety of influencing factors such as corporate strategy, technological trends, social developments and changes in the market.

This book is a prime example of the complementary relationship between industry and science. The joint result marks a point of departure for more research and cooperation. We hope that the book is a source of inspiration for our current and future engineers.

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Chapter I

INTRODUCTION

- Motivation and background
- Trend
- Aims and strategy

1 INTRODUCTION

Chapter 1 examines the motivation behind writing this book and the book's background. It deals with the vision, goals and strategic approach, as well as with the description of the contents of the chapters to come.

1.1 Motivation and background

Often, large industrial installations must periodically be taken out of service. These out of service periods are known as shutdowns or turnarounds, planned outages, overhauls or stops. During a shutdown repairs and cleaning take place, modifications or plant constructions are undertaken and/or inspections are conducted that are not possible when the installation is in use. Production comes to a standstill during a shutdown, leading to loss of income. All work must therefore be carried out in the shortest possible time. This makes a shutdown an unusually complex project, involving high levels of cost and manpower over a short period of time (figure 1.1).



FIGURE 1.1 – *A shutdown can be an extensive operation involving much equipment and many external personnel*

It is therefore not surprising that (especially the process) industry seeks to lengthen the intervals between shutdowns. From once per year or every two years the interval has stretched to once every four, five or, in some cases, eight years. Naturally, this approach has led to changes in operational standards and inspection techniques. As a consequence, more attention must be paid to the

scheduling and preparation of shutdowns, to investment programmes, the work scope of a shutdown, reliability of the installation, purchase and stock of parts and cooperation with specialised maintenance companies.

1.2 Trend

To date, the focus in shutdown management has mainly been at operational level. Yet there is an increasing awareness in industry that modern shutdown management should engage the issue at a higher, strategic level. Such an approach pays for itself: shutdowns become cheaper, more effective, more manageable and carry smaller risks.

At the end of 2009 a Dutch report 'Industrial maintenance needs in the Netherlands 2009-2014; technology, research and knowledge mobilisation' appeared. Based on a review of literature and interviews with companies, experts and educational institutions, six key areas are identified to focus on in industrial maintenance (figure 1.2):

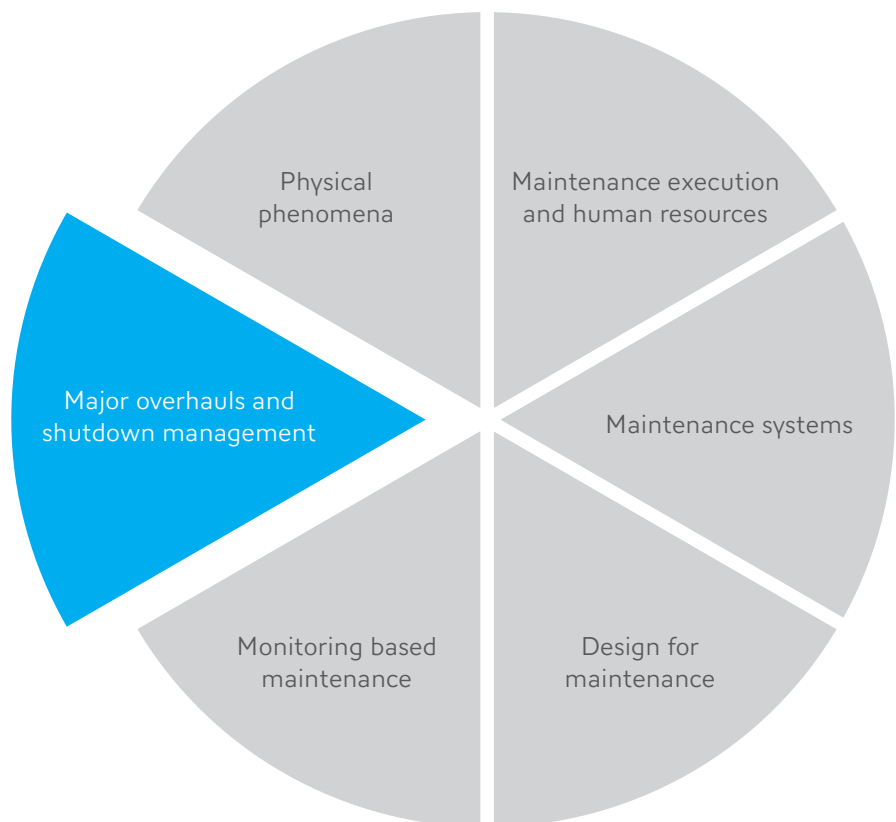


FIGURE 1.2 – The six main areas covering maintenance needs in Dutch industry

1. Maintenance execution and human resources
2. Maintenance systems
3. Design for maintenance
4. Monitoring based maintenance
5. Major overhauls and shutdown management
6. Physical phenomena

In the light of the above, it is not surprising that one of the core areas is shutdown management. As these shutdowns are performed at intervals of several years, the challenges are mainly in securing the relevant knowledge, reducing the number of stops and accessing the right resources at the right time. Given the developments in the field of shutdowns, the following areas deserve attention:

- LOSS OF PRODUCTION AND START-UP PROBLEMS WITH SHUTDOWNS
Installation and assets downtime is sometimes necessary. The fact that machines and installations are out of service during shutdown periods leads to production losses and start-up problems such as re-adjustment and re-alignment of machines.
- RESOURCE PROBLEMS OF LARGE, IRREGULAR SHUTDOWNS
In most companies, large shutdowns take place in the periods March-May and September-November. This makes it difficult for contractors to meet the demand for resources. Many temporary resources are attracted from abroad, resulting in communication problems and the potential for Babylonian confusion.
- KNOWLEDGE MANAGEMENT AND SHUTDOWNS
Knowledge management is a difficult issue when shutdowns occur only every 6 or 8 years. Technical and organisational knowledge gained from previous shutdowns disappears in the course of changes in staffing over the years. Stakeholders recognise the importance of securing knowledge and making it accessible for future shutdowns.
- THE CURRENT TREND IS TO AIM FOR 30 TO 40 PER CENT LESS MAINTENANCE WITHIN A PERIOD OF 10 YEARS
Shutdowns used to take place every 1 or 2 years, with the frequency currently decreasing to 3 to 4 years and sometimes up to 6 or 8 years. The aim is to further reduce the frequency of necessary maintenance of installations. The goal is 30 to 40 per cent less maintenance over 10 years, whereby maintenance costs, shutdown costs and production losses could be significantly reduced.

1.3 Aims and strategy

In view of developments in the field of shutdown management, this book aims to promote integrated, long-term, strategic thinking in relation to shutdowns.

The next chapter provides an introduction to shutdown management. The five phases of a project shutdown are dealt with: initiation, scoping, preparation, execution and conclusion/evaluation. The work to be carried out during a shutdown (the work scope) and the way in which this is drawn up and determined (scope management) have a great influence on the cost, turnaround time and quality of a shutdown (figure 1.3).



FIGURE 1.3 – *Scope management has a major influence on new construction, maintenance, planning, quality, etc.*

Scope management is an important subject and is explored in chapter 3. Work scope is divided into four categories, each with its own background and approach. In practice, it appears that determining work scope is a lengthy process and difficult to manage. Important topics are preventing unnecessary work, gatekeeping and validation and freezing of the work scope.

A number of factors (such as periodic, compulsory inspections in compliance with laws and regulations) have a major impact on work scope, a subject that spans inspections, projects, cleaning and maintenance during shutdown. Chapter 4 is dedicated to these influencing factors and their consequences for a shutdown.

Ultimately, the scope management strategy will determine the efficiency and effectiveness of a shutdown, and thus greatly affect the success of a company. In chapter 5 several business strategies are described, based on

the influencing factors described in chapter 4. The trend from the current preventive maintenance approach towards maintenance prevention plays a large role in this. Useful life extension, knowledge management and design for maintenance are some of the relevant aspects.

Finally, in Chapter 6, the relationships between business strategies and influencing factors are shown using an impact matrix. This provides businesses with insight into the business strategies that could be of potential interest to them.

Chapter 2

SHUTDOWN MANAGEMENT

- Shutdown organisation
- Initiation phase
- Scoping phase
- Preparation phase
- Execution phase
- Evaluation phase
- Conclusion

2 SHUTDOWN MANAGEMENT

Despite our current technological progress, industrial installations require regular maintenance. When the entire installation is stopped for a limited period in order for such maintenance to take place this is termed a shutdown. A shutdown is a cross-functional event that involves many people, both within and outside the business and is frequently experienced as a unique project (figure 2.1).

According to the literature, unique projects frequently exceed deadlines and budgets. This is attributed to changes in project requirements, weak management, client knowledge backlog in relation to contractors, technical setbacks, insufficient budgets, etc.



FIGURE 2.1 – *A shutdown is a multidisciplinary event that often involves third parties*

Shutdowns are often divided into three size categories: small, medium and large (table 2.1). Each category requires a unique approach in terms of budgets, number of budgeted hours, outsourcing of work, etc.

Category	Execution hours	Budget in millions of euros	Number of shutdown items
Small shutdowns	< 6000	< 0,5	< 300
Medium shutdowns	6000 - 50000	0,5 - 5	300 - 1500
Large shutdowns	> 50000	> 5	> 1500

TABLE 2.1. – *Characteristics of small, medium and large shutdowns*

Modern shutdowns are characterised by two key elements: a long-term strategy and, within it, a planned and systematic approach. The scope and the number of (strongly divergent) activities frequently become known at a late stage. Also, many activities must take place within a limited period at the same location, which carries large (financial) risks.

Shutdowns have five project phases: initiation, scoping, preparation, execution and evaluation (figure 2.2). Ideally, the next shutdown should be initiated as soon as the current one is concluded and evaluated.

This chapter describes these five phases in terms of an ideal description of each phase, independent of any specific industry sector.

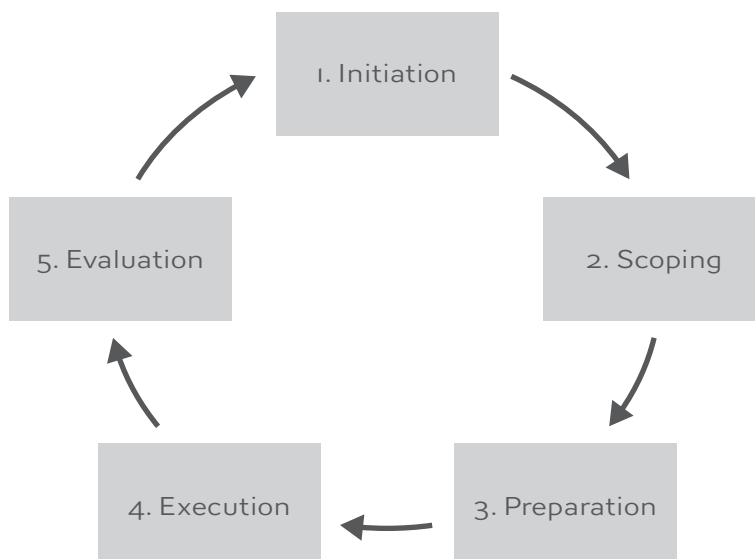


FIGURE 2.2 – *Phases of a shutdown*

2.1 Shutdown organisation

The complex, multidisciplinary and interdisciplinary character of a shutdown requires coordination and execution of a multiplicity of activities. Thorough organisation is essential to the successful completion of the process. The management of the installation undergoing a shutdown, selects people from its own staff and calls in external consultants where necessary for organisation and

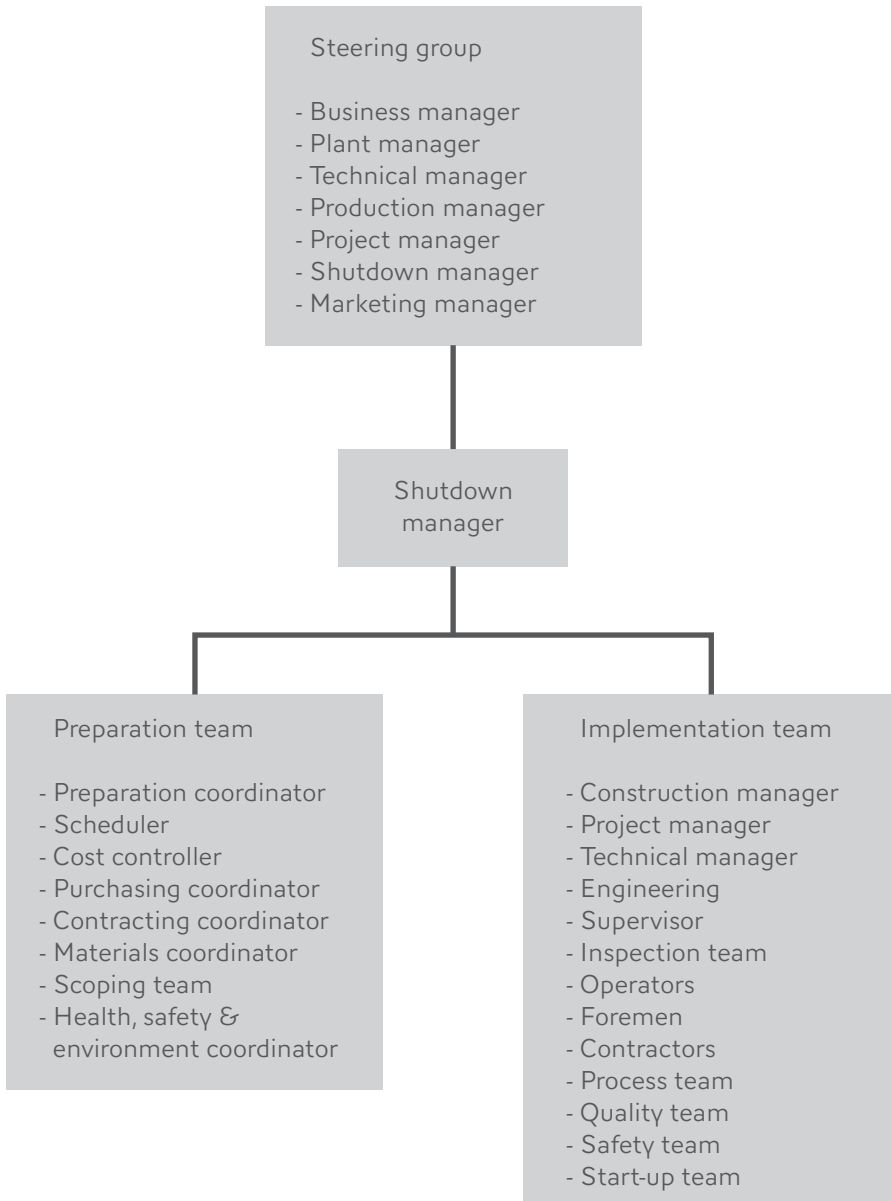


FIGURE 2.3 – *Organogram of a shutdown*

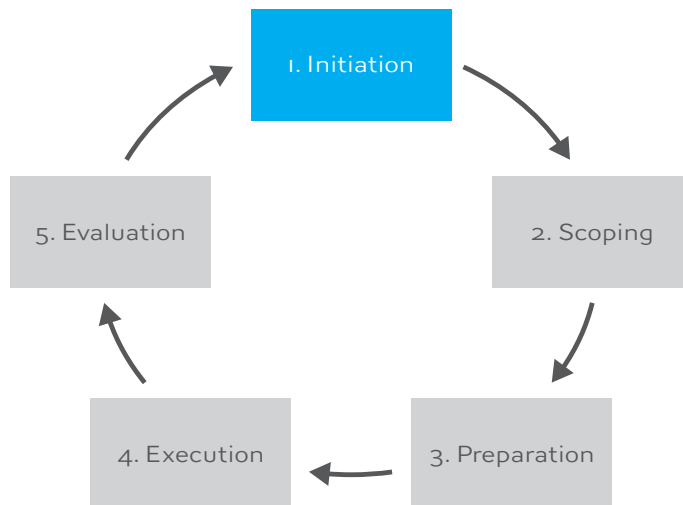
coordination of the shutdown. The complexity of the shutdown determinates the scope of the organisation required.

A small, simple, shutdown (for example that of a small injection moulding company consisting of one machine, halted for one day for legally required safety maintenance) can be performed using a small team. A medium or large shutdown, requiring lengthy preparation can, however, only achieve a successful conclusion when supported by a multidisciplinary team with a broad range of skills. Figure 2.3 shows a general organogram of a shutdown team.

Regardless of the size of a shutdown, the team is at all times responsible for:

- No incidents with regard to safety, health and environment (SHE)
- Execution of only the necessary activities during the shutdown
- Delivery of work at the required quality standard
- Minimum production losses
- Controlled scoping, preparation of the shutdown and execution processes
- Maximum efficiency in both preparation and execution
- Controlled commissioning and start-up of the production
- Monitor execution of the shutdown within agreed time and budget
- Securing and analysis of the acquired knowledge and experience for application in future shutdowns

2.2 Initiation phase



The shutdown is well defined during the initiation phase. This scoping is commenced well ahead of the actual execution of the shutdown. In some cases, this is up to 2 years before the execution phase (figure 2.4).

For this reason it is necessary to define and address, in detail, the strategic and operational objectives that will apply when the shutdown is fully prepared and implemented. This phase is managed by the management of the installation. Management determines when the shutdown takes place, how much budget is made available and how many resource can be allocated to the execution of the shutdown.



FIGURE 2.4 – *In the case of a major shutdown one is well advised to commence initiation 2 years before execution*

The better the preparation, the more streamlined the execution phase will be. In practice it appears that approximately eighty per cent of the work in the execution phase is routine work which can be planned. The nature and extent of these activities can be determined in advance. Approximately twenty per cent of the work cannot be planned and only arises during execution of the shutdown. For example a crack in a boiler that is not visible from the outside but requires complete replacement of the boiler instead of merely the planned cleaning process. Accurate scoping and preparation of routine work means that unexpected developments during the shutdown which cannot be planned can nevertheless be given full attention.

During the initiation phase, experiences and lessons learned from previous shutdowns are reviewed. Because the routine work aspects have for a large part been confronted in previous shutdowns and will again be addressed in future shutdowns, relatively little effort is required to initiate and prepare this work.

The initiation phase ideally consists of the following steps (figure 2.5):

- A. DETERMINATION OF THE SHUTDOWN PERIOD
- B. PREPARING THE PLAN OF ACTION
- C. DEFINITION OF SUBCONTRACTING POLICY
- D. ESTABLISHMENT OF THE PREPARATION TEAM
- E. DRAW UP THE COMMUNICATION STRATEGY

A. DETERMINATION OF THE SHUTDOWN PERIOD

The first step towards a shutdown is stipulating the moment at which it is to take place. Long-term, strategic vision plays a central role in determining

this moment. Other possible activities in relation to other installations and factories in the business chain are taken into account. Are there other shutdowns in the region? Does the shutdown affect other installations/factories? It is also necessary to establish how long the shutdown will last and what the budget will be.

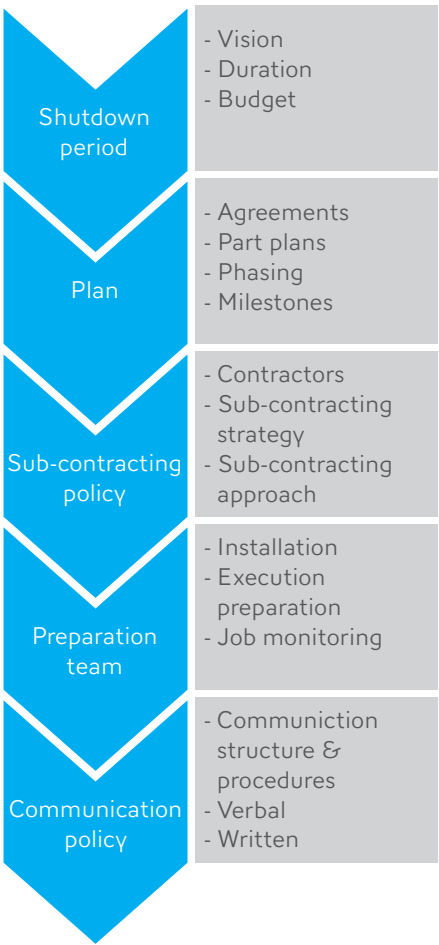


FIGURE 2.5 – Steps in the initiation phase

B. PREPARING THE PLAN OF ACTION

A critical part of the initiation phase is to draw up a plan of action. It records the agreements between client and contractor. The plan of action is drawn up by the shutdown manager and the preparation team and translated into sub-plans. The plan must include shutdown phasing and milestones. This means that the phasing of the shutdown is timed.

C. DEFINITION OF SUBCONTRACTING POLICY

Definition of the subcontracting policy requires setting the nature and scope of outsourcing. This is important because contractors must be contracted at an early stage. In determining the outsourcing strategy, it is important to look at the nature and extent of the shutdown. To this end the following tasks are identified:

- Small, regular (known maintenance tasks, limited in scope)
- Small, special (critical repair or modification work)
- Large, regular (large-scale, more or less known, regular maintenance and modification work)
- Large, special (in addition to the regular maintenance activities, multiple repair and modification activities and complex projects)
- Projects (execution of large capital projects carried out during the shutdown)

A number of aspects must be taken into account in choosing the approach and contact procedures for outsourcing. These include safety, health and environmental aspects, quality of the available contractors and scope and duration of the shutdown.

Projects are usually prepared and implemented by a separate project team. This project team must provide a viable interface between the shutdown team and the execution activities during the shutdown period, particularly in relation to:

- Coordination of the total shutdown package and clear supervision and coordination
- Material supply, use of equipment and facilities
- Management of outsourcing contracting and execution reporting

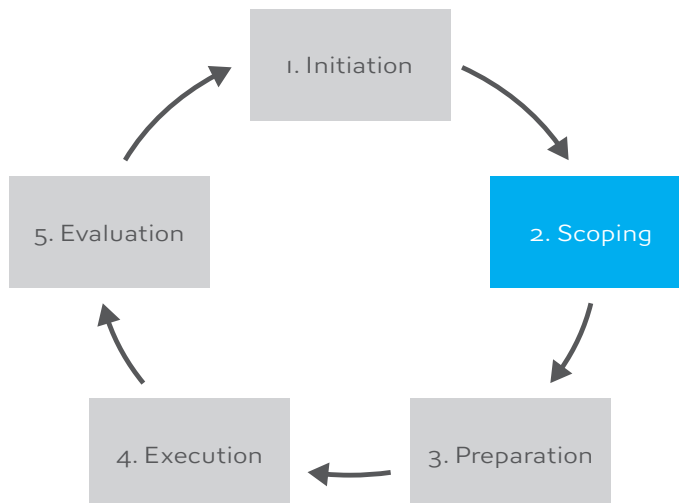
D. ESTABLISHING THE PREPARATION TEAM

Establishing the preparation team consists, in practice, of two steps. In the first place the team is appointed and installed. The initial task of the preparation team is to prepare the shutdown execution process. Furthermore, the team occupies itself with drawing up and recording the work schedule and instigating action where necessary to achieve optimum execution of the shutdown. In addition, the preparation team monitors the number, quality and timing of the task flow to the execution team.

E. THE COMMUNICATION STRATEGY

This strategy records the communication structure of the shutdown. Communication during shutdown is very important and determines, to a great extent, the success of the project. It is therefore important to create procedures for both oral and written communication.

2.3 Scoping phase



The scoping phase follows initiation of the shutdown. The 'what' of the shutdown is determined during the scoping phase, in line with the strategic, long-term vision. What are we going to do and when? What is the approximate size of the project? Which parties should be involved? What will be the impact

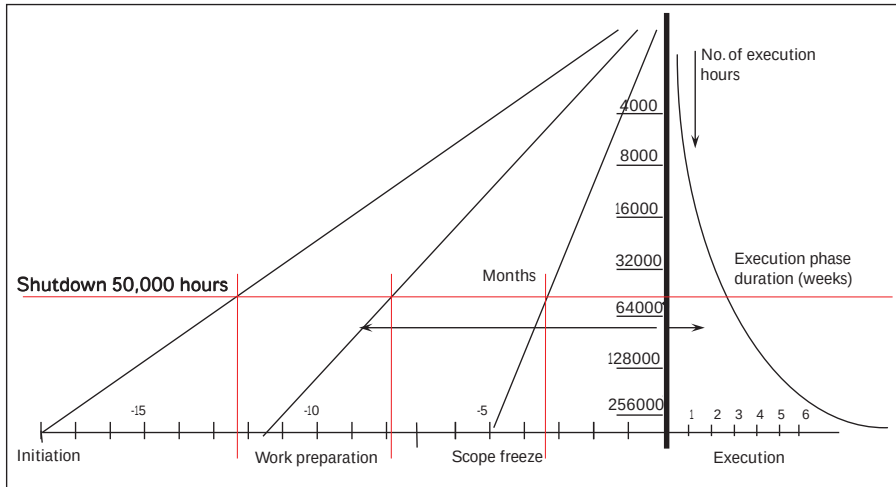
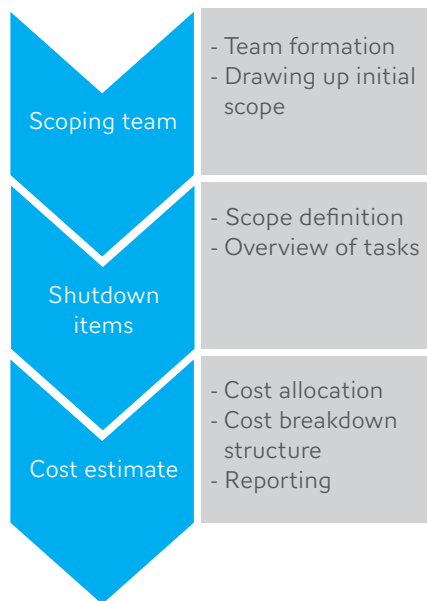


FIGURE 2.6 – Relationship between extent of the shutdown (in hours); the required preparation time and the duration of execution

on the production? And so on. All this must fall within the framework of safety, health and environmental requirements.



The work scope also determines the number of execution hours required for the shutdown. The number of execution hours largely determines the total duration of the project phases of a shutdown, from initiation to closure (figure 2.6: example of a 50,000 hour shutdown). An indication of the execution hours, and therefore work scope, is required in order to start the entire process on time. In the case of a big shutdown this could be up to one and a half years before actual execution.

Essential steps during the scoping of a shutdown are (figure 2.7):

- FORMATION OF THE SCOPING TEAM
- DEFINE BUDGET AND PLAN OF ACTION
- DRAW UP LIST OF SHUTDOWN ITEMS

FIGURE 2.7 – Steps in the scoping phase

A. FORMATION OF THE SCOPING TEAM

The scoping team is responsible for developing a first draft of the scope of the shutdown and for identifying and describing all expected shutdown activities. The scope includes an overview of the activities expected during the shutdown, including extent, execution hours and estimated costs. The team consists of

process engineers, project engineers, reliability engineers and maintenance engineers from the organisation in which the shutdown is to take place.

B. DEFINE BUDGET AND PLAN OF ACTION

Costs and budget of the shutdown are determined. This includes:

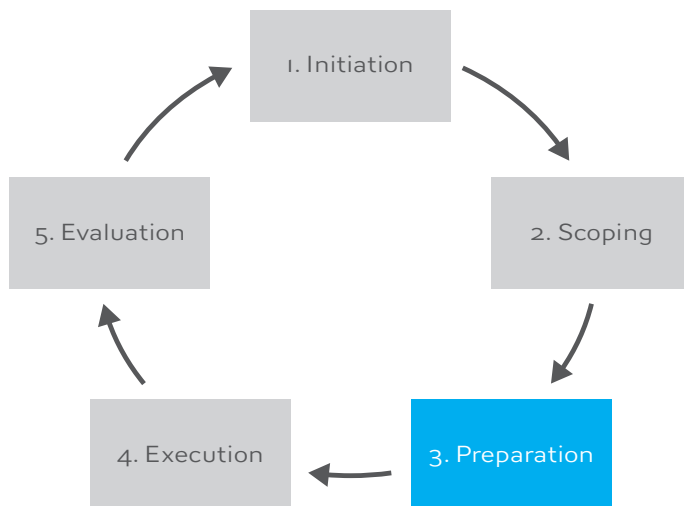
- Defining cost allocation
- The cost breakdown structure
- Determining cost reporting format
- Drawing up the budget for the shutdown

Task description covers the what, when and to what aspects of the required activities.

C. DRAW UP LIST OF SHUTDOWN ITEMS

A list of shutdown items is drawn up during the scoping phase. This is an overview of all work and basic data relating to shutdown items which, all together, determine the scope of the shutdown. This overview is a tool with which to manage the shutdown.

2.4 Preparation phase



In the preparation phase of the shutdown, a small team of people works over an extended period to specify, plan and budget most of the tasks to be performed (figure 2.8). The preparation phase includes an element of uncertainty as some assumptions have to be made as to the condition of the installation. This uncertainty can include everything from small technical modifications to large-scale installation changes. This is because, during the preparation and scheduling of a shutdown, not all installations can be inspected, so assumptions need to be made (ideally based on experience, historical data, etc.).



FIGURE 2.8 – *A small team produces the entire plan, the specifications, the scheduling and the cost estimate*

A way of dealing with such uncertainties is to perform a risk analysis, in which answers are sought to the following questions:

- Which faults are highly likely to arise?
- How much time does it take to repair such faults?
- What does such repair work cost?
- What impact does the repair have on the progress of the shutdown?

Although the main aim of the preparation phase is scheduling the work to be carried out during the shutdown, part of the preparatory effort should also be invested in planning and performing the work of the preparatory phase itself.

In the final stage of the preparatory phase, the requirements and conditions for the shutdown are communicated to all concerned. The plant manager and the shutdown manager are responsible for this.

At the preparation stage the following steps, ideally, take place (figure 2.9):

- A. PREPARING THE WORK ANALYSIS
- B. DRAWING UP A DETAILED BUDGET
- C. MATERIALS MANAGEMENT AND EQUIPMENT WITH LONG DELIVERY TIMES
- D. GENERAL FACILITIES
- e. Services of third parties and specialist work

A. PREPARING THE WORK ANALYSIS

Once the list with shutdown points is complete, a work analysis is carried out. The basic information required for this is set out in the task description.

The work analysis includes information from the task description as to how and by whom these activities will be carried out.

B. DRAWING UP A DETAILED BUDGET

The work analysis must determine what must be done, the criteria with which it must comply and who does it. It is now possible to draw up an accurate cost estimate as the details are known.

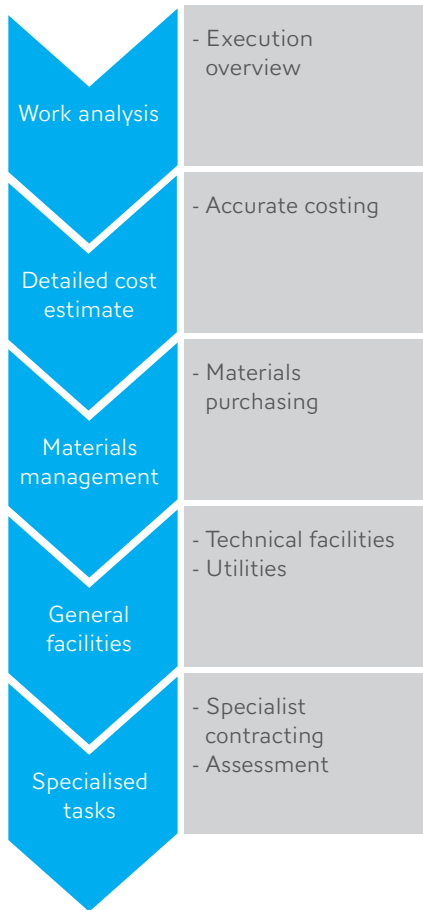


FIGURE 2.9 – Steps in the preparation phase

C. MATERIALS MANAGEMENT AND EQUIPMENT WITH LONG DELIVERY TIMES

An important part of the preparation is the (timely) acquisition of the various materials, spare parts, tools, etc. required for execution of the shutdown. Some of these spare parts have long delivery lead times. It is important to start planning and purchasing as early as possible in the preparation phase, in order to get a clear picture of the critical components and their delivery times. The delivery time for a critical part can even determine the length of the preparation phase.

D. GENERAL FACILITIES

Important aspects of shutdown preparation are the available facilities and utilities such as water, electricity, gas, parking, catering, security, toilets, showers, etc. (figure 2.10). These peripheral issues must be prepared and ready well before execution of the shutdown. In addition, there must be a degree of flexibility in the planning of peripheral aspects, as unexpected delays or increases (for example, from a single day shift to two shifts) can result in a sharp increase in shutdown costs. It is possible that, in pressured situations, extra catering, security, etc. may be required at the last minute.

E. SERVICES OF THIRD PARTIES AND SPECIALIST WORK

Definition of the outsourcing strategy with regard to nature of activities, scope, contract form and selection criteria for the contractors is defined in the initiation phase. This policy is further concretised at this stage by effective requesting of tenders and agreeing contracts.

The increasing number of specialist maintenance functions involving expensive equipment and in-depth knowledge has led to an increasing number of small (spin-off) companies, for which this specialist maintenance work is their core

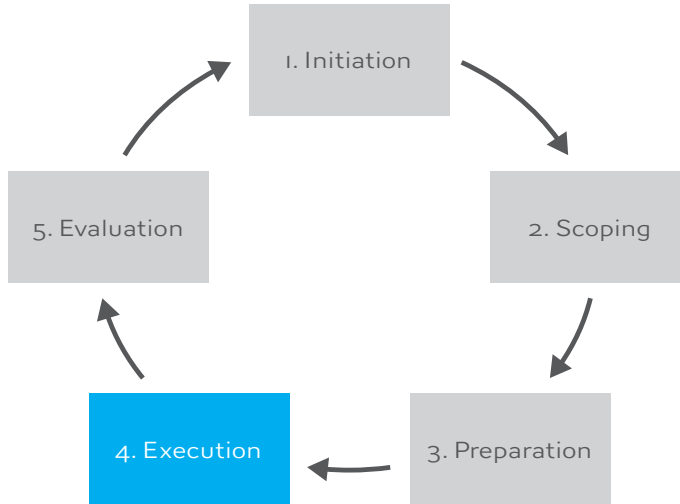
business. It is also possible that the appropriate specialists are not available in the country in which the shutdown takes place and must be sourced abroad.



FIGURE 2.10 – *Good catering is an important aspect of a shutdown*

As only a few companies may be active in a specific, core business area, such specialists must be booked and involved months before the start of a shutdown. In critical cases the quality of (new) specialists may be assessed in advance by means of an on-site demonstration of their work during the preparation phase.

2.5 Execution phase



In the execution phase, planning and preparation are translated into action. The execution phase is characterised by the quality of the execution of a large number of (often simultaneous) tasks by a large, multidisciplinary team operating within a limited work environment and under time pressure. Effective coordination of the work is of the utmost importance.



FIGURE 2.11 – *Efficient execution of the execution phase while meeting quality and timing requirements is of essential importance*

The better the initiation and preparation phase, the smoother the execution phase (figure 2.11). Nevertheless, the execution phase project is extremely complex and intensive and each, unexpected problem can have a domino effect. The organisation must be prepared for unexpected problems and respond effectively to limit negative effects. When an incident is not properly

controlled, routine work can quickly turn into unexpected work and put the entire plan at risk, which could result in additional cost and time requirements.

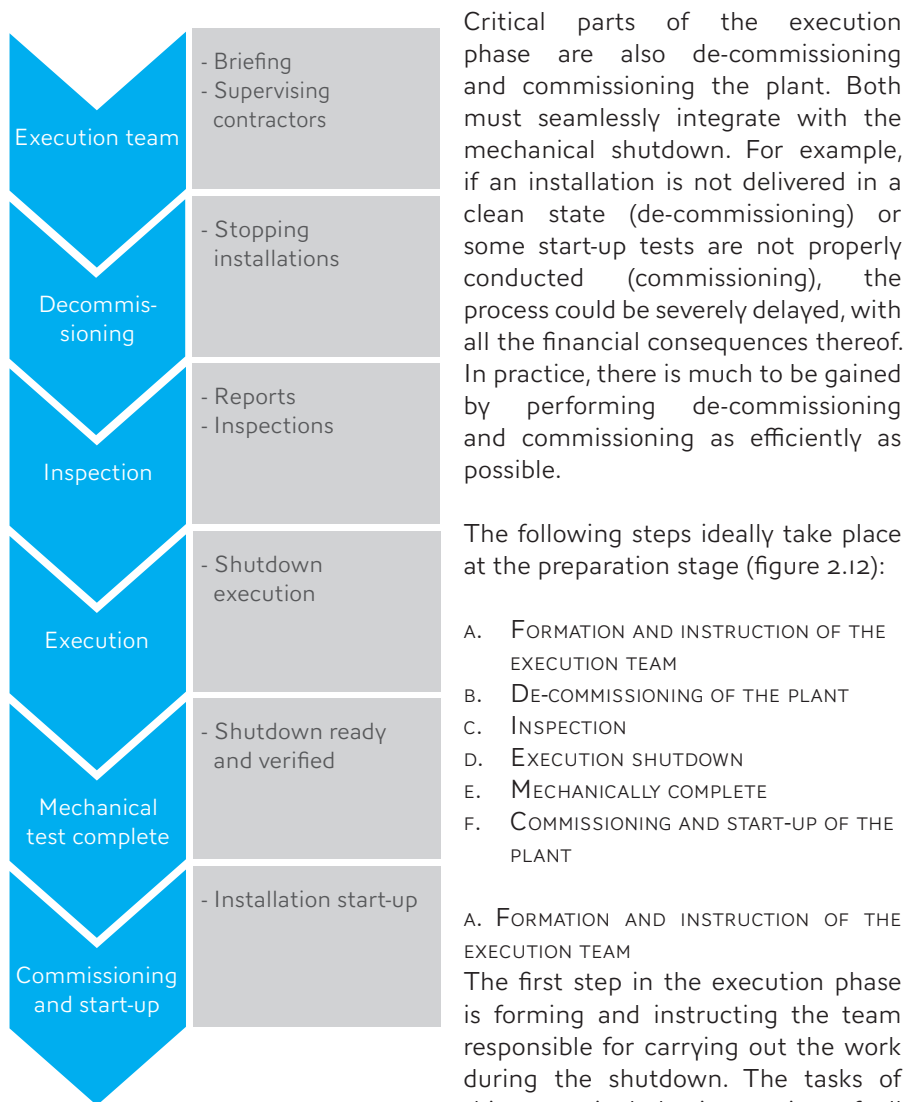


FIGURE 2.12 – Steps in the execution phase

B. DE-COMMISSIONING OF THE PLANT

During de-commissioning, the relevant installations are stopped in stages, in a safe manner (figure 2.13). These installations are identified by system or section and date of release by production department. This step is an extremely critical component of the execution phase. For example, if an installation has not been cleaned before it is delivered, the shutdown process can experience delay and, therefore, increased costs later in the process.



FIGURE 2.13 – *Temporary storage of materials during shutdown*

C. INSPECTION

Inspection is necessary to check if the actual situation is as assumed and necessary changes of what and how it has to be done can be brought in.

D. EXECUTION SHUTDOWN

In the execution phase the planned actions are carried out. Safety, planning, budget and quality must be continuously guaranteed. This requires, in the first place, that a number of organisational and managerial aspects are well arranged. This involves elements such as organisation and communication, good general facilities and safety and quality assurance.

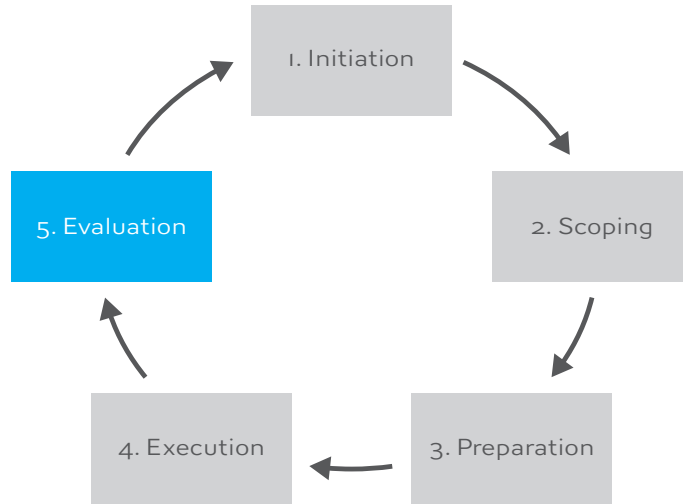
E. MECHANICAL TESTS COMPLETE

This is the moment at which all executional work has been done and verified.

F. COMMISSIONING AND START-UP THE PLANT

During commissioning all equipment and process systems are tested for suitability. After commissioning the plant should be ready for a structured and controlled start-up.

2.6 Evaluation phase



In the evaluation phase all rest work, insulation, scaffolding, demobilization of facilities and housing, etc. be finalized. Further the complete shutdown management control like costing, contractor management, as built documentation, archiving of project files, etc. have to be done.

In spite of good initiation, scoping, preparation and scheduled execution, things can go wrong during a shutdown. Comprehensive evaluation of (the output of) all phases of the shutdown is essential if this is to be prevented as far as possible. So during this phase also a decent evaluation of the total stop should be done. This includes as well as all executed work and all applied methods and processes. In fact action plan and the actual way are compared.

The shutdown manager, all key participators including the contractors are involved. The following items are examined on planned and actual:

- Shutdown strategy
- Scope of work
- Safety
- Quality
- The preparation phase
- Planning
- Costs
- Organisation of the shutdown
- Control and execution of the work
- Performance of contractors
- Logistics
- Communication

The observations and recommendations are reported and implemented in the company management systems to be ready for use for the next shutdown

2.7 Conclusion

The phases described in this chapter indicate that planning and executing a shutdown is an extensive and complex task, in which scoping and preparation are of the utmost importance for successful execution. Furthermore, comprehensive evaluation and securing accumulated knowledge contribute to the success of subsequent shutdowns.

Chapter 3

BASIS OF SCOPE MANAGEMENT

- Work scope
- Non-shutdown-dependent work
- The validated work scope
- Gatekeeping
- Work scope and freezing

3 BASIS OF SCOPE MANAGEMENT

The basis of a shutdown is the list of tasks to be performed, the work scope. The work scope has a major influence on the other aspects of a shutdown, such as safety, health, environment, duration, quality, costs, personnel, materials, tools and equipment (figure 3.1).



FIGURE 3.1 – *The tasks, often on the basis of a 24 hour day, are showed in the work scope*

Initially there is only a list with work requests made by, among others, production, maintenance and technological & engineering departments, project leaders and safety officers. The task of the shutdown team is, on the basis of these requests, whether specific or vaguely defined, to determine the work scope. Ultimately, the work scope of the involved shutdown contains only these jobs that are now necessary to inspect, maintain or improve the installation and cannot be carried out outside the shutdown and or at a later point in time.

3.1 Work scope

The most important questions in determining the work scope are:

- Which jobs have to be carried out and why?
- How much budget is involved?
- What does this scope imply in terms of duration of the shutdown?

The work scope is the basis for scheduling and resource requirements and to a great extent determines the budget. The influence of the work scope on the phases of the shutdown is shown in figure 3.2.

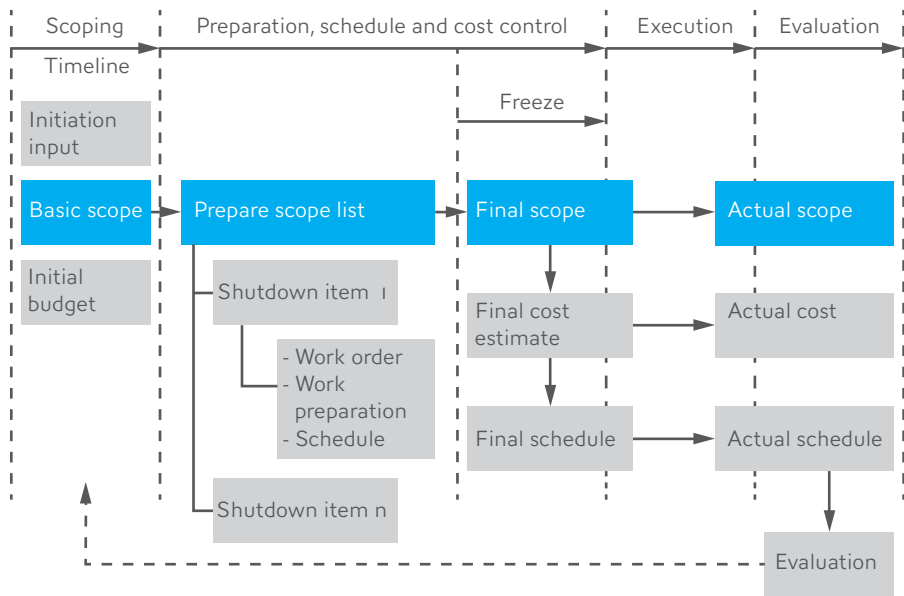


FIGURE 3.2 – *Work scope in the shutdown*

Only the work necessary to ensure the reliability of the installation till the next scheduled shutdown is carried out (the ideal is zero-based scoping). Work request requests are often made on the basis of personal judgments on the condition of equipment, the causes of faults and recurring problems. Preferably objective criteria should be implemented to determine which work has to be performed.

The work scope is divided into four categories (figure 3.3):

- Legally required and company-specific inspections
 - *Legally required, periodic inspections*
 - *Own periodic inspections & preventive activities*
- Modifications and changes to installations
 - *Replacement*
 - *New construction*
 - *Projects*
- Maintenance activities requiring shutdown
 - *Corrective maintenance*
 - *Periodic & preventive activities*
 - *Major overhauls*
- Cleaning/regeneration of installations
 - *Cleaning work*
 - *Specific work based on experience*

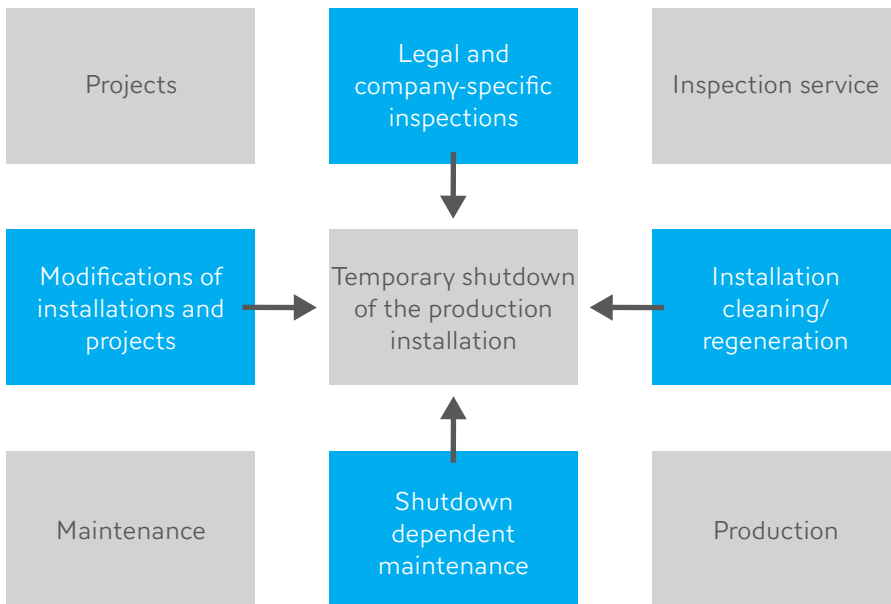


FIGURE 3.3 – *Work scope categories and stakeholders*

‘Specific work based on experience’ is not usually in response to a direct need but relates to components of which it is known that they often experience problems during the start-up of the installation.

In general, the work scope is determined by production, maintenance and development departments, project managers and safety officers. This broad variety of stakeholders indicates the degree of difficulty involved in coming to a clear, work scope which can be executed properly. Moreover, a clear and complete description of the required tasks is often not available.

The information on how to carry out these tasks can be found in a wide variety of sources:

- Maintenance management systems
- Enterprise Resource Planning (ERP) systems
- Inspection systems
- Shutdown management applications
- Own databases
- Desk drawers

As information management improves, determining the work scope becomes simpler. Companies frequently use their own checklist for scoping (see example in figure 3.4).

CHECKLIST	
Legally required and company-specific inspections	Preventive maintenance
• Inspection/repair of pressure vessels • Inspection/repair of piping • Inspection/repair of measuring instruments • Overhaul/replacement of pressure release valves • Inspection/replacement of circuit breakers • Inspection/repair safety equipment • Inspection/overhaul of non-return valves • Inspection/replacement of bursting discs • Pressure testing to detect suspected leaks • Inspect piping for suspected irregularities Repairs must be specified and approved by the responsible managers	• Overhaul of rotating machines • Overhaul of electric engines • Checking and adjusting machine alignment • Checking and adjusting instrument calibration • Revision/replacement of control valves • Inspect pressure-resistant components and repair/replace • Investigate suspected faults • Lubricate, change oil, filling of oil reservoirs Repairs must be specified and approved by the responsible managers
Corrective maintenance	Cleaning work
• Repair leaking pipes and tubes • Repair leaking flanges and couplings • Repair/replace steam gaskets and seals, steam traps • Repair couplings • Repair temporary solutions • Repair/replace instruments, pumps, engines, transmissions, valves, cable guides • Repair/replace handrails, access ladders, landings, insulation • Repair large equipment: - Compressors, turbines, large pumps - Barrel scales, internal and external parts - Columns, supports - Fan coolers, cooling towers - Heat exchangers	• Cleaning instructions: - Heat exchangers, boilers, pipe systems - Components dismantled for overhaul - Fan coolers, cooling towers - Drains, reservoirs, settling tanks, wells. • Cleaning techniques: - Washing, spraying - Chemical cleaning - Sandblasting - Cleaning by hand - Mechanical cleaning • Cleaning locations: - On location - Water tanks - Decontamination tanks - Cleaning facilities

FIGURE 3.4 – *Work scope elements*

Safety and quality related work	Shutdown-dependent work
• Removal of asbestos insulation • Inspection of pipe supports • Removal of superfluous material • Reconfiguration of piping • Special safety checks of equipment • Meeting new safety requirements • Modernisation of equipment • Planned modernisation of packing seals • Modernisation of foundations, roads, etc.	• Flushing and washing • Insulation/removal of deposits • Safety checks on entering vessels • Scaffolding insulation removal and replacement • Removal of redundant equipment • Removal of waste and hazardous substances • Loop checks, alarm checks • Installation cleaning and tidying • Additional tasks: - Contact other production units - Battery isolation - Arrange general services

CONTINUED FIGURE 3.4

The draft list of activities will need to be reviewed to enable the work to be carried out more efficiently, to clearly define responsibilities, to allocate and reduce costs and to enhance the degree of scheduling applicable to the shutdown. In the same way a variety of tasks can be combined into a single work assignment in the final work scope. Examples of this are:

- Combining inspections of a single type of valve
- Combining a small task together with a revision of an equipment at a same location
- Combining tasks for a single contractor

The character of a shutdown is determined by the percentage share of the category and the recognizable repeatability. Table 3.1 shows an example of as well share as repeatability. When the share of the category modifications and changes is high, we are dealing with a 'projects shutdown' – many unique shutdown items, often experienced by late and lesser defined scoping, resulting in difficult estimates of required personnel, material, scheduling, etc.

Category	Share in %	Sub-component	Repeatability
Inspections	25	External legislation	High
		Internal regulation	High
		Reliability engineering activities	Low
Modifications and changes	50	Replacement	Low
		New construction	Low
		Projects	Low
Maintenance	10	Corrective work	Low
		Preventive activities	High
		Maintenance engineering activities	Low
Cleaning & regeneration	15	Cleaning	Medium
		Specific activities	Medium/Low

TABLE 3.1. – *Example of repeatable tasks*

3.2 Non-shutdown-dependent work

To facilitate efficient execution of a shutdown, the work scope contains that which is necessary to maintain, repair or improve the reliability of an installation and which cannot be carried out at another point in time. Because the list with work requests is drawn up by a mixed group of personnel with various aims and priorities, there is a high risk that not all goals will be met. Objective criteria are necessary to stipulate which work must be carried out. Certain types of work, the so-called unnecessary work, do not belong in a shutdown. Unnecessary work has a major influence on several aspects of the shutdown. It is important to have insight into these relations in order to take them into account.

One category of unnecessary work is work that can be performed while the installation is in operation. Experience shows that many companies try to bring as much as possible jobs in the shutdown for reasons of having the work done (figure 3.5). It is also often argued, by both maintenance managers and production managers, that there is insufficient manpower to perform this work during normal operation. If this work is nevertheless carried out during the

shutdown it is advisable to identify a separate budget for this purpose, so the benefit and costs are transparent.



FIGURE 3.5 – A well-defined work scope with accompanying schedule avoids work that is not shutdown-dependent

Shutdowns require extra scheduling, control and preparation, so that work carried out during a shutdown is normally more expensive than the same work performed during normal operation. The following categories of unnecessary work may be listed:

- **REGULAR MAINTENANCE TASKS**
Regular maintenance tasks are transferred to the shutdown. The result is that the cost of regular maintenance goes down, while the shutdown costs rise.
- **DUPLICATED WORK REQUESTS**
The work requests are generated by a large group of employees from various departments. It frequently happens that the same work, differently described, is requested a number of times. If these work requests are not checked, time, money and capacity are wasted.
- **REDUNDANT WORK**
Certain work requests render other work superfluous. For example, replacing a number of seals in a pump which will be replaced anyway. Redundant work is also work requested for equipment that is no longer present.
- **WORK THAT IS 'NICE TO DO'**
This is, in fact, unnecessary work which someone feels, for whatever reason, should be done anyway. For example, opening and checking a pump for no other reason than that the installation has been stopped.

- WORK MOTIVATED BY LACK OF TRUST
On the basis of objective considerations a particular task package (for example checking and replacing bearings) does not need to be carried out. The work is nevertheless done because members of staff do not trust the replaced components.
- WORK THAT IS INTRODUCED AT AN UNNECESSARILY LATE STAGE
This type of work is usually put forward just before the start of the shutdown and is presented as very important. Of course the item has to be checked for necessity. Further on it is important to investigate why this work request has been submitted so late, particularly given its claimed importance.

3.3 The validated work scope

Unnecessary work increases cost and time requirements, scheduling becomes more complicated, demand for limited resources increases and errors can take place. Not to mention the problems that arise when the unnecessary work directly obstructs the critical path. For this reason it is of vital importance that the work requests are validated which can be carried out in the following order:

1. Control
 - *Has the request been approved by a competent person?*
 - *Is the work request not redundant or duplicated?*
 - *Is the information on the work request accurate and does it describe exactly what has been requested?*
2. Need
 - *Is it necessary to perform the task?*
 - *Is it necessary to carry out the task during the shutdown?*
 - *Is it necessary to carry out the task in the proposed manner?*
3. Analysis
 - *Are safety, quality, material, equipment and staff requirements taken into account?*
4. Records
 - *Describe the final work requests and record this in a detailed Technical Order Specification (TOS), which describes what must be carried out and why.*

The result of the previous steps is a scoping list, divided in formally mentioned categories (figure 3.3.):

- Legally required and company-specific inspections
- Modifications and changes to installations
- Stop-dependent maintenance activities
- Cleaning/regeneration of installations

This scoping list serves as a starting point for the work preparation.

3.4 Gatekeeping

As stated earlier, the activities to be performed in a shutdown must be restricted to those activities necessary to guarantee the reliability of the installation. The validation process described in the previous section must be carried out preferably in an objective way. Many companies use nowadays a so called risk matrix for ranking and approving scope items (see figure 3.6).

Each scope point is evaluated with respect to need and priority before being included in the shutdown. This assessment takes place across several sessions and is conducted by a team of specialists that includes the technical manager, production manager, technology manager (process & engineering) and plant manager. Each, individual scope component can be assessed using this risk matrix, in which the severity of failure of the scope component and the probability of occurrence are combined to form the degree of acceptance (green, yellow, orange or red). By linking this risk analysis to a work schedule, the shutdown team obtains more insight into the relationships between risks, cost and lead time.

Every scope change with regard to the contents of the scope and possible extra scope must also pass this process. This structured validation we call gatekeeping. The gatekeeping process remains in force throughout the full shutdown duration.

Severity	CONSEQUENCES		CONSEQUENCES	CONSEQUENCES		LIKELIHOOD						
	People	Economical (direct and indirect costs in Euro)	Environmental	Reputation	A	B	C	D	E			
					F0 Improbable	F1 Rare	F2 Unlikely	F3 Likely	F4 Probable			
S0	N/A	Less than 1 K	None	None								
S1	First Aid Case(s) (nurse)	1-10 K	N/A	N/A								
S2	Medical Treatment Case(s) (doctor)	10 - 100 K	Chemical released within secondary containment or contained within unit (note 1) short-term, simple remediation (e.g. spill cleanup, soil removal)	N/A								
S3	Temporary injury (LTI/RWC); Note 5	100 K - 1 M	Chemical release outside containment but with potential for injury inside company property; flammable release without potential for vapour cloud explosion (note 2) Environmental remediation with cost less than 1 M	Minor offsite impact with precautionary shelter-in-place local media coverage								
S4	Onsite fatality or permanently invalidating injury; multiple onsite injuries (LTI/RWC), one serious offsite injury; Note 5	1-10 M	Chemical release with potential for injury offsite; flammable release resulting in a vapour cloud entering a building or potential explosion site, with potential for damage or casualties if ignited (note 3) Environmental remediation between 1-2.5 M	Shelter-in-place or community evacuation Government investigation (local) Regional media coverage or brief national media coverage								
S5	Multiple fatalities or permanently invalidating injuries onsite, offsite fatality or multiply offsite injuries	More than 10 M	Chemical release with potential for significant onsite and offsite injuries or fatalities (note 4) Environmental remediation with costs above 2.5 M	Other significant community impact government investigation (national) National media coverage over multiple days								

FIGURE 3.6 – Risk matrix

3.5 Work scope and freezing

In the cases of somewhat larger shutdowns it may be necessary to introduce a number of work scope freezes.

In practice three freezes are often used in sequence, as shown in table 3.2:

- Freeze I includes fixing the desired topics, estimates of the required budget and associated lead times.
- In freeze II newly introduced scope items and amendments to existing scope items are again assessed. New insights and recently available information can be used during this freeze to come to a more accurate scope. Freeze II takes place after preparation of the scope points, at the start of the contracting phase.
- Freeze III repeats the approach of freeze II, resulting in the definite and approved scope of the work which is to be carried out in the shutdown.

Freeze	Budget and work scope deviation	Months preceding shutdown
I Sufficient overview shutdown	+/- 25%	8 – 15
II Start contracting/ procurement	+/- 15%	4 – 6
III Final scope, budget, duration	+/- 10%	1 – 2

TABLE 3.2 - *Work scope freezes; the identified months depend on the extent of the shutdown*

The advantages of the described freezes are:

- The overview continues to improve over time.
- Choices as to whether or not to continue with certain scope items are made early.
- Timely insight into the budget for and duration of the shutdown.
- Time for preparation of the scope items including work preparation, material purchasing and engaging specialists.

Gatekeeping and freezing ultimately result in a work scope that is transparent, rationalised and justifiable

Chapter 4

THE SHUTDOWN AND ITS ENVIRONMENT

- Business, installation, production activity
- Business chain, industrial environment, partners
- Market and customer
- People, society and environment

4 THE SHUTDOWN AND ITS ENVIRONMENT

Shutdowns are not isolated events. The content of a shutdown is, to a certain extent, dictated by a company's financial situation. It is unlikely that the shutdown will be executed in a period of significantly increased sales. The type and frequency of inspections is dictated by laws and regulations. A large

number of factors determine, to varying degrees, the nature of a shutdown and can therefore influence shutdown strategies.

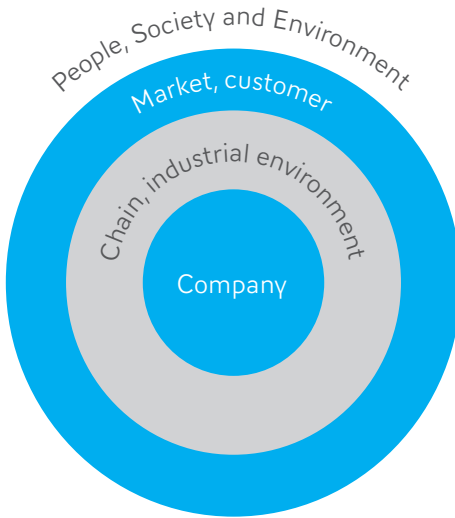


FIGURE 4.1 – *Shutdown of an installation and its environment*

This chapter provides an overview of important influencing factors on the bases of the literature and interviews with directors, asset owners and maintenance managers. An installation which is stopped, is part of a company. This company has customers and suppliers and is part of a chain. The products eventually find their way to various markets. A shutdown is therefore not independent of people, society and environment, all of which set criteria which must be met.

This zooming out from the company to its environment, from installation via chain and market to society (figure 4.1), gives us the four categories of shutdown influencing factors. The following four paragraphs deal with the influencing factors arising from these four categories

1. BUSINESS, INSTALLATION, AND PRODUCTION ACTIVITY
These are factors that are determined by the situation of the company or by internal business choices.
2. BUSINESS CHAIN, INDUSTRIAL ENVIRONMENT, PARTNERS
Position in the business chain, arrangements with partners and the integration of the company with its industrial environment all influence shutdowns.
3. MARKET, CUSTOMER
The type of market, market developments, customer needs and customer perceptions are factors which must be taken into account.

4. PEOPLE, SOCIETY AND ENVIRONMENT

The entire set of influences that can emerge from society and nature. This includes laws and regulations, macro-economic developments and natural phenomena.

4.1 Business, installation, production activity

1. TECHNOLOGICAL INNOVATIONS

Technological breakthroughs can increase factory efficiency, improve product quality, reduce outages, etc. The consequence could be that installations or components are replaced ahead of schedule for commercial reasons, for example replacement of old heat exchangers with ones that deliver higher efficiency (figure 4.2).



FIGURE 4.2 – *Manufacture of a high efficiency heat exchanger*

Parts supply can be interrupted for various reasons (bankruptcy, discontinuation, etc.). If there is no appropriate replacement part this can lead to an early shutdown to adapt the installation for more durable and available parts.

2. FINANCIAL SITUATION

A company can decide, for accounting reasons or because of its financial situation, to postpone a shutdown or phase it over several years. This reduces the costs for the relevant year and/or has the effect of postponing investments. Increased risk due to an unplanned stop and/or lower profit from the installation could be consequences.

3. PERSONNEL

A shutdown is a disruption of the normal, routine production process in a company. A shutdown often creates extra demands on staff in terms of flexibility, effort and time. A shutdown often involves less routine-oriented work. The increased workload of a shutdown can also lead to high degree of staff fatigue and resulting errors, delays and accidents.

4. COMMUNICATION WITH OWN AND THIRD PARTY PERSONNEL
Companies sometimes have a specific 'language' (abbreviations, technical terms) which can be confusing for outsiders. In addition, the increasing number of contractors has led to an increase in the number of languages spoken. Ambiguous or unclear communication between own and third party staff can lead to errors, delays and accidents.
5. POSITION AND INFLUENCE OF MAINTENANCE MANAGEMENT
In many companies maintenance management reports to production, in others maintenance is represented at senior management level. This is often a good indication of the way maintenance is regarded. Maintenance as a cost item or as strategy. The position and influence of maintenance management will therefore also have a major effect on the efficiency and effectiveness of shutdowns.
6. COMPANY STRATEGY
Is the company focused on maximisation of short-term profit? Is life cycle thinking important? What is the life cycle phase of the product? Answers to these and similar questions determine how long and under which conditions the production facilities are required. And this in turn largely determines the form and content of the shutdowns.
7. INSTALLATION AND EQUIPMENTS
The characteristics of the technical installation will have a significant impact on the frequency and complexity of shutdowns. Installation characteristics are:
 - *The number of machines and equipment*
 - *The complexity of the technology*
 - *The degree of interaction between systems*
 - *The quality of the machines and parts*
 - *Operational staffing*
 - *The age of the installation*

4.2 Business chain, industrial environment, partners

8. PARTNERS IN THE SUPPLY CHAIN
Every company has a position within a chain of businesses (raw materials, intermediate products, end products, distribution, end consumer). There is an interdependence, to a greater or lesser extent, in the continuity of supply and purchase of materials, intermediate products and end products. This can mean that a shutdown has implications if one or more links in the chain are inoperative for a period and can no longer supply or consume.

Coordination of planned shutdowns and prevention of the consequences of involuntary purchase and supply restrictions can therefore be important (figure 4.3). This is often recorded in the form of contracts.



FIGURE 4.3 – *Shutdown of business chain partners: refinery and tank storage*

9. COMMON FACILITIES

In many industrial areas a situation has arisen in which, for economic reasons, several companies rely on the same local suppliers and on their installations. These include storage tanks, generators, networks and water, steam, electricity and compressed air piping. Examples include Air Liquide and Vopak at Europort in Rotterdam. Matters such as the use and maintenance of these installations are regulated via agreement between several, involved companies. The aim, depending on the situation, is often synergy and minimisation of total shutdown costs and downtime.

10. CHANGES IN THE USE OF RAW MATERIALS

As a result of large fluctuations in the price of raw materials or government incentive systems it can be beneficial to adapt installations earlier than planned. For example, power stations which partly switch from gas to coal or biofuel.

II. SIMULTANEOUS SHUTDOWNS IN THE NEIGHBOURHOOD

A few large shutdowns taking place at the same time in the same area can create problems in terms of the supply of human resource. A shortage of qualified maintenance personnel increases cost and risk. For example, the demand for manpower caused by large shutdowns at DSM, Shell or BASF in Limburg, Europort, Rotterdam and Antwerp can result in a shortage in the supply of workers for other businesses in these areas.

4.3 Market and customer

12. MARKET DEVELOPMENTS

- *Fluctuation in product sales*
The market demand for a product can change suddenly and significantly. This is not always predictable. A strongly increasing or decreasing demand can significantly impact the decision to implement a shutdown sooner or later.
- *Exit strategy*
Companies find themselves in situations in which their production location will only be required for a limited period. This affects the maintenance policy.
- *Joint venture or takeover*
Companies find themselves in takeover or merger situations that lead to reconsideration of production locations and volumes. The condition/state of maintenance of the assets may play a role in their valuation in a deal.

13. SEASONAL INFLUENCES

Companies strive to perform shutdowns under criteria and at minimum, integral costs. Shutdown during periods with a strongly increased product demand is often avoided. The same applies to periods in which holidays for maintenance staff fall, or the winter months when the weather can impede maintenance activities.

Most of the shutdowns in The Netherlands are planned for the period March-April-May or September-October-November:

- *Outside staff holiday periods*
- *Acceptable weather conditions*

4.4 People, society and environment

14. LAW AND REGULATIONS

New legislation can have a major impact on industrial activities. Legislation often relates to:

- *Health and safety of production personnel*
- *Health and safety of people and their environment*
- *Sustainability of product and production process*
This is regulated by legislation and regulation aimed at the efficiency of energy and material consumption during the life cycle of the product, which includes the production process and production plant.
- *The promotion of free market and competition between companies*
- *Periodic compulsory inspection of installations*
For various reasons periodic inspections, checks and maintenance work are obligatory. Examples are:



FIGURE 4.4 – *Replacement of wooden sleepers with concrete sleepers and new track ballast*

- Maintenance schedules imposed by suppliers of installations or their components, so the warranty remains valid. Routine maintenance and inspection, for example of aircraft, turbines and marine engines.
- Avoidance of major financial risk as a result of outages and extensive consequential damage and repair costs.
- Inability to perform according to contract in terms of accepting goods from suppliers or supplying customers as a result of involuntary production downtime.
- Insurance companies that impose periodic checks to maintain cover for damage and downtime.
- Health and safety of staff and environment. For example observing noise, temperature, air quality, waste and energy consumption standards in the interests of a healthy and safe living environment.
- *Replacement or new construction instead of maintenance*
Amendments to the law and regulations can result in current installations failing to meet prescribed standards. This leads to mandatory additional maintenance or replacement (figure 4.4). Examples are excessive emissions of harmful substances (gases, liquids), excessive energy consumption (by generators, cooling units) or an unsafe work environment (loading platforms).
- *NCA regulation*
The Netherlands Competition Authority (NCA), ensures that businesses compete in a free market. For example, competitors may not agree selling prices. The NCA establishes the criteria. Regulation is aimed at:
 - Horizontal agreements
 - Agreements between two maintenance companies.
 - Vertical agreements
 - Agreements between a manufacturer and maintenance company or supplier.
 - Concentrations
For example, a maintenance company takes over its closest competitors with the result that competition becomes too limited.

- Abuse of dominant positions
As a result of concentration there are very few maintenance companies. These may abuse their dominant position in the market by setting a high price for their services (cartels).

The government also prohibits leveling of work by maintenance companies - in other words spreading a scarce maintenance resource across maintenance customers and over time. This can drive up the costs for their customers.

15. TRADE BARRIERS

Many countries protect their own industry and employment opportunities against foreign competition. Trade barriers on the basis of import restrictions and levies are often employed.

16. INTANGIBLE ASSETS

Intangible assets are identifiable, immaterial, durable assets which are not always quantifiable. Examples of intangible assets are integrity, reputation and image, ethics and morality and goodwill.

The goal of many companies is a minimisation of total maintenance. Losses attributable to any resulting deterioration of intangibles are factored in. The correct balance is sought between minimising the integral cost of maintenance and minimising losses on intangibles. Risk management (and other) techniques are employed to achieve this.

For example: A waste incinerator will exhibit decreasing performance after two years, with an increased risk of exceeding the permissible emissions to the environment. Based on statistics derived from the historical data of the plant, the shutdown is stretched to 3 years. This involves a risk of failure of essential components and/or emission of environmentally hazardous substances. This can lead to outage and loss of intangible asset value.

- *Integrity*

A company with integrity acts honestly and sincerely and is not corruptible. The organisation has an intrinsic trustworthiness, is transparent and delivers on its obligations. It has no hidden agenda and does not feign emotions. An organisation with integrity will not open itself to improper influences.

- *Reputation and image*

The way in which stakeholder groups see and appreciate an organisation defines its (corporate) reputation. Reputation is the totality of the impressions made on all stakeholders - for example employees, customers, suppliers, press, politicians and the surrounding area - by the organisation. The reputation of an organisation says something about the bond between a company and its environment. This reputation cannot only be cosmetic, it must be authentic. The members of an

organisation express its reputation: each, individual employee influences the corporate reputation.

There is a difference between an organisation's image and its reputation. The corporate image is determined by the impression that people have of a particular organisation or brand. This is independent of whether they have a relationship with the organisation. Reputations, on the other hand, are influenced by the stakeholders of an organisation. Reputations develop over time as a result of consistent behaviour and are endorsed by effective communication. Corporate images may, however, change within a short period of time, for example as a result of a single campaign or incident.

- *Ethics and morality*

Which moral standards are adopted by a company and observed by its employees? Managers often rely on technical, social and psychological facts as a way of avoiding moral argument.

If an employee is forced by the company to do something which is distasteful to him, then it is his moral obligation to object (by whistle-blowing). In some cases this can be communicated externally by the employee, while in more extreme cases it is justifiable to do it anonymously.

Law and justice do not always go hand in hand. A company that exhibits moral responsibility towards the rights of others and is not tempted by short-term opportunism will better manage any threats and opportunities that may arise. It is often suggested that a manager who does not act ethically is unwise and short-sighted

- *Goodwill*

The word goodwill can denote a friendly, helpful, or cooperative feeling or attitude: Within the financial world, however, the term is used to indicate that part of the market value of an organisation that is not directly attributable to the assets and liabilities. In most cases the issue of goodwill (or its opposite) comes into play during takeovers and is regarded within the financial world as value over and above the net asset value of an organisation. In this view goodwill represents the value of future income of the organisation that is not yet recognised on the balance sheet but which already exists in the form of knowledge, customers, brands, staff, etc.

17. CLIMATE INFLUENCES

The climatic seasons can greatly affect the supply side (harvesting) as well as the demand side. Examples of highly seasonally-dependent activities:

- *Potato starch (harvest time)*
- *Sugar beet campaign (harvest time)*
- *Gas consumption (winter)*

Shutdowns are often avoided during these periods. The same applies to periods in which weather conditions may hinder maintenance (figure 4.5).



FIGURE 4.5 – *Indoor maintenance avoids the influence of weather*

18. GEOGRAPHICAL LOCATION

The present infrastructure depends on geographical location. The (non-) availability of adequately trained staff, of suppliers, raw materials installations and customers is dependent on geographical location. Moreover, the climatic conditions within which people work are also determined by the location of installations. This must be taken into account in the preparation and execution of a shutdown.

19. UNPREDICTABLE EVENTS

- *Disaster in the plant*

An unexpected event such as an explosion within an installation can result in an unplanned shutdown. The duration of the shutdown will depend on the extent of the damage and the delivery lead times of the required components. Moreover, personal injury and damage to the surroundings can be extensive. Consumers and suppliers can experience problems. Customers cannot produce due to lack of raw materials and suppliers cannot get rid of their products.

- *World economy*

Long and short-term developments in the world economy can have a major impact on the selection of or changes in production locations, production volumes and markets. This applies both to recessions and to new markets. Examples of this are the developments around the turn of the century in the Eastern bloc and Far East.

- *Wars*

A political conflict that results in a war generally has major consequences for the survival of a company. Disruptions to infrastructure, supply and distribution can lead to unwanted shutdowns. In addition to human issues and damage to the plant caused by acts of war.

- *Natural disasters*

An earthquake or flood can lead to an unplanned shutdown of an entire plant. The direct cause of the stop may be the natural disaster, but a stop may also be imposed by the authorities or by the affected business itself due to high risks to safety, health or the environment.

The chance of a business suffering an involuntary stop is also increased when one of its chain partners (consumer or supplier) can no longer meet its obligations as a result of a natural disaster. An example is the nuclear disaster in Fukushima (2011), where many factories could no longer supply products due to flooding, power failure and evacuation.

Chapter 5

STRATEGIES FOR SHUTDOWNS

- Interval
- Duration
- Costs
- Complexity/Risk
- Efficiency and effectiveness of the installation
- External factors

5 STRATEGIES FOR SHUTDOWNS

In a plant manager's ideal world, shutdowns would be unnecessary. Apart from legal and insurance requirements, technical and financial limitations in the design and construction of industrial installations ensure that shutdowns remain necessary.

An evolution is taking place in asset management, from the current situation of technically-driven preventive maintenance to business-driven maintenance prevention. A preferred strategy is increasingly to extend the interval between shutdowns while reducing the duration of the execution phase (see chapter 2) of each shutdown.

Every company determines its strategy based on its knowledge and the opportunities available to accomplish its goals at minimum cost and risk. This also applies to shutdowns and can be achieved by means of a variety of strategies based on the influencing factors described in chapter 4.

Strategies that can be followed to minimise shutdowns and costs may, in practice, be divided into six main categories:

1. Interval (period between successive shutdowns)
2. Duration (length of time of a shutdown)
3. Costs (costs of shutdown)
4. Complexity/risk (level of difficulty of organisation and execution)
5. Efficiency and effectiveness of the installation
6. External factors

This chapter describes the most relevant strategies by category.

5.1 Interval

Inspections, cleaning, repairs, replacement of components and new construction take place during a shutdown. The time between successive shutdowns can be influenced by many factors other than the technical aspects:

- *Technical*
Components require maintenance to prevent reduction of production volume and product quality.
- *Governments*
Inspections regarding safety, health and environment requirements.
- *Insurance companies and suppliers of installations*
Continuity of insurance and guarantees during shutdown to cover the extremely large risks of failure and associated damages.
- *Market, product demand*
No demand (as there is oversupply in the market) or improvement of the installation to meet an increasing demand.

- *Suppliers and customers*
Taking customer needs into account.
- *Other production units of the company*
Sufficient capacity to continue to be able to supply customers.
- *Competition*
Knowing when their shutdowns will take place.
- *Availability of (external) maintenance staff*
In terms of quantity and quality.



FIGURE 5.1 – *Lifetime extension of 'weak' components*

1. STRATEGY: BASED ON THE INSTALLATION'S HISTORICAL DATA, DEMONSTRATE THAT THE MAINTENANCE INTERVAL CAN BE EXTENDED
Extending the shutdown interval can, in many cases, be technically sound. This is because the shutdown rules are often based on a worst case usage scenario and not on the real situation. On the basis of historical shutdown data, longer in-use periods for installations and components can be shown to be viable.
2. STRATEGY: TUNING THE SHUTDOWN INTERVALS FOR PARTS AND INSTALLATIONS SO THEY CAN BE REPLACED AT THE SAME TIME
Components of an installation have different service lives and, therefore, maintenance intervals. By choosing installations using components with matching service lives, shorter or longer shutdown intervals can be achieved with, as end result, lower total life cycle costs for the installation.
3. STRATEGY: LIFE TIME EXTENSION OF THE 'WEAKEST' COMPONENTS
The intervals at which shutdowns are to take place vary by component and installations. The shutdown interval is determined by the 'weakest' component. Aligning the shutdown intervals of all parts and installations and addressing how to extend the intervals of the weakest components can deliver cost savings. It is also possible to replace components of 'excessive' quality with more inferior components requiring shorter maintenance intervals, if this delivers cost benefits (figure 5.1).

4. STRATEGY: AGREEMENTS WITH THIRD PARTIES IN THE SAME INDUSTRIAL AREA
Companies that make use of common facilities (steam, compressed air, etc.), may experience interruption of supply from those common facilities when one of them is undergoing a shutdown. It is necessary to have agreements and procedures in relation to the use of common facilities.
5. STRATEGY: ACTION PLAN FOR UNSCHEDULED SHUTDOWNS
In the event that the installation must temporarily stop its process, shutdown activities can then be carried out in this period.

An example is a collapsed floodgate in a canal, as a result of which transporting output by boat from a process plant is no longer possible and several installations have to be stopped. The decision is then made to perform shutdown maintenance in this process plant earlier.

5.2 Duration

The duration of a shutdown is the period in which the physical execution of the shutdown takes place, the execution phase. The ultimate scenario is that the execution phase is not required at all. As stated in the introduction of this chapter, this is never completely possible. The aim is to keep the duration of the shutdown to a minimum.

6. STRATEGY: BETTER MONITORING OF INSTALLATIONS ON MAINTENANCE SENSITIVE PARAMETERS
The approach of using sensors to monitor the performance and condition of an installation in order to predict and determine maintenance requirements is increasingly winning territory. The technologies for this approach are available and the required investment is becoming increasingly economical. The basic ingredients are:

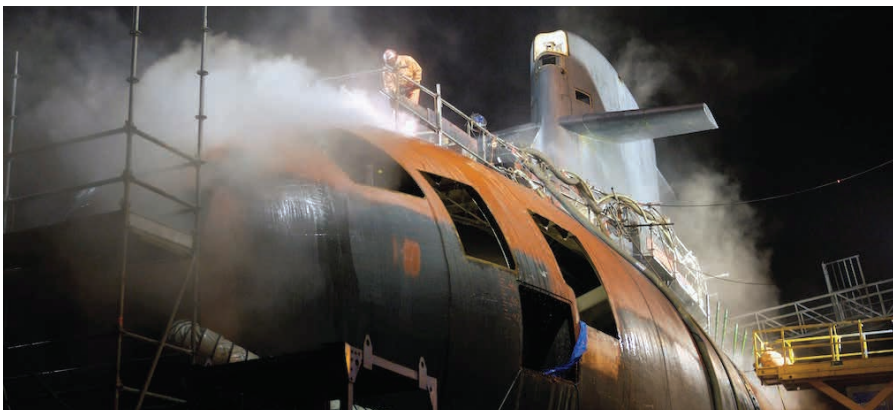


FIGURE 5.2 – *Design for maintenance can save much unnecessary work*

- *The sensors*
 - *Wireless transmission of measurement data*
 - *Storing and updating data*
 - *Algorithms and knowledge required to analyse the data*
 - *Representation of the data in workable form*
7. STRATEGY: APPLY DFM AND CBM
Design installations to take maintenance into account (figure 5.2) and allow measurement of their condition without having to stop the installations.
- *DFM (Design For Maintenance)*
 - *CBM (Condition Based Maintenance)*
8. STRATEGY: DRAW UP OF (PREVENTIVE) MAINTENANCE SCENARIOS
It is advisable to prepare all scenarios (condition and actions), together with associated risk analyses, in order to properly plan a shutdown and not be surprised during the shutdown by the condition of parts incapable of prior inspection.
9. STRATEGY: PERFORM ONLY THOSE ACTIVITIES THAT REQUIRE A COMPLETE SHUTDOWN
Fewer, shorter shutdowns ensure better continuity within the business chain in which the company is located. Shutdowns are, in principle, only necessary for those components and installations for which the total installation must be turned off (figure 5.3). In practice, however, it appears that much work also takes place on components that could have been accessed outside the shutdown.
10. STRATEGY: DE-BOTTLENECKING
Many components that need to be opened or disassembled for maintenance require a shutdown. In order to avoid a shutdown, 'de-bottlenecking' can be applied. Potential strategies for this are:



FIGURE 5.3 – *The objective is minimisation of shutdown duration*

- *Construct bypasses*
- *Parallel redundant construction of the affected components*
- *Alternative design*

5.3 Costs

A shutdown is an event that involves high costs. These are not only the operational costs of maintenance and hire of 'externals', but also the costs of lost income, interruption of the business chain, etc.

11. STRATEGY: APPLY RISK ASSESSMENT AND MANAGEMENT

A well-known phenomenon in large infrastructure projects is that estimated timing of duration and budget are exceeded. As shutdowns are often not routine projects they also frequently experience overruns. Risk assessment should form part of the management decision processes. Based on a risk approach in which taking the right decisions is not just about better and more rational information, companies must draw up institutionalised regulations as regards accountability, with associated risks for uncertainties.

12. STRATEGY: COOPERATIVE INVENTORY OF EXPENSIVE COMPONENTS

Expensive components are kept in stock on the basis of cooperation with a number of companies which require the same parts. This lowers costs and risks, as fewer of these expensive parts need to be kept in stock. The same applies to components with long delivery periods.

The use of such stock in a shutdown must be aligned with the needs of all the participating parties.

Example: An expensive, re-usable part with an overhaul frequency of every 6 months means there must be at least 6 months between two shutdowns.

13. STRATEGY: DIFFERENTIATE THE SHUTDOWN STRATEGY ACCORDING TO LOCALLY APPLICABLE LAWS AND REGULATIONS

Every company determines its strategy on the basis of its knowledge and the opportunities available to accomplish its goals at minimum cost and risk. This also applies to shutdowns. The standards for installation and work are not the same for each country. The same applies to the permissible and acceptable risks on site.

14. STRATEGY: CREATE A REALISTIC SHUTDOWN COST ESTIMATE, INCLUDING LOST SALES AND ONGOING PERSONNEL EXPENSES

Normal maintenance activities are, in contrast to shutdowns, frequently very efficient and carried out at minimal cost. The unique character of a every shutdown and the lack of time means that much less attention is paid to efficiency and cost. A company is often just happy that a shutdown is finished and that the everyday situation has resumed. This deserves extra attention as a considerable part of the total maintenance budget often goes to shutdowns.

A realistic picture of the total cost of a production shutdown must include the cost of lost production and lost sales. Production staff has no output during a shutdown. This results in reduced turnover, while personnel costs remain unchanged. This also applies to purchasing, warehouse, control, etc.

The pre-calculation of shutdown costs are usually too optimistic, as the costs of unforeseen work have not been taken into account (figure 5.4). Third parties may also use these unforeseen activities as an opportunity to charge high rates.



FIGURE 5.4 – *Does the schedule take unforeseen work into account?*

Many maintenance activities that take place in a shutdown could also be performed during regular maintenance. In most cases it is better, from a cost point of view, to exclude these activities from the shutdown. Reasons for inclusion in the shutdown include a shortage of regular maintenance staff and insufficient screening of the work to be performed.

5.4 Complexity/Risk

A shutdown is a complex event, typically with many shutdown items. It is also a process that carries increased risk, as it is a deviation from the everyday routine. Both financial and health risks arise (figure 5.5).

15. STRATEGY: APPLY STATISTICS TO QUANTIFY RISKS

Beside laws and regulations it is the weakest technical link in the installation that determines when a shutdown is necessary. Each component in an installation has its own time to failure risk curve. In risk management an extension of service life can be rationalised and accepted on the basis of historical data. Long-term collection, verification and validation of reliable data on the installation are important in this regard.



FIGURE 5.5 – *Health and safety aspects are key issues for any shutdown*

16. STRATEGY: DESIGN FOR MAINTENANCE ALSO FOR SHUTDOWNS

In the design of installations and their parts, most attention is paid to the functional requirements and to achieving the lowest possible cost for the customer. As maintenance costs afterwards often turn out to be a substantial part of the cost of an installation, maintenance aspects are increasingly included in product specifications. This provides a number of additional specifications for use by installation engineers. Design for Maintenance (DFM) focuses on this area.

17. STRATEGY: DETERMINING THE INTEGRAL COST ACROSS THE ENTIRE LIFE CYCLE OF AN ASSET

Despite the higher initial investment, purchasers of installations are increasingly thinking in terms of minimisation of their total life cycle cost. This involves, in addition to the initial investment, the maintenance costs and cost of use and disposal of the installation.

18. STRATEGY: MODULAR THINKING

Maintenance benefits from fast, error-free replacement of parts, without requiring specific knowledge or experience. This has led to modular thinking, modular solutions and modular products.

- *Minimisation of the number of components and the variability of parts*
There are a number of benefits to minimising the number of parts (e.g. the number of types and sizes of bolts and nuts):
 - Larger numbers mean lower purchase prices (scale effects)
 - Fewer types and numbers of components in stock
 - Fewer tools required
 - Less expertise required
- *Modularisation*
Modular component replacement saves effort, turnaround time and costs. For example: a dirty heat exchanger is integrally replaced by a clean one. The dirty exchanger can subsequently be cleaned outside the shutdown period.

19. STRATEGY: GATEKEEPING, OBJECTIVE (MEASURABLE) ASSESSMENT/CRITERIA, WHAT IS/ WHAT IS NOT INCLUDED IN THE SHUTDOWN (WEIGHT FACTORS/GATEKEEPING RULES)
Many applications for work to be included are made during preparation for a shutdown. The absence of good process and regulation within the company may lead to duplication of the work requested (for example: replacing the seal of a pump and, at the same time, replacing the pump).
20. STRATEGY: CONTINUITY OF PARTICIPATING SHUTDOWN PERSONNEL
The ongoing deployment of new staff who do not know each other and have no knowledge or experience of the installation will lead to delays and errors. A core, coordinating team with installation shutdown experience deserves recommendation.
21. STRATEGY: THOROUGH EVALUATION
Evaluating a shutdown with the personnel involved and capturing the experience and knowledge gained in scenarios boosts efficiency and effectiveness in subsequent shutdowns.
22. STRATEGY: SHUTDOWN TRAINING
A shutdown involves activities and situations that differ from regular maintenance and thorough preparation and training of the personnel concerned is therefore advisable.
23. STRATEGY: BALANCING OWN PERSONNEL AND CONTRACTORS
Successful execution of a shutdown is determined for a large part by the experience, knowledge and skills of the staff involved. Shutdowns are often staffed partly by employees and partly by temporary workers. Experience in the execution of previous shutdowns is a major advantage. There is no norm for the number of maintenance people present during a shutdown (contrary to what management sometimes assumes). The correct ratio of employees to temporary staff is very important. The ability of employees to execute the tasks with the right quality of completed work is very important.
24. STRATEGY: SCREEN AND ASSESS TEMPORARY WORKERS ON THEIR EXPERIENCE, SKILLS AND TEAM WORKING ABILITIES
Hiring the right maintenance personnel for a shutdown is a prerequisite for success. Factors which must be taken into account when evaluating third parties for participation in a shutdown:
- *Demonstrable records of experience*
 - *Skills*
 - *Already existing collaboration with and between external parties*
 - *Communication in professional (company's) jargon as well common native and modern languages*
 - *Knowledge of projects and materials*
 - *Use of current, proved techniques*
 - *Agreements/commitments: not everything detail to be done has to be in writing. The external party must take responsibility and not only work on a prescriptive basis*

25. STRATEGY: FOCUS ON CRITERIA FOR OUTSOURCING

In order to get a realistic budget for a shutdown, subcontracting criteria must not focus exclusively on cost minimisation. Evaluation and comparison of the proposals of third parties must also include factors like quality, experience, materials knowledge and the treatment of cost overruns.

26. STRATEGY: EARLY BOOKING OF MAINTENANCE AND SHUTDOWN SPECIALISTS

If the supply of maintenance specialists is (periodically) limited it may be strategically advisable to employ them or to confirm availability of the appropriate specialists for the shutdown period well in advance (figure 5.6). This significantly reduces the risk of disappointments in a properly run shutdown. A shutdown is not a daily activity for companies and many (external) people are involved. In addition to the organisation of the shutdown, the quality of the people determines a good result.



FIGURE 5.6 – *Timely contracting of maintenance specialists avoids unnecessary delays and quality issues*

27. STRATEGY: INTRODUCE SHUTDOWN MODULES AND SCENARIOS

Create well-documented, ergonomically viable scenarios at various levels (total installation, sections of installation, modules, components, etc.). This facilitates shutdown scheduling and execution quality.

5.5 Efficiency and effectiveness of the installation

The purchase of an installation is often a major investment and payback period involves in a large number of years. To avoid purchasing an installation that rapidly becomes outdated and no longer competitive, the purchase decision-making process must take technology and the experience and knowledge of its own staff into account.

28. STRATEGY: ONGOING MONITORING OF NEWLY AVAILABLE, PROVEN TECHNOLOGIES

Many components will satisfy requirements in terms of functionality, but

may suffer from a significant increase in periodic costs as a result of high wear rates and reduced output. On the other hand, new technologies continue to emerge, which can make replacement economically justifiable.

29. STRATEGY: SECURING KNOWLEDGE OF THE INSTALLATIONS

Collection and securing data on the installation is often a condition for generating more insight and, therefore, an improved level of knowledge and experience (figure 5.7). More knowledge and skills lead directly to more efficient and more economical use and maintenance of the installation. The same applies to the application of a best practice approach (visiting and exchanging knowledge with other users of the same installations) and to competitive research.

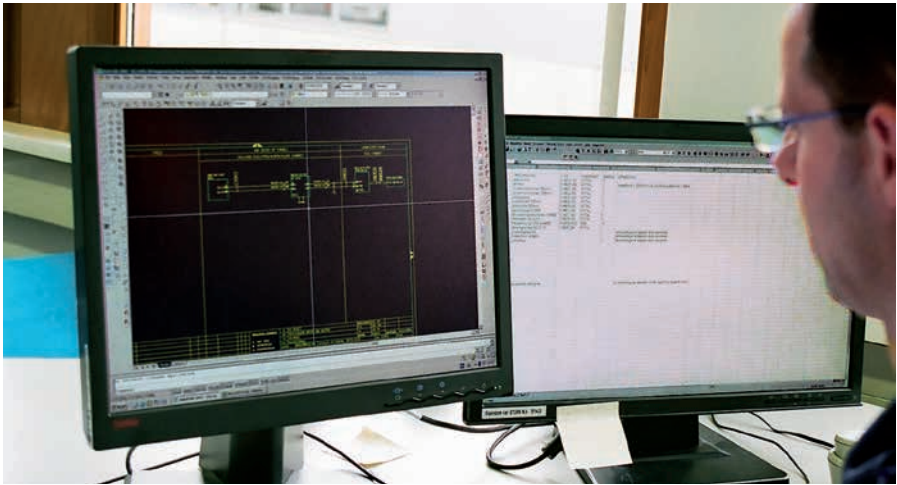


FIGURE 5.7 – *Securing and accessibility of knowledge, scripts and procedures improve the quality of the shutdown*

30. STRATEGY: FORM LONG-TERM R&D COOPERATION AGREEMENTS WITH SUPPLIERS

Long-term cooperation with suppliers in order to reduce maintenance requirements and increase maintainability in installations.

5.6 External factors

In addition to internal aspects (installation, staffing, personnel, etc.) shutdowns are also affected by external influences. Examples are: laws and regulations, the surroundings of the installation, material and equipment supply and delivery aspects, facilities for large numbers of personnel.

31. STRATEGY: ACTIVE MONITORING OF AND PARTICIPATION IN COMMITTEES CONCERNING LAWS AND REGULATIONS

Laws and regulations applying to businesses in a particular industry are, for a considerable part, influenced and determined by international or European committees made up by representatives of governments,

independent experts and industry. These often concern health, safety and environmental issues relative to industrial premises. These committees advise governments on the interpretation, introduction and feasibility of new regulations. Companies represented in these committees are often well-prepared to future regulations and can also exert influence on their content.

32. STRATEGY: FOCUS ON BUILDING A POSITIVE IMAGE TO THE ENVIRONMENT

In addition to its effect on the company itself, the execution of a shutdown can be the cause of much inconvenience to those living in the immediate surroundings of the plant. Examples are the influx of temporary labour in the local town, parking problems of cars, heavy transport traffic, excessive noise, nocturnal activities at the shutdown site, etc. Some factors that lead to greater acceptance and tolerance among residents in the immediate vicinity of the business are, for example:

- *Good communication*
- *Subcontracting of work in the surrounding area*
- *Employees recruited from the surrounding area*
- *Sponsoring local clubs and societies*

Chapter 6

SHUTDOWN MANAGEMENT AND STRATEGY

- The Impact matrix
- Company issues and strategies
- Company situations and strategies

6 SHUTDOWN MANAGEMENT AND STRATEGY

Shutdowns are not business isolated events. They are part of the business environment and of business operations. In general shutdowns take up 2 to 4 per cent of the available gross production time. In addition, 30 to 50 per cent of the available yearly maintenance budget is often spent on shutdowns. Approximately 90 per cent of all large modification projects require a form of shutdown. The global objectives for shutdowns are therefore:

- Shortening of total shutdown duration over a long-term period in which multiple shutdowns will take place. The expectation is that a halving of the total shutdown duration time and substantial lowering of production losses are possible.
- Direct savings on shutdown cost. A saving of more than 25 per cent seems realistic.
- A considerable increase in the quality of shutdowns. Improving shutdown management will result in an increase in the quality of the four quality-related aspects of shutdowns (safety, health and environment, quality of execution, planning and budget).

Choosing and implementing the correct shutdown strategies is important for the achievement of these objectives. The specific situation in which a company finds itself is determined by a large number of factors. The factors that, to a greater or lesser extent, determine shutdowns are listed in chapter 4. In the following paragraphs we look at the influencing factors that are affected by the strategies described in chapter 5. This supports the decision process for selecting the shutdown strategies to be used in achieving the objectives.

6.1 The Impact matrix

The impact matrix is shown in figure 6.1. The possible influencing factors for shutdowns are on the vertical axis, the strategies for shutdowns on the horizontal. A dot in the matrix indicates that the relevant strategy affects the influencing factor. The degree of this impact has not been indicated. This will be strongly dependent on the relevant situation and is often difficult to quantify. The indicated relationships were based on interviews with shutdown specialists and managers and literature. Other interpretations and classifications are possible. In fact, the best result is obtained when the impact matrix is formulated for a specific situation.

The appropriate strategy will thus vary by type of industry. One of the most characteristic differences between industrial processes is whether they use fully continuous or discrete processes. In the matrix this difference has been taken into account distinguishing between strategies for continuous processes (open dot) and those for fully continuous and discrete processes (filled dot).

An example is component production with its mainly discrete processes and absence of large-scale shutdowns. Strategy number '24. Screen temporary workers' is, for example, less relevant here.

In the matrix the same group classification has been used for influencing factors of shutdowns (chapter 4) and strategies of shutdowns (chapter 5).

The influencing factors have been classified into the following categories:

- The company, installation, production activity
- Chain, industrial environment, partners
- Market and customer
- People, society and environment

The strategy categories are:

- Interval
- Duration
- Costs
- Complexity/Risk
- Efficiency and effectiveness of the installation
- External elements

Cluster cells (sub-fields) emerge in the matrix. For example 'duration strategies' have no influence on the chain influencing factors: there are no dots at the intersection. This is, of course, not surprising. Usually, measures that influence the duration of a shutdown have little influence on specific characteristics of the chain. Monitoring of maintenance parameters has no influence on the shutdown of a chain partner.

There are relatively many dots in the cluster cell formed at the intersection of 'Company, installation, production activity' with efficiency strategies. Efficiency measures can of course have a large influence on the functioning of an installation.

If we look at the cluster row formed by the chain influencing factors we see that this is relatively empty. Apparently there are few strategies that have influence on the chain aspects. These strategies could well be very important if chain aspects were to play a large role.

The column cluster of the external factor strategies is also relatively empty. It could be concluded that these strategies are of less importance. Caution is advised here. As mentioned earlier, a dot in the matrix only indicates a connection, but not the weight of this relation. Focusing on a good image, for example, only influences intangible assets. However, as commonly known, this influence is very strong, if not decisive.

		Interval					Duration					Costs			
	Strategies	Interval					Duration					Costs			
	Influencing factors	Interval					Duration					Costs			
		1. Maintenance interval on the basis of historical data	2. Tuning of intervals	3. Lifetime extension of 'weakest' components	4. Agreements with third parties	5. Action plan for unscheduled shutdowns	6. Monitoring maintenance parameters	7. DFM and CBM	8. Draw up maintenance scenarios	9. Only shutdown-dependent work	10. De-bottlenecking	11. Risk assessment	12. Cooperative inventories	13. Shutdown strategy in line with local regulations	14. Realistic cost calculations
Business, installation, production activity	1. Technical innovations 2. Financial situation 3. Personnel 4. Communication 5. Maint. Man. influence 6. Company strategy 7. Installations/equipment	•	•	•			•	•		•	•	•	•	•	•
The business chain	8. Partners in supply chain 9. Common facilities 10. Changes in raw materials 11. Shutdowns neighbourhood	•		•		•	•	•				•		•	•
Market	12. Market developments 13. Seasonal influences				•				•	•				•	•
People, society and environment	14. Law and regulation 15. Trade barriers 16. Intangible assets 17. Climate influences 18. Geographic location 19. Unpredictable	•			•	•	•	•	•			•	•	•	•
Impact		7	4	5	3	6	5	6	6	4	6	8	6	6	18

○ Continuous processes
 • Fully continuous and discrete processes

FIGURE 6.1 – *Impact matrix: overview of relationship between shutdown influencing factors and strategies*

The row and column sums of the dots are also shown, i.e. the number of influencing factors that are affected by a strategy and the number of strategies that affect an influence factor.

An effective strategy impacts a large number of influencing factors. It may be useful to follow such a strategy. The strategy '14. Realistic cost calculation' influences 18 aspects. A good understanding of the costs of the various options is always important for decision support. A strategy that also affects a large number of aspects is '26. Early booking of maintenance specialisations'. Specialists can be scarce for many reasons: they may not be available in the area surrounding the installation, the company's own specialists may be overloaded, similar shutdowns in the surrounding area may have already hired the relevant

Complexity / risk											Efficiency	External factors						
15. Apply statistics	16. Design for maintenance	17. Asset life cycle costs	18. Modular thinking	19. Gate keeping for scoping	20. Continuity of shutdown personnel	21. Thorough evaluation	22. Shutdown training	23. Balancing own personnel and contractors	24. Screen temporary personnel	25. Focus on subcontracting criteria	26. Early booking of maintenance specialists	27. Create scenarios	28. Scanning new technologies	29. Securing knowledge of installations	30. Long-term R&D cooperation agreements	31. Participation in legal and regulatory commission	32. Positive image to environment	Impact
•	•			•				•				•	•	•				14
•				•	•			•						•	•			15
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		16
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		9
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		14
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		17
											•		•	•	•			25
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•	•	•	•	•			•	•	•	•	•		•	•	•	•	•	23
•	•	•	•				•		•	•			•	•	•	•	•	4
•		•						•	•	•	•		•	•	•	•	•	18
			•	•				•	•	•	•	•						7
				•				•	•	•	•	•						15
							•	•				•				•		6
8	7	8	7	9	3	4	6	9	8	7	10	9	7	8	8	6	1	

CONTINUED FIGURE 6.1

specialists. Early scheduling and hiring of maintenance specialists is then also important.

Strategies which only impact a small number of influencing factors are possibly of less importance, provided that such influencing factors are significantly affected by other strategies.

On the other hand, there are influencing factors that can only be affected by a single strategy. When these influencing factors play a large role there is little choice in the strategy to be followed. Thus strategy '4. Agreements with third parties' only has influence on three aspects. And these aspects, such as influencing factor '9. Common Facilities', can be influenced by only a few

strategies. Strategy '4. Agreements with third parties' could well be of great importance, despite the fact that this strategy only affects a small number of factors.

6.2 Company issues and strategies

Certain situations are requiring solutions, for example:

- *Problems arise, such as insufficient staff or problems within the chain. What is to be done?*
 - *Typically one can only focus on a limited number of strategies. The question is which strategies?*
 - *Unfortunately, with disappointing business profits, a company has less to spend. Which strategies do we drop?*
 - *We have a choice between two strategies. How do we decide on which one to use?*
- PROBLEMS. WHAT IS TO BE DONE?
- A shutdown often creates extra demands on staff in terms of flexibility, effort and time. The increased workload of a shutdown can also lead to high degree of staff fatigue and resulting errors, delays and accidents. What can be done in this situation?

According to the impact matrix this situation primarily concerns influencing factor '3. Personnel'. By looking up the strategies in the matrix that impact '3. Personnel' we get an overview of the possible approaches. Some possibilities are:

- *Strategy 1: Increase the maintenance interval on the basis of historical data.*
Increasing the maintenance interval will reduce the frequency of necessary shutdowns. Additional demands on staff will occur less often.
 - *Strategy 9: During a shutdown, perform only those activities that require a complete shutdown.*
Staff workload is more evenly spread over time. Workload peaks will be less intense or of shorter duration.
 - *Strategy 24: Screen temporary personnel.*
Effective screening will provide a better guarantee of quality as regards the temporary workforce. This means less work for incumbent staff as regards management and monitoring. In addition, there will be less repair work.
- ON WHICH STRATEGIES DO WE FOCUS?
- This same question can also be put on a more general basis. It is important to get a good picture of the influencing factors that are important for the installation. With this as starting point the matrix can be inspected for strategies which frequently or heavily influence the most important factors.

If chain influences are of great importance then relatively few relevant strategies are available:

1. *Increase the maintenance interval on the basis of historical data*
4. *Agreements with third parties*
5. *Action plan for unscheduled shutdowns*
12. *Cooperative inventories*
14. *Realistic cost estimation*
24. *Screen temporary personnel*
26. *Early booking of maintenance specialists*
27. *Create scenarios*
28. *Scanning for new technologies*
31. *Participation in legal and regulatory commissions*

A more detailed analysis can lead to more attention, for example, to cooperative inventories and the creation of scenarios. A large number of strategies are available that may have an effect on the group of influencing factors that relate to the installation. The group of 'complexity/risk' strategies seem particularly important.

– WHICH STRATEGIES DO WE DROP?

In a situation in which we want to reduce the strategy activities we can use the matrix to inventory the value of the strategies. For each strategy we can identify what is influenced. For example '5. Planning for involuntary shutdown' has effects that differ from '11. Risk assessment'. These insights are useful for making decisions about choices in the strategy activities.

– CHOOSING BETWEEN TWO STRATEGIES.

A choice between two strategies can also be facilitated in this way. A thought-out choice can be made by using the impact matrix to determine the effects of a strategy.

6.3 Company situations and strategies

In this section three examples of common types of shutdowns are provided. For each type of shutdown a description of the situation is given, characteristics are identified and relationship with the impact matrix is established.

I. FREQUENT, SMALL SHUTDOWNS

Small shutdowns lasting a few days usually take place in parallel with the daily production processes. Production lines are stopped one by one for periodic, maintenance. Such maintenance is mostly carried out by own employees, with the help of a few temporary personnel. Repeatability of work in frequent, small shutdowns is high, resulting in a fast learning curve for personnel. Large shutdowns have an interval of four to five years while small, frequent shutdowns occur often every few months. Staff turnover and consequent loss of shutdown knowledge is therefore a lesser problem.

Situation description:

- *Plant with a number of production lines.*
- *Every production line has a 'small' shutdown every 3 months.*
- *The entire plant has 10 to 15 of these line shutdowns per year.*
- *The production lines are not necessarily identical, which also applies to the shutdowns.*
- *Shutdown duration is approximately 3 days.*
- *Regular, periodic maintenance is carried out during the shutdown (preventive maintenance, minor corrective maintenance, cleaning, minor modifications, etc.).*
- *Execution of most of the maintenance activities takes place during the working day while some (critical path) activities require a 24 hour shift.*
- *Preparation takes a few months.*
- *Shutdown is performed by a team of about 40 people.*
- *Small (part time) shutdown team available, consisting of a project manager and some planners.*
- *Direct shutdown costs amount to approx. 150,000 euros.*
- *Production losses are about 100,000 euros.*

Characteristics:

- *Small shutdowns are scheduled within the factory's annual plan.*
- *In practice, however, schedules are often interrupted - often shortly before the execution phase of the shutdown.*
- *Small shutdowns mainly affect the internal supply chain, while buffers prevent the external supply chain being affected.*
- *The work scope contains a high number of repeatable shutdown items (preventive, cleaning, etc.).*
- *Repeatable activities are easy to record and secure and are quickly learnt by staff.*
- *Often small jobs are added to the schedule at the last moments, for instance forgotten corrective maintenance work.*
- *Organised within the company's own maintenance department, with some employees doing the work 'next' to their regular tasks.*
- *Often multiple shutdowns running in parallel and in various stages of preparation and execution (multi-shutdown management), which makes things difficult for the employees involved.*
- *Repeatability of shutdowns makes it possible to use scenarios and information systems.*
- *Temporary personnel are often needed (insufficient personnel). The contractor experiences acute peaks in the demands made on their employees, which necessitates timely and reliable arrangements prior to the shutdown period.*
- *High demands made on production employees during decommissioning and safe handover and recommissioning following completion of the work. This results in a peak load on the production department, which cannot always be absorbed and introduces an overload risk.*
- *Insufficient attention is often paid to direct shutdown costs and losses. There is too much focus on execution of the work. The large number of shutdowns can however involve high integral costs for the plant.*

Impact matrix

- Influences relevant to frequent, small shutdowns are mainly in the category 'business, installation and production activity.' The most important influencing factors are: '3 personnel', '5 position and influence of maintenance management' and '7 installation' (figure 6.2). Shutdowns of partners in the chain are also important, but to a lesser degree (because of buffers).
- It is important to adhere strictly to agreed annual plans, resulting in a high level of plan reliability.
- High repeatability favours exploitation of shutdown activities (maintenance tasks, schedules, etc.) and shutdown processes (work preparation approach, scenarios, etc.).
- Lessons learned are recorded well and the learning curve is steep due to the high number of shutdowns, resulting in quick and effective application of acquired knowledge.
- Involvement of temporary personnel and contractors in the planning and repeatability aspects, resulting in a pool of regular temporary personnel and contractors.
- Attention to the cost factor: many small shutdowns add up to a major cost item.

2. LARGE PROJECT SHUTDOWN

A large project within an organisation may result in an installation being stopped for a long period of time. Such interruptions can be caused by installing a new production line or the replacement, modification or periodic

	Interval	Duration	Complexity / risk	
Strategies	1. Maintenance interval on the basis of historical data 3. Lifetime extension of 'weakest' components 4. Agreements with third parties 6. Monitoring maintenance parameters 7. DFM and CBM 8. Draw up maintenance scenarios 14. Realistic cost calculations		15. Apply statistics 18. Modular thinking 20. Continuity of shutdown personnel 21. Thorough evaluation 22. Shutdown training 24. Screen temporary personnel 27. Create scenarios 29. Securing knowledge of installations	
Influencing factors				
3. Personnel	•	•	•	•
5. Maint. Man. Influence	•	•	•	•
7. Installations/equipment	•	•	•	•
8. Partners in supply chain	•	•	•	•

- Continuous processes
- Fully continuous and discrete processes

FIGURE 6.2 – Impact matrix: low frequency shutdown

maintenance of large, process-critical machines. A plant stop lasting weeks interrupts the chain. This makes it necessary to coordinate the shutdown with chain partners and make various purchase and delivery agreements. Large projects demand lengthy preparation and the involvement of a large shutdown and execution team. Prior to execution a large number of temporary personnel must be employed.

Situation description:

- *Shutdown affects the entire plant.*
- *Major project execution is ideally coordinated with the applicable plant shutdown frequency, (for example 4 years).*
- *Plant is turned off for approx. 4 weeks.*
- *Execution of a very large new construction/modification project often determines the duration, criticality and cost of the shutdown.*
- *Execution of regular activities within the shutdown, such as inspections, cleaning, preventive maintenance and small-scale corrective maintenance, are seldom duration determining factors.*
- *Preparation time is 1.5 to 2 years.*
- *Executing the work using multiple shifts.*
- *Shutdown is carried out by a large number of employees (e.g. 500).*
- *Dedicated shutdown team of approx. 20 persons.*
- *Direct shutdown costs amount to approx. 12,000,000 euros.*
- *Production losses are about 15,000,000 euros.*

Characteristics:

- *Project shutdown scheduling falls within the multi-year company plan.*
- *Preparation period starts approximately 1 to 2 years before execution; attracts limited attention within the company (planning window is too long).*
- *Effect on both internal and external supply chain is substantial, as is the degree of coordination required with chain partners.*
- *This concerns large projects with unique activities, as a result of which the shutdown risk is high. Projects will determine the quality (or loss), cost (or incremental cost) and scheduling (or timing overrun) of the shutdown.*
- *Knowledge of the current company configuration is essential for project engineering.*
- *A project shutdown presents opportunities to adapt installations in such a way that future shutdowns are simplified. These opportunities are not sufficiently exploited in practice. Opportunities include modular replacement parts, increased accessibility for transport and use of stainless steel instead of materials needing periodic painting, etc.*
- *In addition to shutdown items, project-specific items are introduced (cleaning, inspections, preventive maintenance, etc.).*
- *Organisation of projects is carried out by a large, dedicated shutdown team. The shutdown team focuses only on the preparation and execution of the coming shutdown.*
- *Larger organisations generally have detailed scenarios and utilize*

information systems. Knowledge transfer to the project team on the use of these systems does not always take place.

- Need for detailed preparations and work schedules is high as a result of the many tasks to be carried out and the number of parties involved.
- Temporary personnel are necessary (insufficient personnel and need for specialists). Agreements with contractors must be made well in advance.
- High demands are made on production employees during decommissioning the shutdown, safe handover and recommissioning following completion of the work. This results in a peak in the workload of the production department, which cannot always be absorbed and introduces a timing overrun risk.
- The large number of projects results in a (partially) new installation with new and modified instructions for operation and maintenance. Management must ensure that these changes are implemented, including adapting information systems and training all personnel involved. For this reason transfer of the information and knowledge acquired in projects is essential.

Impact matrix

- Many influencing factors, occurring within all clusters, are important in the case of a project shutdown.
- 'The business, installation, production activity' (figure 6.3) - for example '1 technical innovations' and '14 laws and regulations' - are particularly important.
- Risk assessment (strategy 11) is important as a result of the uniqueness of this type of shutdown and the associated, high risks for HSE, quality, scheduling and costs. Do only those things that are strictly necessary. An objective (re)view is essential for this.
- Creation of scenarios (strategy 27) for the many topics/processes (work preparation approach, scheduling, costing method, etc.).
- Agreements and coordination of the shutdown with internal and external parties (strategy 4). Early involvement and engagement of temporary resource for work preparation (strategy 26).
- The aim is minimisation of integral shutdown cost (strategy 17). This implies minimisation of the sum of direct shutdown costs and losses rather than their individual minimisation. For example, the organisation spends an additional 100,000 euros on direct shutdown costs by adopting a different approach, but shortens shutdown duration by 2 days (avoiding loss of 400,000 euros per day) in return.

3. A CALAMITY SHUTDOWN

Calamities within the organisation that require shutdown are mostly major fires or explosions. Such calamities disable a large part of the machine park. As a result, the installation, and often the entire plant, has to shut down. A calamity takes place suddenly and cannot be predicted. However, scenarios can be prepared for such an event. Large-scale clearing-up and enquiry activities are the direct result of a disaster, followed by rebuilding or renewal of the affected part of the installation. These are mostly long-term projects

Strategies Influence factors																				
	3. Lifetime extension of 'weakest' components 9. Only shutdown-dependent work 10. De-bottlenecking 11. Risk assessment 12. Cooperative inventories 14. Realistic cost calculations 17. Asset life cycle costs 18. Modular thinking 19. Gate keeping for scoping 23. Balancing own personnel and contractors 25. Focus on subcontracting criteria 26. Early booking of maintenance specialists 27. Create scenarios 29. Securing knowledge of installations																			
1. Technical innovations	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
2. Financial situation	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
3. Personnel	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
4. Communication	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
5. Maint. Man. influence	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
6. Company strategy	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
7. Installations/equipment	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
8. Partners in supply chain	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
9. Common facilities	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
11. Shutdowns neighbourhood	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
13. Seasonal influences	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
14. Law and regulation	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o

- o Continuous processes
- Fully continuous and discrete processes

FIGURE 6.3 – Impact matrix for shutdown projects

which, in addition to the team in charge of the repair work, also heavily involve official law and regulation parties, insurers and government.

Situation description:

- The situation involves a plant with a number of fully continuous production lines.
- A large-scale disaster takes place at a primary production line.
- The event is not predictable and is totally unexpected.
- Production may be stopped for a period ranging from a couple of weeks to many months.
- The primary execution task is repair or perhaps new construction of the damaged installation. This determines the nature of the shutdown, in terms of duration, criticality and costs.
- It also presents an opportunity to carry out regular maintenance activities. The latter seldom determine the shutdown.
- Execution activities exploit all possibilities, certainly on the critical path.
- Shutdown as a result of the disaster is performed by a team numbering about 200.
- Dedicated project team.
- Direct recovery costs from a disaster requiring shutdown are in the

order of 5,000,000 euros.

- *Losses can run up to 20,000,000 euros and are generally a multiple of the direct recovery costs due to the lengthy stop that is required.*

Characteristics:

- *A disaster shutdown is always totally unexpected.*
- *Direct damage to installation with possible incidents/accidents in the area health, safety and environment.*
- *Major effects on the external supply chain; the supply of products to customers' stops for a period of months; the influence on company profits can be critical.*
- *The same applies to any internal supply chain; other production lines may be required to stop.*
- *Scope is totally unpredictable; the analysis of damage is decisive.*
- *Enquiry into the cause of the disaster is prescribed. This involves deployment of external specialists, which requires organisation. An emergency shutdown requires a lot of effort, on an ad hoc basis, from external parties, inspection services, insurers, etc.*
- *The recovery plan is mostly twofold, on the one hand focusing on the repair of damage to restore the installation to its original condition, while on the other hand focusing on adapting the plant to avoid a repeat of the disaster.*
- *Often the business model is reviewed in relation to direct damage repair costs and the losses incurred.*
- *Organisation of shutdown by a rapidly-assembled, dedicated project team of specialists in damage research, re-engineering and repair. This has a large impact on the organisation as a result of the removal of these project specialists from the regular organisation, as a result of which their normal work is neglected.*
- *Approach in terms of situational project plans, (relevant scenarios are often insufficiently available).*
- *The use of external specialists and contractors is almost always a necessity; requirement is sudden/short term; resource mobilisation will take time.*
- *Configuration/documentation management related to the existing installation is often not optimal. High demand on many employees to obtain information on the installations, processes, operational management, etc.*
- *Re-engineering of the installation and extra safety features mean that business operations have to deal with a (partly) new installation, with new and changed instructions for production operations and maintenance. Management must ensure that these changes are implemented, including adapting information systems and training of all relevant personnel. For this reason transfer of the information and knowledge acquired in projects is essential.*
- *Ongoing, high involvement and input of external parties, government, inspection services and insurers in relation to a wide range of subjects. The permission of some external parties, for example inspection services,*

is needed before subsequent work may be carried out and before the installation is recommissioned. A major focus on prevention of serious reputation damage.

Impact matrix:

- *The health of the company (factors 2, 3, 6 and 7), the environment (factors 14, 16, and 19) and the chain partners (factors 8 and 11) are important in this case (figure 6.4).*
- *Risk assessment unforeseeable events (strategy 11). This includes 'what-if' questions in the areas of HSE, corporate reputation (strategy 32) and the (internal and external) supply chain.*
- *Guidelines and scenarios (strategies 5 and 27) for the treatment of disasters are derived from the risk assessments.*
- *Installation knowledge assurance (strategy 29) is of essential importance.*
- *Calamity management can be based on the impact matrix of a project shutdown (see business situation 2: large projects shutdown).*

Strategies		Influence factors										
		5. Action plan for unscheduled shutdowns	11. Risk assessment	13. Shutdown strategy in line with local regulations	14. Realistic cost calculations	15. Apply statistics	17. Asset life cycle costs	19. Gate keeping for scoping	25. Focus on subcontracting criteria	27. Create scenarios	29. Securing knowledge of installations	32. Positive image to environment
1. Technical innovations			•		•	•	•	○			•	
2. Financial situation			•		•	•		○			•	
3. Personnel			•		•			○	○	○	•	•
4. Communication					•				○	○		
5. Maint. Man. influence					•	•	•	○	○	•	•	
6. Company strategy			•	•	•	•	•	○			•	
7. Installations/equipment	•	•	•		•	•	•	○		•	•	
8. Partners in supply chain					•							
9. Common facilities					•					•		
10. Changes in raw materials	•				•							
11. Shutdowns neighbourhood					•					•		
12. Market developments	•		•	•		•	○				•	
13. Seasonal influences				•								
14. Law and regulation	•	•	•	•		•	•	○	○		•	
15. Trade barriers				•								
16. Intangible assets	•	•	•	•		•	•		○		•	•
17. Climate influences				•						•		
18. Geographic location		•	•	•	•	•		○	○	•		
19. Unpredictable	•		•			•				•		

- Continuous processes
- Fully continuous and discrete processes

FIGURE 6.4 – *Impact matrix: disaster shutdown*

TO BE CONTINUED

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Shutdown scope management is an important area when it comes to minimising the total life span costs of industrial installations. The scope of a shutdown includes all work to be carried out during the shutdown.

Scope management focuses on the strategic aspects that span multiple shutdowns, rather than on the preparation, implementation and evaluation of a single shutdown.

This book provides an overview of shutdown process steps, influencing factors - such as company policy, technological innovation, societal trends and market developments - and the strategies with which shutdowns can potentially achieve cost optimisation in the longer term.

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