

UNIVERSITY OF KWAZULU-NATAL

**The challenges of shutdown management in the petrochemical  
refineries: a case study of PetroSA GTL Refinery**

By

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## DECLARATION

This declaration hereby confirms that this research has not been previously accepted for any degree and is not being currently considered for any other degree at any other university.

I declare that this Dissertation contains my own work except where specifically acknowledged

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Signed.....

Date.....27<sup>TH</sup> JULY 2007

## **DEDICATION**

### ***To my wife and two daughters***

This Dissertation is dedicated with love and gratitude to my wife, Priscilla, for all her care, patience and encouragement through my studies for this degree – I thank you and I love you very much. To my daughters, Kay and Mwansa, for all the joy and laughter that you’ve brought into our lives – You are our special girls.

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Last, but not least, a big thank you to my supervisor, Dr A. S. Gani, for the support, guidance and encouragement through the course of this research.

## **ABSTRACT**

The aim of this research study was to identify and highlight the challenges experienced during the different phases of the shutdown or turnaround management processes in the petrochemical refineries. The data for the research, mainly through qualitative interview sessions and some quantitative comparison data, was obtained from PetroSA GTL Refinery as a case study.

The research was subdivided into three areas: the planning, budgeting and shut execution processes. The qualitative interview sessions were conducted with managers and engineers who are directly involved with the shutdown management processes at PetroSA. The research identified the critical departments involved in the process, i.e. the shutdown team, operations, mechanical maintenance, inspection, projects, services etc., and selected respondents from these departments. Two senior managers from one of the large shutdown and turnaround contractors in South Africa were also included in the sample.

The findings from the research highlighted interesting responses from the interview respondents. The challenges experienced in the various phases were discussed, with emphasis being placed on the planning, budgeting and shut execution phases of the process. The findings indicated that in order to be competitive in the petrochemical industry, a refinery must strive to achieve higher productivity from the field execution teams, as well as to incorporate proper cost control structures in the process. The research findings and recommendations are shown in chapters 4 and 5 of this report.

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<b>ACRONYMS</b>
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<b>Abbreviation</b>	<b>Meaning</b>
CFO	Clearance For Operation
COIDA	Compensation for Occupational Injuries & Diseases Act
EPC	Engineering Procurement Construction
EPCM	Engineering Procurement Construction Management
EXCO	Executive Committee
GTL	Gas To Liquid
KPI	Key Performance Indicator
PPE	Personal Protective Equipment
PRA	Piping Repair Approval
QA	Quality Assurance
QC	Quality Control
RBI	Risk Based Inspections
SD	Shutdown
SRA	Structural Repair Approval
VRA	Vessel Repair Approval

## **Chapter 1. INTRODUCTION**

### **1.0 Introduction**

At regular intervals, petrochemical refineries shut down part or all of their production units in order to carry out equipment inspections and to perform maintenance work. Most of this work cannot be done while the plant is still in operation. The need for shutting down the refineries is necessitated by various factors; the major ones include the compliance to legal requirements, as well as the necessity to maintain the equipment integrity. The insurance companies also insist that the refineries comply with statutory requirements in case of a claim. Bloch & Geitner (2006) say that being aware of one's equipment availability needs is also important for intelligent planning of downtime events for inspection and repair.

During these outages, a lot of maintenance and project works are carried out in order to maintain the reliability of various pieces of equipment. The management of shutdowns in the petrochemical refineries is such a complex process involving a lot of activities across various functional disciplines. The challenges faced in all the refineries are delivering the shutdowns on time as well as within the budget, with minimum safety and environmental implications. The implications of a prolonged and expensive shutdown are felt directly through financial losses incurred by the refinery, as well as the failure to meet the supply commitments to external customers.

In South Africa, the scheduling of refinery shutdowns is supposed to be coordinated at national level to ensure that two or more refineries are not shut down during the same period because this would affect the supply of petroleum products in the country. The shortage of critical skills in the South African market affects the quality of work performed during these outage periods, leading to a lot of re-works and hence increasing the costs.

Depending on the size of the shutdown and the lead time of the critical spares, the planning and preparation could start as early as two years in advance. According to Lenahan (1999), there are four phases to turnaround management: initiation, preparation, execution and termination phases.

- **Initiation:** The need for having the shutdown is established and the initial worklist is presented for review. The initial budget estimate is also presented at this stage.
- **Preparation:** The shutdown work scope, generated from the approved work list, is used to make the shutdown plan. The procurement of spares and the implementation of systems are done during this phase. The activities done during this phase determine the success of the whole shutdown process.
- **Execution:** “Normally 2 to 8 week period when planned work is carried out and monitored against the event schedule, duration, cost, quality and safety requirements”, Lenahan (1999).
- **Termination:** The post shutdown activities include close-out reports and performance reviews.

## 1.1 Background

Historically, shutdowns and turnarounds have been driven by schedule performance rather than costs. The old cliché that “if we do a good job in execution, the cost will take care of itself” still influences shutdown and turnaround management thinking. (Singh 2000)

The challenges faced by shutdown management in the petrochemical industry are enormous, and as indicated above, most shutdown management teams focus more on achieving the schedule deadlines and neglect the costs and hence are quite inefficient. In order to be cost effective and efficient, the refineries must streamline their shutdown or turnaround management processes by formulating policies and procedures that are aimed at achieving set milestones for each phase, and fully mitigating for all the challenges that can be experienced in the various phases.

In order to be competitive in the commodities market, the shutdown or turnaround management teams must be competent, and must fully understand the challenges or pitfalls that could be encountered during the different phases of the process. The ability to fully understand the shutdown challenges, as well as having the capability of formulating sound policies and procedures, would give a refinery a competitive edge in the market.

## **1.2 Motivation for the study**

One of the major problems experienced during the October/November 2006 shutdown was that of contract labour management. The other areas of concern included planning, recruitment, site supervision, quality of the direct field labour and the wage bureau arrangements. (PetroSA 2006 shutdown Lessons Learned Report)

The findings of the research will add value to the body of knowledge on the shutdown management processes in the petrochemical refineries. The findings and recommendations of this research can be used to streamline the shutdown management processes in the various refineries in order to achieve higher efficiencies as well as to reduce costs. Most refineries deliver way beyond the budget as well as past the planned completion date. The research will identify and highlight the critical challenges are faced in the various phases of the shutdown management process, especially focusing on the planning, budgeting and execution phases.

## **1.3 Problem Statement**

Most petrochemical refineries in South Africa over-run the budget and exceed the planned completion date of the shutdown. The number of safety, environmental and health incidents are also high during the planned shutdown outage periods. Therefore, Shutdown Management in the petrochemical refineries is faced with many challenges including poor planning and execution, over-expenditure, poor skills and high incident levels. These problems are similar across the various refineries and affect the quality of the workmanship, the duration and the costs of the shutdown. The number of safety

incidents experienced by a particular refinery determines how much money the refinery contributes to the fund governed by the Compensation for Occupational Injuries and Diseases Act (COIDA).

### **1.3.1 Planning Process Sub-problem**

In most instances, the actual shutdown execution deviates from the planned activities. The planning process is the most critical phase of the whole shutdown management process. The effectiveness of the planning process is directly seen in the failure or success of the shutdown execution phase. A lot of factors come into play during the plan preparation phase. The questions to be asked are whether all the activities were considered as well as how much detail was included in the plan.

According to O'Brien & Plotnick (1999), refineries also have the problem of fixed workforce and limited time to accomplish shutdown or turnaround assignments. The research will look at how refineries could achieve high productivity from workforce within the schedule deadlines.

Feedback control systems and key performance indicators will be studied as part of the planning process. In most instances, the fact that actual work progress falls behind on the plan is testimony to the absence or ineffectiveness of the feedback control systems. The study will identify systems that could be incorporated into the process to act as early warning signs so that remedial action is taken to avoid slippages on the plan.

### **1.3.2 Budgeting Process Sub-problem**

Most refineries over-run the budget at the end of the shutdown execution period. The study will identify all the key variables that should be included in order to achieve an accurate budget estimate for the shutdown. The study will also identify the stage at which a fairly accurate budget proposal could be presented to Senior Management for approval.

The handling of scope growth and emergent work during the shut execution will also be discussed.

### **1.3.3 Shutdown Execution Sub-problem**

The problems experienced during the execution phase include the coordination of work activities among various individuals, disciplines, departments and contractors. Most refineries use Key Performance Indicators to highlight the achievements during the execution phase, but in most instances the area of concern is with the effectiveness of the feedback control systems. The quality and skills of direct field labour is one of the major concerns experienced during the shutdown execution phase. The research will evaluate the weaknesses seen in the direct field labour and will propose measures to mitigate such weaknesses.

The research will also identify and evaluate the other areas of concern experienced during the actual shutdown execution phase and then propose improvements to overcome such challenges.

## **1.4 Research Objectives**

The objectives of this research are to identify the challenges experienced in the shutdown management processes at the PetroSA GTL Refinery. The objectives of the research are:

- To identify all the relevant functional disciplines and evaluate their contributions to the whole shutdown management process. This evaluation will be highlighting the level at which each functional disciplines play their roles.
- To identify and evaluate the activities achieved in each phase of the shutdown or turnaround management process. The research will investigate how the refinery compiles its plans, whether it uses historical data or standard refinery estimating norms or a combination of both.
- To identify the challenges experienced in coming up with an accurate budget estimate for the shutdown, as well as the causes of the budget over-runs.



- To identify the areas of weakness experienced during the actual shutdown execution phase, and to propose solutions to overcome such weaknesses. The research will compare various statistics (e.g. planned shutdown duration versus actual duration, as well as the relative sizes of the shutdowns) with the best industry or international best practices, including safety and health incidents.

### **1.5 Limitations of the Research**

The data collection for this research will mostly be restricted to PetroSA GTL refinery. The qualitative interviews will be conducted with key PetroSA management staff who are involved with the shutdown management process at the refinery. At least two interviews will also be conducted with senior managers of Kentz, one of the major shutdown and turnaround management contractors (Kentz) in South Africa.

In highlighting the challenges, the research will mainly focus on the planning, budgeting and shut execution phases of the shutdown management process. The other phases will just be discussed in general.

### **1.6 Summary**

The ability to understand the challenges that could be experienced during the various phases of the shutdown management process could help a refinery formulate sound and effective shutdown policies and procedures. In order to compete effectively in the commodities market, a refinery would require high productivity from the field execution teams and must have effective cost management structures in place.

## **Chapter 2. LITERATURE REVIEW**

### **2.0 Introduction**

This chapter gives a good background to the theoretical framework of shutdown and turnaround management processes in the petrochemical refineries. Mather (2002) says that shutdown or maintenance outage management can often be one of the key areas of control required by a computerised maintenance management system. The chapter discusses the different phases of shutdown management and explains the milestones to be achieved in each phase.

The chapter goes on to discuss the planning, budgeting and execution phases in detail. The deliverables and some pitfalls experienced in these phases are also discussed in detail.

### **2.1 Shutdown Phases**

The planning and execution of shutdowns and turnarounds in the petrochemical refineries go through various stages or phases. According to Singh (2000), the following are the six distinctive turnaround management process phases (based on specific objectives, work scope and deliverables):

- Business Planning
- Strategy and Alignment
- Planning
- Pre-Turnaround
- Execution
- Post-Turnaround and Evaluation

Brown (2004), *Managing Shutdowns, Turnarounds and Outages*, talks about minimizing downtime and costs, as well as creating new revenue opportunities with shutdown activities. He says that the sequence of performing the shutdown or turnaround process is:

identifying the needed work, defining the project's scope, planning and scheduling, executing the shutdown and finally writing the closeout reports.

The primary focus of the business planning phase is to align an organisation's business goals with the intended outcomes of the turnaround or shutdown execution. The timing and duration of the plant shutdown is determined at this stage taking into account the mechanical reliability of the equipment and the legal requirements imposed by the state, as well as the commitments that the organization has made with its customers during that period. At the corporate level, any opportunities to create revenue and save costs during the shutdown period should be explored. Kelly (2006) says that devising optimal strategy for maintaining industrial plant can be difficult task of daunting complexity.

*"As we look at shutdowns and turnarounds from a broader perspective, we soon realize that shutdowns and turnarounds are not merely maintenance or plant events, but are a significant component of the company's business planning process"* (Singh 2000).

After the business planning phase, the objectives and strategy of performing the forthcoming shutdown or turnaround are worked out and then clearly documented and communicated to all parties involved. This phase would involve the setting out of the shutdown success criteria and the procedures to be followed in each phase in order to accomplish the set goals. According to Harris *et al* (2006), there are two main levels of planning associated with construction projects: strategic and operational planning. Strategic planning deals with the high level selection of the project objectives, as outlined in the business planning phase. Operational planning involves establishing a method statement for each activity to be executed, as outlined in the detailed planning phase.

The planning phase is one of the most critical stages of the whole shutdown or turnaround management process. The success of the execution phase almost entirely depends on the success of the planning phase. During this phase, the pre-shutdown preparation and the execution plans are generated from the shutdown work lists submitted by various departments. According to Lenahan (1999), the preparation phase takes 3 to

18 months (depending on the size and complexity of the event) during a large quantity of data, technical and non-technical, is validated and transformed into a set of plans that will be used to execute the shutdown or turnaround.

The pre-shutdown phase takes place 1 to 2 months before the execution phase (depending on the size and complexity of the shutdown). Pre-fabrication jobs and site logistics mobilizations are some of the activities done in this phase, as well as ensuring that all shutdown materials, spares, tools and equipment are all in place. Moore (2004) says that the stores or procurement function is to provide high quality spare parts and other materials as needed and where needed, primarily supporting the maintenance function. The pre-shutdown phase is also an opportunity to check the effectiveness of the actual execution performance tracking indicators. The outcomes of this phase can be used to accurately predict the success of the execution ahead.

The execution phase of the shutdown process takes 3 to 8 weeks depending on the size and complexity of the event. All the long months of planning and preparations are put to practical application in the few weeks of the execution period. During this phase, high volumes of work are executed with large numbers of people on site. The main focus is usually to complete the work safely, to the highest standards and within budget. According to Singh (2000), this is the most resource intensive phase of the turnaround with major involvement from several groups such as operations, safety, inspection, mechanical, etc. The biggest challenge during this phase is to keep all participants focused and follow the established shutdown or turnaround plans.

The post-turnaround phase is used to compile all the shutdown reports and to document valuable learning points for the future shutdowns. According to Levitt (2004), this is the phase that helps create a project history in a form that can be passed onto new project teams. Levitt (2004), goes on to say that the goal is to promote the creation of a body of knowledge so that future shutdowns are not as costly in either money or downtime, or both. The learnings from the whole shutdown management process must be documented for future reference so that the refinery does not repeat the same mistakes.

## **2.2 Planning**

Lack of strategic planning and focus is one of the common reasons for poor performance on resource intensive projects such as shutdowns and turnarounds. Research by think tanks such as Construction Industry Institute clearly demonstrates that the success rate of projects increase tremendously if detailed planning is guided by a well thought out strategic planning process (Singh 2000).

Planning is one of the most critical phases in the whole shutdown management process. The entire planning phase should be set out with clear, achievable milestones and deliverables. The planning process involves the collection of valuable and relevant information, which is then used to generate the shutdown or turnaround plan. The planning process should involve all the key stakeholders or disciplines in generating the overall shutdown plan. The key stakeholders in this phase include, and are not limited to the following:

- Shutdown or Turnaround management team
- Mechanical Reliability or Maintenance department
- Operations or Production department
- Process engineering department
- Inspection department
- Projects
- Safety, Health and Environment (including security)
- Finance
- Marketing and Sales

### **2.2.1 Work Scope Identification**

According to Singh (2000), the following groups are primarily responsible to identify potential turnaround work scope:

- Operations or Production
- Inspection and Mechanical Integrity

- Maintenance
- Rotating and Machinery
- Instrument, Electrical and Analyzer
- Process and Technical
- Capital Projects and Engineering
- Turnaround Planning
- Safety, Health and Environment
- Outside Parties, e.g., Vendors, Regulatory Agencies, Insurance etc.

Pyle (2003) says that a good scheduling system involves good estimates, the planner or the foreman needs to be familiar with the job to be done. The work scope for the shutdown or turnaround is generated from the statutory or RBI requirements, including requests from various functional disciplines. During normal operations, the various functional disciplines identify defects that they add onto the shutdown work list.

A shutdown or turnaround is a complex process and like any other the quality of the outputs depend upon the quality of the inputs. Data gathered from the plant personnel and records are transformed into the specifications and plans required to carry out the shutdown or turnaround. It is essential that the basic data gathered from the plant and other sources is checked by the shutdown or turnaround team members before being used (Lenahan 1999).

The raw data collected from site should be checked before being used. The refinery should use standard estimating norms that it have acquired over the years of experience to convert the raw data into realistic information. This is one of the most crucial stages of the planning process, if the raw data is not efficiently converted into realistic and competitive information, then all the activities that follow beyond this point would not be accurate and competitive.

A shutdown or turnaround is a maintenance event (in part) and so should conform to this principle. Work lists, however, are not generated by business managers – who have an

eye on the bottom line, the profit margin – but by people who work on the plant (or are closely concerned with it) and who form certain personal judgements about the state of the equipment (Lenahan 1999).

The work scope identification process must be properly scrutinized to ensure that only the relevant scope is short-listed to be done during the execution period. The people identifying the scope of work must be made aware of the fact that it costs more money to do maintenance work during the execution period than during the normal operation of the plant. This is because of the higher rates that are paid during the execution period.

Turnaround managers and planners seem frustrated in their unfulfilled efforts to get the work scope defined early and to minimize work scope changes. In order to achieve world-class results on plant shutdowns and turnarounds, companies must strive to finalize the work scope 8 – 12 months before the turnaround (Singh 2000).

The poor exercise of work scope identification and validation done during the preparation phase results in a lot of additional and emergent work creeping up during the execution period. This can cause a lot of constraints on the available resources resulting in schedule slippages and escalation of costs.

Partnering and integrated teamworking affords a way of achieving better value in whatever way this is defined by the client. However, many organisations are still reluctant to embark on the partnering and teamworking route or are failing to apply a structured approach to lead to major value enhancements in timeliness, better quality and lower costs. In our experience, the greatest value enhancements have accrued to those organisations that select their teams and operate their arrangements in a structured way – months or even years ahead. (Thomas & Thomas 2005)

The relationships that get created between the company and its contractors largely determine the quality of the work output from the contractors. A sense of ownership and responsibility needs to be instilled in all the contractors working for the company. To

achieve this, the major contractors should be made part of certain decision making process, and hence they would achieve a total buy-in.

### **2.2.2 Criteria for accepting final work scope**

According to Singh (2000), for timely and complete definition of the turnaround work scope, it is recommended that a cross-functional turnaround work scope review team be established. This team becomes the focal point in establishing the work scope criteria assigning responsibilities and in approving the turnaround work requests for inclusion in the final work scope. Lenahan (1999) goes on to say that the participants in this team should include:

- Shutdown or Turnaround Manager (who is also the chairman)
- Preparation Engineer
- Planning Officer and relevant planners
- Plant or Production Manager
- Maintenance Manager
- Plant Supervisors
- Electrical/Instrumentation Engineers and Supervisors
- Nominees of either Plant or Turnaround Manager

The composition of the review team should be as inclusive as possible so that all the disciplines are represented. This would ensure that proposed work scope would be fairly assessed, especially the nice-to-do jobs. The team members should be encouraged to be objective in their approach so that only the value-adding jobs are approved for the final shutdown or turnaround work list.

The criteria for accepting the final work scope should be based on the following requirements (see fig. 2.1 below):

- Whether it's possible to do the work during normal operations
- Statutory or legal requirements (including RBI requirements)
- Mechanical reliability of plant equipment



- Safety and quality requirements
- Operational requirements

The first step of planning after the work is identified is to purify the work list. The work must be whittled down to essential items only. Does the work have to be done during this shutdown (or any shutdown)? Work done during the shutdown is more expensive due to the cost of premium time and extra control needed. Is the work a duplicated job or is it a small job that is part of a larger job already on the schedule. Avoid nice-to-do work for which there is no business justification (Levitt 2004)

The work scope validation process is an essential part of the planning process. The jobs on the shutdown list should be carefully scrutinized in order to avoid the nice-to-do jobs which do not add any value to the shutdown initiative. The cost of doing a job during the shutdown or turnaround is more expensive than during the normal operation of the plant. Many a times, the operations and maintenance personnel try to use the opportunity of the shutdown to clear their outstanding backlogs. It is incumbent upon the shutdown or turnaround manager to ensure that all the proposed jobs on the shutdown list are carefully evaluated to ensure that only the necessary ones are short-listed for the forth coming event. The following flow chart can be used to purify the proposed work scope:

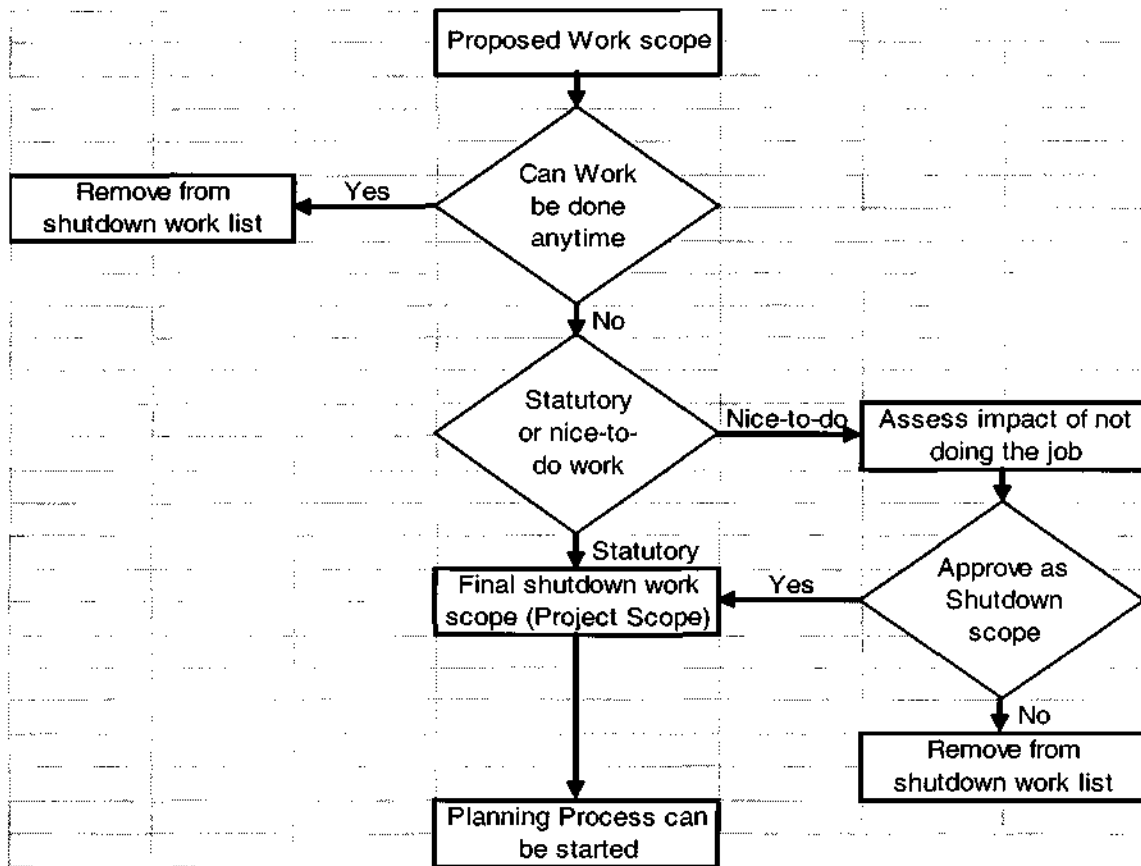


Fig. 2.1 - Work scope validation process

The first step in the work scope validation process is to identify work that can be done during the normal operation of the plant. As mentioned above, the cost of doing work during the shutdown is more expensive because of the higher rates that are paid during this period. The work that can be done during normal operations should therefore be removed from the shutdown or turnaround work list, leaving the work that can only be done when the plant is shut down.

The shortened list should be further segregated into statutory or nice-to-do work. The main intentions of shutdowns and turnarounds is to perform maintenance work according to statutory or RBI (Risk Based Inspections) requirements. The jobs that do not fall under the statutory or RBI requirements should be assessed to determine the impact or consequences of not doing them in the shutdown period. If their impact would negatively

affect the operability and profitability of the plant, then these nice-to-do jobs should be approved to be done during shutdown period. The jobs that are short-listed then form as the starting point of the detailed planning process.

### **2.2.3 Detailed Planning**

Wireman (2003) says that the work order is the fundamental document request, track and record maintenance activities as well as plan and schedule. The detailed planning is a crucial stage in the whole planning process. The accuracy of the information that is fed into the bar chart plan greatly contributes to identifying the right resource requirements for the shutdown. According to Levitt (2004), in maintenance planning, the planned job packages are detailed methods to achieve the end (that is the repair or replacement).

After the shutdown work list has been finalized and approved, a step-by step process of executing each job should be developed. The information on the step-by-step process can be obtained from the historical files if the job has been performed before in the previous events. If the job has never been done before, then the planner and the field personnel should work out the step-by-step sequence of executing the job, including identification of all resource requirements. According to Levitt (2004), the following steps should be followed in executing a detailed job planning:

- Search through the historical files or library to find a similar job to establish a starting point for your planning activity (if possible). The planner must check the records from the previous shutdowns to check if the particular job has been done before. If the job exists in the historical records, the planner and the field personnel need only confirm the accuracy of the sequence of execution and the resource requirements.
- If the job does not exist in the historical records, the planner and the field personnel need to accurately visualize the steps required in order to execute the job. This should involve a logical sequence of executing the various tasks by the different disciplines involved in that job. During this process, consider lock-out, confined space entry, fall protection and all other safety factors.

- For every task identified, determine the labour and other resource requirements. The planner, with the help of field personnel, should accurately identify the various craft's and skills required to accomplish a particular task. The critical equipment, like mobile cranes, required to accomplish particular tasks should be identified at this stage.
- For each task of the job sequence, establish the duration hours. The number of crafts and the quantity of the other resources should also be established. Determine whether special or extra allowances are required for the specific job being planned. Some reasons for extra allowances might be working at heights, heat, cold, moving machinery, etc.
- After the resources have been accurately estimated for the various tasks, the planner can optimize the plan to ensure that the resources are evenly distributed through the execution period. This leveling exercise ensures a smooth distribution of resources, avoiding the valleys and the peaks.
- When all the jobs are aggregated, the planner should determine whether contract resources are needed. All the work to be contracted out can be quantified at this stage and sent out on tenders.
- With the help of operations personnel, the planner should determine the time required for decommissioning and sweetening the plant equipment. Sweetening, in this case, means ridding all the equipment of the hydrocarbons.
- The bill of materials for each job can be prepared, listing the materials and spares required. The quantities of the materials required should be carefully worked, as any shortages might cause serious delays during the execution period, and any surplus would increase the costs of the whole event. It is important at this stage to segregate the materials and spares needed into stock and non-stock items. The procurement department should establish an acquisition plan.
- The special tools and equipment required should be identified at this stage.
- The handling and disposal of waste materials should be considered. The different types of waste that would be generated during the execution phase should be

identified and planned for. The number and positions of the various waste disposal skips should also be established.

- The shutdown logistics planning should be done, involving the establishment of temporary offices and facilities on site. The estimated number of crafts from the schedule plan must be used to work out the quantities of the various facilities to be used on site.
- Turnaround monitoring and control systems should be established at the detailed planning stage.
- The safety and permit requirements should also be established at this stage.
- The pre-shutdown preparation schedule should be drawn up during the detailed planning stage. This would involve a plan of all pre-fabrication jobs, setting up of all site logistics, mobilization of resources and a trial-run of all the shutdown procedures and permit systems.

According to Singh (2000), the turnaround planning phase focuses on information gathering in order to facilitate the development of effective schedule plans and associated control documents. The level of detail and the accuracy of the information gathered during the detailed planning stage go a long way in the development of an accurate execution schedule plan.

#### **2.2.4 Pre-shutdown Preparations**

According to Singh (2000), pre-shutdown activities can constitute up to 10 – 15% of total shutdown costs. He says that is a significant level of work load which should be effectively managed and controlled to ensure efficient field execution. Depending upon the size and complexity of a shutdown, the pre-shutdown phase can commence from 1 – 4 months before the shutdown.

Although the main business of the preparation phase is to plan the work which will be performed during the execution phase, part of the preparation effort must be dedicated to ensuring that all work which has to be completed beforehand (if the event is to be

performed effectively) is also planned and executed. It must be identified, progressed and completed just like the other jobs identified for the actual execution phase. Lenahan (1999)

The main focus of the pre-shutdown preparations is to get everything into place just before the execution starts. The pre-shutdown schedule, just like the final shutdown schedule, will have milestones dates and deadlines to achieve before the start of the execution phase. Every effort should be made to achieve success during the pre-shut preparation stage as it has a direct impact on the success of the actual execution phase.

The pre-shut preparation phase is also used to test the effectiveness of the various shutdown procedures, guidelines or systems before the start of the execution. This gives enough time to make changes and to re-implement any procedures, guidelines or systems that do not meet the expectations. Apart from the implementation of shutdown procedures or guidelines, some of the main activities achieved during this phase include:

- Pre-fabrication works
- Bagging and tagging of materials and spares
- Mobilization of resources and contractors
- Scope challenge and workability review sessions

#### **2.2.4.1 Pre-fabrication Works**

According to Lenahan (1999), pre-fabrication may have no time pressure on it whatsoever and that in itself can be a problem. Due to the belief that there is plenty of time, it is constantly put off until it does become a time pressure problem. Therefore the shutdown manager must ensure that all pre-fabrication is carried out in a timely manner.

The pre-fabrication jobs in the petrochemical refineries are mostly done on piping and structural sub-assemblies. All pre-fabrication jobs should be completed before the start of the execution phase to ensure that time and labour resources are not constrained during the execution phase. The shutdown manager should ensure that all materials for pre-

fabrication are received in time, so that all the known pre-fabrication jobs can be done during this period.

The amount of pre-fabrication jobs depends on the size and complexity of the shutdown, as well as the nature of the major work scope for the event. In order to avoid delays during the execution phase, the large numbers of pre-fabricated spools or assemblies should be clearly marked and placed in the correct lay-down areas. The inspection and QC documentation for all the pre-fabricated jobs should be properly stored in a central document control centre.

#### **2.2.4.2 Bagging and Tagging of Spares and Materials**

The materials and spares procured for the shutdown should be sorted out according to the specific jobs or work breakdown structures. The process of bagging and tagging involves the physical identification of the materials or spares required for a particular job, and then installing a tag so that the materials or spares are reserved for that particular job. This exercise serves the important purpose of identifying all the materials or spares for each individual job. If done properly, possible gaps in the procurement system could be identified and rectified before the start of the execution phase.

Singh (2000) says that the timely and cost effective procurement of turnaround materials and equipment is an important function in ensuring the success of plant shutdowns and turnarounds. He goes on to say that since materials and equipment can constitute up to half of the total turnaround costs, it is imperative that good procedures, guidelines and systems are established to effectively plan, manage and monitor all facets of the materials procurement effort.

The shutdown management team should make sure that all the materials and spares required for the event are identified early and procured in good time to avoid paying high premiums for any short-notice procurement needs. The suppliers will normally charge a

higher price for any materials or spares requested for delivery in a period shorter than the normal lead time.

#### **2.2.4.3 Mobilization of Resources and Contractors**

Some firms bring in a contractor at the initiation phase and the added expertise is invaluable in keeping expectations in line with reality. Many firms hire the contractor to prepare the individual job packages with job safety analysis. Contractors need to be a true part of the team. As soon as they are on board, they should be included in all relevant meetings, e-mails and document distribution lists. (Levitt 2004)

The period of mobilizing the contractors and resources onto site depends on the size and complexity of the shutdown. Ideally, most contractors and resources are mobilized during the pre-shutdown preparation phase, i.e. 1 – 4 months before the execution. If directly involved with the preparation of the schedules, some of the contractor's personnel could be mobilized at the scope identification phase. Depending on the roles that the various contractors will be performing on site, they need time to familiarize themselves with the schedules, procedures guidelines and systems for the shutdown. Alignment of the client's and contractor's expectations is crucial to the success of the whole event.

The labour resources should be mobilized just before the start of the execution phase. The mobilization time for the labour should allow enough time for site inductions, medical examinations and issuing of site access badges, i.e. approximately a week before the execution. The field labour should also be allowed at least one day to familiarize with the site logistics and to collect all their personal protective equipment requirements. As far as is practical, the tools and equipment should only be hired as and when required, taking into consideration the availability of the various tools and equipment. This would avoid paying standing-time for the tools or equipment that are not being used.



#### **2.2.4.4 Scaffolding and Insulation Removal**

In order to avoid work congestions and delays, the scaffold erections and insulation removals for all accessible positions should be done before the execution starts. After the detailed planning exercise, the schedule for the pre-shutdown scaffold erections and insulation removals should be clearly communicated to the contracting companies. The scaffolding to be erected before the execution should be accurately quantified so that the scaffolding contractor allows for enough labour and materials for the job.

#### **2.2.4.5 Scope Challenge and Workability reviews of Execution Schedule**

According to Singh (2000), to ensure total compliance and effective use of the turnaround schedules, the turnaround management team should ensure that execution groups actively participate in the schedule development. Without a complete buy-in of the turnaround schedule plans by the execution groups and contractors, it is impossible to ensure their effective use implementation.

The workability reviews and scope challenge sessions will achieve buy-in and commitments from all stakeholders. The scope challenge sessions are a good forum to review the scope of work, including the required resources for each and every task in the schedule. The workability reviews involve the brain-storming sessions on the coordination of certain critical activities and equipment, like the handling of catalyst and the utilization of higher tonnage cranes. Depending on the size and complexity of the shutdown, these sessions could take 1 – 3 weeks.

### **2.3 Budgets**

#### **2.3.1 Budget Estimates**

The cost performance on a shutdown is traditionally judged by the overall final cost as compared to the shutdown budget. According to the Joint Development Board (1997), the

ability to forecast costs accurately is important in all industries, but essential where substantial sums are to be committed to a project whose final cost may not be known. In many cases budgets have been getting smaller, being dictated without the input of the shutdown management teams and are decided a long time before the shutdown teams have been assembled. Shutdown budgets are sometimes based upon company financial criteria and priorities, which may be different from the criteria used to develop the shutdown work scope and execution plans. (Singh 2000)

The compilation of the shutdown budget does not strictly follow the same criteria as that of developing the work scope in most refineries. It is true that in most instances the budget proposal is done even before the work scope is finalized. If there is a previous shutdown budget to work from, top management can use orders of magnitude and inflationary figures to roughly estimate the new budget to within 30 – 40% accuracy. Before a final accurate estimate (within 5%) can be presented, it is important to have all the work scope development processes frozen, as well as to ensure that all parameters that form part of the shutdown or turnaround costs are taken into account.

According to Lenahan (1999), the following should be included in the budget estimate:

- Shutdown Planning and Management
- Labour
- Contractors
- Spares and Materials
- Tools and Equipment
- Accommodation
- Utilities

From the onset, the top management and the shutdown management team should define what will constitute a shutdown cost. This will assist in identifying the actual costs as opposed to sunk costs, which would be absorbed by the organization with or without the shutdown event happening. The major parameters that contribute to the shutdown budget are the labour resources, spares and material costs. The services of the various contractors

also constitute a large portion of the budget, depending on the nature of the contracts entered into. For the major contractors, the following two types of contracts are common:

- EPC contracts (Engineering Procurement and Construction): This is where the contractors are responsible for all design and technical responsibilities, procurement of the spares and materials, as well as the actual construction works.
- EPCM contracts (Engineering Procurement and Construction Management): The major difference with the one above is management responsibility that contractor is given by the client. In this case one major contractor would be give the overall responsibility of managing the whole shutdown or turnaround process and would have a number of sub-contractors reporting to him.

Singh (2005) says that there is no common consensus in the industry as to which turnaround cost components constitute the turnaround budget. He says that each company has its own unique budgetary composition which, either by intent or default, has evolved over the years. However the shutdown or turnaround estimates should be broken down to show the following key cost components:

- Direct field Labour costs
- Spares and Materials costs
- Equipment and tools hire costs
- Contractors, sub-contractors and vendor costs
- Overhead and support facilities costs
- Contingency allowances – This is to ensure that budgets can cover the inherent uncertainties of a shutdown or turnaround. According to Singh (2000), the shutdown or turnaround contingency allowances can vary from 10 to 20% or even more.
- Company's shutdown or turnaround related costs

Apart from using historical information, the company should always use the latest industry information in coming up with the best budget estimates. The whole budget estimation process should be well structured to ensure that it relates to the work scope identification and validation criteria. All the parameters indicated above should be taken

into account at the various stages of the estimation process. One of the major problems encountered during this process is making allowances for emergent or unknown work scope that comes up during the execution phase. Depending on the size and complexity of the shutdown, as well as from past experiences, the company should make a contingency allowance for this type of work.

During the initial stages of the shutdown management process, the company should also implement cost control measures. Apart from appointing a qualified person to do the costs management functions, measures and procedures should be put in place to ensure that all responsible persons (including contractors) in the various areas effectively control their budgets to prevent escalations. According to Singh (2000), the recognition and establishment of an effective cost management function will go a long way towards the company's in-house capabilities to maintain accurate data and develop realistic shutdown or turnaround estimates and budgets.

## **2.4 Shutdown Execution**

The day finally arrives when all the planning and preparation are (hopefully) complete, the materials and equipment are in place and the resources have been organized and briefed. The business of shutting down the plant and executing the turnaround begins. Work that has been planned, scheduled and resourced, and where necessary, appropriate allowance has been made for contingencies. The emphasis here should be on exercising control over this work, by means of the shutdown or turnaround planning and control system, to meet or beat the schedule and budget. (Lenahan 1999)

The success of the shutdown execution phase will almost entirely depend on the successes of the planning and preparation phases that have gone past. The success criteria for the execution should have defined in the initiation phase, whether depending on safety incidents, quality of work done, completing within budget costs, duration of execution period or a combination of these. The execution phase is characterized by the high

intensity or volumes of work, large numbers of people on site and a short space of time in which all the work must be completed.

The shutdown or turnaround manager should strive to make sure that all the work is done and completed according to the schedule as far as possible. The coordination of work and various activities between the different parties involved in the execution is one of the challenges faced by the shutdown management team. The emergent work or additional work that comes up during the execution period should be handled according to the laid procedures, making sure that the impact on the schedule and costs is minimal.

According to Levy (2002), the growing shortage of skilled workers and experienced managers that began to appear in the 1980s has reached dangerously low levels in today's market place and remains one of the major challenges facing the construction industry. He goes on to say that the ability to grow experienced managers from field personnel has also been somewhat hampered by the tendency of some trainees to jump ship in the process of training when a more attractive offer is presented by the competition.

The shortage of skilled labour affects the whole industry. This has a direct impact on the quality of the workmanship and contributes to the increase in the shutdown or turnaround costs because of re-works.

#### **2.4.1 Safety**

It is important to re-emphasize that safe execution is the number one shutdown or turnaround success criteria. The shutdown management team and the contractor's staff should collectively reinforce the importance of safety and re-energize the crafts' commitment to safe work practices. Even though safety responsibility ultimately lies with each individual, it is the turnaround management's leadership and enforcement that is key to achieving exceptional safety performance. Turnaround safety inspectors and contractor safety staff play an active role in ensuring compliance with turnaround SHEQ guidelines, regulations and requirements. (Singh 2000)

In terms of safety, one of the major challenges faced by the shutdown management team is the large numbers of labour on site that are not familiar with the plant and the company's safety procedures. In most refineries, site inductions are conducted for all new personnel coming to site. Due to the fact that these initial inductions cannot cover all the aspects of plant safety, alignment and re-enforcement sessions should follow to ensure that the company's safety culture is entrenched in all the site personnel. According to Narayan (2004), there are a number of reasons for poor operating practices. These include lack of ownership, time pressures, lack of training or motivation, and previous success in taking short cuts.

In order to receive the attention that safety deserves, a senior person in the organization must be appointed to lead the safety initiatives for the whole event and he should be part of the shutdown management team. The appointed person should make sure that the safety procedures and guidelines for the shutdown are communicated to all persons coming onto site. He should also make sure that there are enough safety officers and watchers to police the number of people on site.

#### **2.4.2 Coordination of Planned Activities**

The accuracy in coordination of the various activities during the execution phase determines the success or failure of the whole event. Depending on the size and complexity of the shutdown, the whole event is sub-divided into a few manageable physical units. The coordination and execution of activities is then done at these unit levels, with dedicated management team members. These units or areas would each have a meeting room, where all schedules and performance monitoring systems would be displayed and tracked.

For each area the actual critical path and all other near-critical path activities would have been identified during the planning phase, and these would be tracked to ensure there is no slippage on the overall plan. To ensure adherence to shutdown schedules, the best

resources are normally assigned to the critical path activities. Singh (2000) says that since the critical path defines the turnaround length, every possible effort has to be made to meet or improve on the critical path activities. He goes on to say that experience shows that in most turnarounds somewhere during the execution, the critical path changes and new critical activities emerge.

The daily schedule is the key to success in running a shutdown. The daily schedule is generated from the master schedule, and is designed in two parts. The first part is a list of jobs that can be run the next day. The second part is the assignment of people or crews to each job. The key is to control the shutdown on a job-by-job basis and intervene, when necessary, soon enough to make a difference in that job. (Levitt 2004)

The areas teams are responsible to ensure that the execution goes according to the plan. The area planner would normally issue one or two-day look-ahead schedules to the site supervisors. The supervisors would in turn, on a daily basis, inform the planner of the site progress, highlighting any potential threats or problems. The quality of the information and feedback between the planners and the field supervisors is critical to the decision making process during this phase.

The field supervisors and contractors are responsible to ensure proper utilization of labour and other resources on site. In order to achieve higher shutdown execution efficiencies, the supervisors and contractors should be aligned with the expectations of the organization. The handling of all emergent work or any additional scope should follow the approved procedures, and the supervisors should be well informed not to tackle any work without proper documentation. Levitt (2004) says that the plan is based on what people knew or guessed at the time the plan was made. He goes on to say that some shutdowns experience an additional 15 to 40% emergent work.

## **2.5 Summary**

The chapter extensively covered milestones and deliverables for the various phases of the shutdown management process. For the area of work scope identification and validation, a model has been proposed to streamline and to achieve better results in the process.

The various inputs and deliverables for the budgeting and execution phases were also highlighted and discussed. The chapter highlighted the complexity of the shutdown management processes in the refineries and also emphasized the importance of adherence to the deliverables in order to gain a competitive edge over the peers in the industry.



## **Chapter 3. RESEARCH METHODOLOGY**

### **3.0 Introduction**

The research questions will be answered in this section. Data collection, analysis of the data and the other issues concerning this research will be addressed in this section. The quantitative comparisons part of the research will be discussed to highlight how the data will be collected and analyzed. The quantitative data will focus on some selected shutdown or turnaround variables.

The qualitative questionnaire will also be discussed. The reasoning and objectives behind the questions will also be highlighted. The content analysis that is used to analyse the responses of the interviewees will be explained. The section will discuss the results of the data analysis including other issues that could be misleading to the research.

The research instruments that will be discussed in this section will be focused mainly on the planning, budgeting and execution phases of the shutdown management process. The other phases of the process, namely the initiation, pre-shut preparations and post shut activities, will also be discussed under the general overview of the whole process.

### **3.1 Background of PetroSA GTL Refinery**

PetroSA GTL Refinery is situated in Mosselbay, in the Western Cape. This refinery produces various petroleum products, i.e. petrol, diesel, kerosene and many other products, by the process of converting gas to liquids (hence the name GTL). The gas is mined from the offshore wells and is collected at a platform on the sea, 90 km south of Mosselbay. The gas is then transported to the refinery via a sub-sea pipeline. PetroSA is the only refinery in South Africa using this technology.

In order to comply with statutory and other legal requirements for the equipment integrity, shutdown and turnarounds are put of PetroSA's normal maintenance plans. The

refinery goes through a total shutdown cycle every three years, when the plant is totally shut to carry out maintenance inspections and repairs. Like the other refineries, PetroSA also faces a lot of challenges during the process of preparing and executing the shutdowns and turnarounds. This research will highlight the areas of concern during the planning, budgeting and execution phases of the process and will recommend ways of improving the efficiencies and productivity so as to gain a competitive advantage.

### **3.2 Importance of the Research**

*“A recent consortium study on Shutdown and turnaround Management Benchmarking confirmed the following trends:*

- *Over 90% of shutdowns and turnarounds failed to meet the company’s business and turnaround goals*
- *Eight out of ten shutdowns and turnarounds experienced cost overruns of 10–40%*
- *Half of the shutdowns and turnarounds suffered from schedule slippages*
- *Almost nine out of ten shutdowns and turnarounds reported work scope growth of 10-50%*
- *Most shutdowns and turnarounds were impacted by shortages of qualified staff and crafts*
- *Three out of four times the schedules were abandoned in the first week of the turnaround*
- *Most of the turnaround staff reported stress and organizational conflicts as their biggest personal concerns*
- *90% of post-shutdown critique report recommendations are never implemented*

*In spite of poor past performances, overall expectations for future shutdowns and turnarounds is for exceptionally higher results. However, we can’t expect higher results if status quo is maintained in the way that companies plan and manage their shutdowns and turnarounds” (Singh 2000).*

From the business perspective, it is imperative that refineries plan and execute their shutdowns in the most cost-effective and efficient ways in order to gain and maintain a

competitive advantage. This research will add value to the body of knowledge on the shutdown management processes in the petrochemical refineries in South Africa. The findings and recommendations of the research can be used to streamline the shutdown management processes in the various refineries in order to achieve higher efficiencies as well as to reduce costs. The research will highlight critical factors that affect the success of shutdown operations:

- **The Planning Process:** The various inputs and deliverables of the planning process will be critically analyzed. The people and functional disciplines that give input into the whole planning process will be identified, including the stages at which they give their inputs to the plan.
- **The Budgeting Process:** The research will endeavour to highlight the critical inputs into the budgeting process. The various causes of cost creep will also be identified and discussed.
- **The Execution Phase:** The challenges that are experienced during the actual shut execution will be identified and possible corrective measures proposed. The importance of skills as well as coordination and documentation during the shut execution will be discussed.\*

Exploratory research seeks to find out what is happening in a particular scenario and also seeks deeper understanding of the causes of concern. The approach is to ask open ended questions and seek expert opinion, allowing an expert to give his or her insight on the subject of discussion. A descriptive study seeks to portray an accurate profile of events or situations, and quantitative comparisons would achieve that. This research is a combination of exploratory and descriptive as it seeks to identify the causes of the challenges to shutdown management, as well as highlighting the actual performance in certain areas.

### **3.3 Framework Application of the Theory**

The researcher will use the following sources for collecting the theory on the subject. These sites have been recommended by Rembrandt Klopper, a professor in communication at the Graduate School of Business – University of Kwa-Zulu Natal:

- University of Kwa-Zulu Natal's electronic databases, namely nexus and sabinet.
- The google meta-search engine
- The University libraries

In using the google meta-search engine, invaluable material was obtained while doing a literature survey. The work by Levitt (2005), Lenahan (1999) and Singh (2000) provide a good source of theoretical material that will be quite useful for this research. These authors outline the various phases of the shutdown management process, including the requirements and deliverables of each phase.

### **3.4 Data collection**

The approach of this research will use the qualitative method of data collection, as well as quantitative comparisons of certain shutdown and turnaround parameters. For the qualitative analysis, interviews will be used and are primarily designed to engage the participants to respond to open ended questions. Being exploratory in nature, the interview questions will prompt the participants to give in-depth insights and knowledge on the various aspects of the shutdown management process. This will ensure that the responses given would adequately address the critical questions and objectives of this research.

For quantitative comparisons between PetroSA and the local and international industries, the research will make use of the PetroSA shutdown reports, as well as published journals on shutdown management and various internet sources. The following data will be collected:

- The planned duration of the shutdown versus the size of the shutdown (the size of the shutdown could either be measured in terms of man-hours or the budgeted cost of the shutdown)
- The size of the shutdown versus the total number of people involved
- The total number of people versus the total number of safety officers on site
- The total number of people on site versus the total number of safety incidents
- The proportion of work scope growth and emergent work
- The percentage of labour costs versus the total shutdown costs

#### **3.4.1 Sources of the Data**

The data for the research will be collected from the PetroSA GTL Refinery. The primary source of the research data will be gathered through interviews with key personnel involved in the shutdown management processes, while the secondary data will be collected from the refinery's shutdown reports. For the sake of comparisons with the local and international industries' performances, the research will also obtain data from published journals and other internet sources.

The research findings on the PetroSA GTL refinery would be representative of the broad spectrum of the petrochemical refineries in South Africa. The researcher will guarantee the non-disclosure of confidential information on PetroSA GTL refinery that may be encountered during the period of conducting this study. Only information relevant to the subject matter will be published.

#### **3.4.2 Sample Size**

How you identify your sample size must depend on what research question(s) you want to answer. If you want to draw inferences about an entire population or body of objects, then you must choose a sample that can be presumed to represent that population or body (Leedy & Ormrod 2005: 145).

This research study is exploratory in nature, and as such the sample was taken to select the individuals that would yield the most information about the topic under investigation. The sample was taken from the following departments that play critical roles in the shutdown management processes at the PetroSA GTL refinery:

- Shutdown Management Team
- Mechanical Reliability
- Operations
- Inspection
- Projects and Planning
- Engineering services

For this study, a convenience sample of 13 persons was selected to represent the whole population of the management team involved with shutdown and turnaround management at PetroSA. 2 additional persons were selected from Kentz, one of the major shutdown and turnaround management contractors in South Africa. The interviewees were prompted to give their insights and understandings on the challenges that face shutdown management at PetroSA and rest of the petrochemical refineries in general.

The following procedure was used to arrive at a convenience sample of 15 persons (13 persons at PetroSA & 2 persons at Kentz):

- At PetroSA, there are six departments that are fully involved with the shutdown management process. According to Leedy & Ormrod (2005), the data of a convenience sample offers you the deep thoughts and insight on a subject matter. In order to obtain quality representation, 2 managers and engineers from each department were deemed to be representative. A total of 13 managers and engineers from PetroSA were selected.
- To receive input from the contracting companies, 2 senior managers from one of the major contracting firms (Kentz) in South Africa were selected.

### 3.5 Research Methods

To answer some research questions, we cannot skim across the surface. We must dig deep to get a complete understanding of the phenomenon we are studying. In qualitative research, we do indeed dig deep: We collect numerous forms of data and examine them from various angles to construct a rich and meaningful picture of a complex, multifaceted situation (Leedy & Ormrod 2005).

The research methods used for this study will involve qualitative interviews with key individuals involved with the shutdown management processes, as well as quantitative comparisons of selected shutdown management parameters. All the interview sessions for this research will be recorded, with full consent from the participants.

#### 3.5.1 The Planning Process

*“Strategic planning should clearly establish company’s business expectations, turnaround objectives, success criteria and a realistic plan, along with resources to accomplish pacesetters results” (Singh 2000)*

The research will identify the important deliverables to be achieved in each phases of the shutdown management process. The data will be collected using the template shown in Appendix A (The Planning Process Template). Using this approach, the research will investigate the level of information is collected, including the various activities that the planning process is engaged in during the various phases of the shutdown process. The purpose of this review is to determine how much information as well as what processes the planning department goes through in order to contribute to achieving a successful shutdown.

For each activity on the template (Appendix A), the shaded area will indicate a tick (✓) or a cross (X). A tick will indicate that the refinery does incorporate the particular activity during that phase of the shutdown process, whereas a cross will indicate that it does not.

The list of activities on the template may not be exhaustive, but as the research is conducted more activities might be added to the list.

Quantitative comparisons will also be done using the templates shown in tables 4.1 & 4.2 and figure 4.1. The information on the comparisons will be obtained from the PetroSA shutdown reports and other internet sources. The analysis of these activities, together with information from the interview sessions, will highlight the following critical factors:

- The challenges of planning in the various phases of the shutdown management process
- The effectiveness of the KPI's during the various stages of the planning process
- The effectiveness of the labour utilization during the shutdown execution phase. The effects of just increasing the labour force to get the jobs done will be analysed.
- Opportunities of using the planning process to gain a competitive advantage will also be explored

### **3.5.2 The Budgeting Process**

The data for the budgeting sub-problem will be collected from the qualitative interviews with the key shutdown management personnel. The structure of the qualitative interviews on budgeting is designed to highlight the following:

- The identification and analysis of critical inputs in the formulation of an accurate budget estimate. Clark & Lorenzoni (1997) say that every estimate has a basis, and for early estimates, much of the basis is developed through assumptions and extrapolations of past history.
- The phase in which an accurate budget estimate can be presented
- The ratio of the labour costs to the entire shutdown costs
- The causes of budget over-runs during the whole shutdown management process
- The escalation of the invoiced price, as opposed to the quoted price by some contractors



Quantitative comparisons of the planned / actual duration with other shutdown variables like number of activities (size of shutdown) will be done for each refinery shutdown period, refer to figure 4.1 (Shutdown Statistics). The research will explore the existence of correlations between the shutdown duration and the different variables, i.e. duration and size, as well as duration and the amount of emergent work. Firstly, these comparisons will be done within the refinery for the different shutdown periods. The comparisons will then be done between the refinery and best industry or international practices, especially on emergent work.

### **3.5.3 The Execution Sub-problem**

The data for the shutdown execution sub-problem will be collected from the interviews with the refinery's key shutdown management personnel. The structure of the questions is designed to highlight the following:

- The challenges of coordinating the activities among the various disciplines, departments and contractors
- The critical skills' shortages during the shutdown execution
- The handling and controlling of scope growth and emergent work during the shut execution
- The management of shutdown documentation, like emergent work requests, pipe repair approvals, pressure test certificates, and so on.
- The supervision and controlling of work done by the contractors
- The effectiveness of key performance indicators and feedback control systems
- The challenges of maintaining low safety incident levels

Again, quantitative comparisons for selected shutdown execution data will be generated. The size of shutdown will be compared to the duration of the shutdown execution. The percentage of emergent work for the refinery, and for a particular shutdown period, will be compared with the generally accepted level for petrochemical refineries on an international basis.

The research will use the template shown below in figure 4.2 (Safety Statistics), to identify and highlight the challenges experienced in maintaining low safety incidents during the shut execution phase.

### **3.6 Questionnaire Design**

Interviews in a qualitative study are rarely as structured as the interviews conducted in a quantitative study. Instead, they are either open-ended or semistructured, in the latter case revolving around a few central questions (Leedy & Ormrod 2005).

The questionnaire for this study, shown in Appendix C, was developed to suit the topic being tackled. The exploratory nature of the research demand that the interview questions be of an open-ended type. In addition, the interview questions were designed to answer the critical questions of the research whose main focus was to identify the challenges of shutdown management in the petrochemical refineries.

### **3.7 Analysis of the Data**

Almost invariably, one crucial step in a content analysis is to tabulate the frequency of each characteristic found in the material being studied. Thus, a content analysis is quantitative as well as qualitative (Leedy & Ormrod 2005).

From the transcribed research interviews, salient points will be picked up for each interview question through a thorough content analysis process. According to Leedy & Ormrod (2005), a content analysis is a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes or biases. A table outlining all the interview questions, including the salient points from each interviewee will be drawn up. This table will contain a wealth of information and some of the salient points may be similar between the various interviewees (see Appendix E – The Responses from the Interview Sessions).

The interview questions will then be split up to align with the sub-problems of the research, namely; the planning, budgeting and shutdown execution. For each sub-problem, all the responses given by the interviewees will be systematically outlined and analysed to ensure consistency and validity. The researcher will use an informed judgement to highlight the challenges identified for each sub-problem. The combination of the analyses of all the sub-problems will then culminate into the overall problem statement for the research.

The second part of data analysis will involve the comparisons of the specific shutdown and turnaround parameters. As far as possible, the data obtained from the PetroSA shutdown reports will be compared with the best industry practices for both the local and international petrochemical refineries. These comparisons can generate very interesting findings that could pin-point problem areas in the shutdown management processes at the refinery.

The analyses will identify the following:

- The functional disciplines involved in the shutdown management process, including the level at which each functional discipline plays its role. The involvement of contractors in the whole process will also be analyzed.
- The planning process; the challenges experienced and the deliverables of planning in the whole shutdown and turnaround management process
- Budgeting process; the factors to be considered when compiling a shutdown budget, including the causes of cost creep in the whole shutdown and turnaround management process
- The shutdown execution phase; the critical skills' shortages experienced, including the effective utilization of labour resources and safety concerns

### **3.8 Validity and Reliability**

Validity is defined as the extent to which a measuring instrument (e.g. the interview questionnaire) measures what it is supposed to measure. Reliability is the consistency

with which the measuring instrument yields a certain result when the entity being measured hasn't changed (Leedy & Ormrod 2005).

For this research, the interview questions have been designed to highlight the challenges of shutdown management in the petrochemical refineries. The research has targeted those individuals directly involved with the shutdown and turnaround management processes, and has avoided including personnel not directly involved with shutdowns so that the research findings are not distorted.

The responses to the open-ended questions may not lead to similar responses from all the interviewees, but will ensure that any critical points missed by one interviewee may certainly be picked up and discussed by another interviewee. In this way, the research has a higher probability of identifying and highlighting all the objectives as required.

### **3.9 Summary**

The structure of the questionnaire will prompt the respondents to give their insights to open ended questions. Using this approach, the research will receive a wealth of information, i.e. if a salient point is missed out by one respondent, there is a high probability that the point could be picked up by one of the other respondents. In this way, a lot of issues are expected to be covered and discussed.

The quantitative comparison data would be helpful in assessing PetroSA's performance against its peers. By analyzing this data, some areas of concern could be identified.

## **Chapter 4. RESULTS AND DISCUSSIONS**

### **4.0 Introduction**

The qualitative interviews conducted for this research yielded a lot of good responses from the respondents, who were drawn from a pool of managers and engineers responsible for the various aspects of the shutdown management process at PetroSA. The focus for the interviews was on highlighting the challenges, from the respondent's point of view, based on the planning, budgeting and execution phases of the shutdown management process.

Selected quantitative comparison data on the 2003 and 2006 shutdowns at PetroSA was retrieved from various sources, including the shutdown close-out reports and other planning reports. The data was used to calculate the rate of emergent work during the execution period at PetroSA, and this was compared with the generally accepted norms on emergent work in the industry.

The interview responses and the comparative data highlighted some of the challenges faced by the shutdown management team at PetroSA. On a number of topics, most of the respondents raised similar issues as affecting the shutdown management process at PetroSA and other South African refineries at large.

### **4.1 Shutdown Management in General**

#### **4.1.1 Functional disciplines involved in the Process**

80% of the interview respondents indicated that almost all the departments in the refinery should play a role in the shutdown management process at one point or the other. However, the following functional disciplines were highlighted as giving the major input into the whole process:

- Exco (Executive committee) – Top management

- Operations & Process
- Mechanical Reliability
- Inspection
- Electrical & Instrumentation
- SHEQ
- Commercial & Finance
- HR & IR
- Contracts & Procurement, Supply & Logistics
- Projects & Engineering Services
- Legal

All the above mentioned departments give their input during one or several phases of the shutdown management process. The Exco (Executive Committee) is mainly involved during the initiation phase, where the high level business decisions and strategy formulations are done. The commercial, finance, Supply and logistics departments are also heavily involved during the initiation phase in order to align the organisations business objectives and the customers' requirements. Approximately 50% of the respondents felt that the commercial and finance departments are not as involved as expected, especially during the other phases of the process.

The inspections, operations, mechanical reliability, services, projects, electrical and instrumentation departments get fully involved from the concept development phase onwards. These departments are involved in generating and validating the work scope for the whole shutdown or turnaround. Almost 75% of the interview respondents felt that the work scope identification and validation processes were not properly done during the 2003 and 2006 shutdowns at PetroSA. During the 2006 shutdown, the amount of emergent and additional work scope that was picked up during the execution phase was 23% of the original scope.

The contracts and procurement departments get involved after the work scope has been identified. From the interview sessions, almost 70% of the respondents indicated that the

contracts and procurement processes were not handled properly. Firstly, most of major contracts for the shutdown (PetroSA 2006) were not done in time and secondly, the structure or wordings on the contract documents left a lot of room for the contractors to manipulate the client (PetroSA). This goes to show that the legal department was not as involved as it should have been.

The procurement and warehousing department is responsible for the sourcing of all the spares, materials and consumables for the shutdown or turnaround. The communication between the procurement department and the end user departments had some flaws in the PetroSA 2006 shutdown. 70% of the respondents felt that the procurement procedures for shutdown and turnarounds could be improved. The expediting function of the procurement department could be improved to ensure that tracking of all orders is efficiently followed up.

The shutdown management workflow model outlining the involvement of the various functional disciplines during the different stages of the process is shown in Appendix D. The model outlines the input from the various departments and the stage which procurement of spares and the awarding of major contracts is done.

#### **4.1.2 Communication between the Departments**

Communication between the departments plays a big role in achieving effective shutdown planning and efficient field execution. 95% of the interview respondents felt that good communication is a continuous process and is accomplished through various channels:

- Central shutdown meetings
- Area shutdown meetings
- Emails – through the internet and intranet systems
- Reports on the central database through the intranet system
- Memos and telephones

- Through informal discussions between the various participants in the shutdown management process

### **Communication Challenges:**

However, two challenges were highlighted in the shutdown or turnaround communication process at PetroSA. Firstly, the tracking of physical documents or paperwork, like pressure test certificates and pipe repair approvals, was not well communicated during the execution phase. There was lack of ownership and a clear absence of a centralized document centre (PetroSA 2006 shutdown), who's main objective would be to track and coordinate all shutdown documentation. Secondly, the shutdown execution meetings at PetroSA (2006 shutdown) accommodated a lot of people, even those that were not directly involved with the execution. 70% of the interviewees said that the meeting formats could be streamlined to improve the sharing of information and giving feedback to those directly involved with the execution process.

## **4.2 Planning Process**

### **4.2.1 The Shutdown Phases**

The shutdown planning process at PetroSA can be divided into seven phases:

- Phase 1 – Initiation; this is the starting point of the shutdown management process. Top management is heavily involved at this stage to set the strategy and direction for the whole process. The commercial and finance departments also play major roles in aligning the organisation's business focus and customer requirements. The shutdowns in the petrochemical refineries are normally necessitated by statutory or legal requirements, as well as the equipment integrity requirements. And as such, the inspection, operations and mechanical reliability departments are also involved at this stage.
- Phase 2 – Conceptual Development; this phase involves the stating of the shutdown objectives, as well as highlighting the shutdown success criteria. The shutdown organisation chart is also drawn up at this stage, indicating the various



reporting structures. The various shutdown policies and procedures are also drawn up at this stage.

- Phase 3 – Scope Detail; the compilation of the work scope is done at this stage. Various departments are involved in submitting the work scope to the shutdown team, including inspection, mechanical reliability and operations departments. The criteria for accepting the work scope is clearly communicated by the shutdown team to the other departments (see fig. 2.1 on page 15). 75% of the interview respondents indicated that the work scope identification and validation process at PetroSA was not well managed for the 2006 shutdown. The respondents indicated that a thorough exercise should have been done to avoid new work creeping up during the execution phase. The process of ordering the materials and spares, especially the critical ones, is also started during this phase.
- Phase 4 – Detailed Planning and scheduling; this phase involves the preparation of the overall shutdown schedule. For each item on the work list, the shutdown planning team obtains information from the field personnel in order to compile the detailed task lists. The task lists are submitted to the contracts department for all work to be contracted out. The resource requirements for the various activities are also worked out at this stage. Apart from compiling the shutdown execution schedule, the planning team also makes up the pre-shutdown preparation schedule.
- Phase 5 – Pre-shut Preparations and Mobilisation; with a pre-shut preparation and mobilisation schedule done during the detailed planning phase, this phase ensures that everything is in place before the execution begins. This phase is used to test the readiness of executing the shutdown, the various shutdown procedures and policies are checked for effectiveness. The prefabrication of piping and structural assemblies is also done to ensure smooth installation during the execution phase. The mobilisation of resources and the establishment of site resources is also done at this stage.
- Phase 6 – Shutdown Execution; the actual execution is done at this stage. The tracking of actual progress versus plan is also done. The planning team issues daily progress and look-ahead reports.

- Phase 7 - Close-out; the final completion reports are done at this stage. The learnings from the shutdown are properly documented for future reference.

#### **4.2.2 The Challenges of the Planning Process**

From the interview responses, the following were highlighted as the challenges faced by the planning department:

- **Failure to achieve set milestone dates** – During the preparations for the 2006 PetroSA shutdown, the planning department did not meet the set milestone dates in the various phases of the process. One of the major challenges highlighted by the planning team was the failure to receive relevant information early enough. The planning team was entirely dependent on various individual from key functional disciplines to gather information for the different processes.
- **Poor work scope development and validation process** - During the work scope development period (PetroSA 2006 shutdown), there was poor input from the end user departments, especially operations, mechanical reliability and inspection. The interview respondents from the PetroSA Planning team indicated that there was a clear lack of cooperation and ownership from these departments in generating the shutdown scope. The planners had to constantly remind the participants to submit their work requests. The work scope identification and validation process plays a key role in the success of the whole shutdown event.
- **Conflicting priorities** – During the preparation phase (PetroSA 2006 shutdown), the area teams (mechanical engineers, operations personnel and inspectors) had the responsibility of looking after the running plants, and as such they were faced with conflicting priorities when it came to shutdown issues. The running plants demanded their full attention, while the shutdown planning team expected these individuals to play active roles in the shutdown preparation process.
- **Poor review of final work scope** – The final work scope for the shutdown (PetroSA 2006 shutdown) was not properly challenged and reviewed. The review process should include representatives from all the key functional disciplines, including the major contractors.

- **Lack of timely and accurate reporting of progress feedback** - During the shutdown execution (PetroSA 2006 shutdown), the area planners struggled to obtain feedback on completed work from the field personnel.
- **Planning tool** – The planning tool used for the 2006 shutdown at PetroSA, SMS (Shutdown Management Systems), was not linked to the organisation's SAP system.
- **Lack of qualified and experienced planners from the industry market** – Most of the contract planners that were hired for the PetroSA 2006 shutdown were not well qualified and experienced enough. There is a general shortage of qualified planners in the South African market at the moment, and this problem is compounded if more than one refinery is shut at any one time in the country.
- **Control measures** – Putting control measures to track the plan versus actual was a challenge for the planning team.
- **Poor signing off of all completed work** – The planning department struggled to get the area teams to sign off all completed work on the master schedule.

Depending on the size and complexity of the shutdown, the planning process can be started 2 – 3 years in advance. The PetroSA 2006 shutdown was started 24 months before the execution in October 2006. To kick start the procurement process, the critical materials and spares for the shutdown can be identified during the course of the work scope validation phase.

The information for the shutdown work scope is gathered from various sources, including:

- RBI (Risk Based Inspections) requirements
- Previous Inspection reports
- Equipment reliability and integrity requirements
- Defects highlighted by maintenance and operations
- Projects

The activity resources and durations on the overall shutdown schedule are estimated by the experienced personnel on site and from historical shutdown information. There were no standard estimating norms used on the 2006 shutdown at PetroSA, the engineers and foremen estimated the resource requirements and durations.

In appendix A, a table of comparisons was drawn up to highlight the various activities achieved during the different phases of the shutdown management process at PetroSA versus its peers in the industry (both local and international petrochemical refineries). Comparing with pacesetter companies, the major shortcomings at PetroSA were seen in the absence of a well defined documentation control system, as well as the lack of input from the major contractors in generating the project plans. The other differences included the inability to achieve accurate budget proposals at various stages of the process, the non-availability of a well documented pre-shut pre-fabrication plan and the absence of review sessions to analyse challenges and the workability of the shutdown plan.

### **4.3 Budgeting Process**

According to the interview responses, 95% of the respondents indicated that the historical budgets are mostly considered when formulating a preliminary budget estimate for the shutdown. However, if the previous budgets were poorly planned, the efficiency of the new one would be heavily compromised. The starting point for the budgeting process is the scope of work. A good understanding of the scope of work is needed before any orders of magnitude could be applied to the existing data on previous budgets. The scope of work for the shutdown must be well defined at the end of phase 3. After defining the scope, a preliminary budget estimate can be achieved to within 30% accuracy.

From the final work list, the major tasks to be performed should be identified. These tasks should then be analysed to see whether they have been done before in the past. Orders of magnitude, taking into account all price changes and inflationary rates, should be applied to all tasks that have been performed before. Budget prices for all the other major tasks that an organisation has never done before, should be obtained from industry.

Costs of similar size shutdowns by other refineries in the industry can also be used to determine how accurate the estimate is.

Singh (2000) says that there is no common consensus in the industry as to which turnaround cost components constitute the shutdown or turnaround budget. He goes on to say that each company has its own unique budgetary composition which, either by intent or default, has evolved over the years. At PetroSA, 70% of the interview respondents indicated that the previous shutdown budgets form the basis for estimating the new requirements. However, the following inputs should be considered as well:

- Shutdown Duration
- Procurement of spares and materials
- Tools and equipment hire costs
- Labour resources to be hired directly by the client (PetroSA), taking into account all the scarce skills
- Transport, accommodation and catering costs for all labour coming from out of town
- Costs for site logistics and mobilisations
- Costs for the various contractors to be used during the shutdown
- Completion incentives for the contractors
- Shutdown philosophy
- A reasonable escalation factor for emergent work and possible delays due to bad weather

After the completion of the detailed planning phase, an accurate budget proposal can be presented to within 5% accuracy.

#### **4.3.1 The Challenges of the Budgeting Process**

*Completing shutdowns and turnarounds within approved budgets and cost estimates has recently emerged as a key turnaround performance objective. To achieve this goal, it is essential that the company have a sophisticated cost management function as part of the*

*turnaround management process. Despite the added focus on cost performance, most turnarounds have done a poor job in developing good budgets and managing turnaround costs. Over three-fourths of shutdowns and turnarounds have experienced cost overruns and failed to meet the established cost targets. (Singh 2000)*

The study of the PetroSA 2003 and 2006 shutdowns revealed that the organisation experienced cost overruns from the last two shutdowns. From the interview responses, 70% of the participants indicated that a lot of focus needs to be directed to area of budgets and cost management for the future shutdowns and turnarounds. The following were highlighted as the main causes of budget overruns at PetroSA:

- **Poor Budgeting** – The study of the PetroSA 2003 and 2006 shutdowns indicated that the shutdown budgets, in most instances, were not based on the actual scope of work. The procedures for generating the budgets were not the same as those for generating the scope of work, and this was a major discrepancy. The budgeting process should follow similar procedures as outlined for the work scope identification and validation process. The budgeting structures should be broken down to the lowest levels to ensure that all inputs at those levels are considered, including all contractor requirements.
- **Poor work scope identification** – As indicated above, poor work scope identification has a commensurate effect on the budgeting process. The effects of poor work scope identification could either cause an over or under-budgeting depending on the scoping process. The study of the PetroSA 2003 and 2006 shutdowns revealed that the work scope identification processes were under-estimated, resulting in the budgets being under-estimated as well.
- **Poor planning and scheduling of work** – The poor planning and scheduling of shutdown work leads to inefficiencies in the execution of jobs. If not optimized properly, poorly scheduled work leads to higher estimated costs. 75% of the interview respondents felt that the planning and scheduling of the 2006 shutdown work at PetroSA was not properly done. The scheduling of shutdown work should be given the necessary attention and enough preparation time that it deserves in order to develop an efficient execution plan. The scheduled work

should be broken down into smaller, manageable packs in order to avoid standing time of the field labour.

- **Poor supervision of the field labour and contractors** – Poor supervision leads to the inefficient execution of work on site and hence causing the costs to increase. The general tendency of the field labour and some contractors is to stretch the job durations especially if they are being on hourly rates. The study of the PetroSA 2003 and 2006 shutdowns revealed that poor site supervision, and hence low productivity, was a major contributing factor to the increase of the site costs.
- **Poor or non-existent cost management structures** - The study of the PetroSA 2003 and 2006 shutdowns revealed that cost management procedures were not properly developed and not well communicated. The main push on these shutdowns was to achieve the execution within schedule, without paying special attention to costs.
- **Emergent work** – Since majority of the emergent work is not budgeted for, it increases the costs when it comes up. According to Lenahan (1999), the petrochemical industry norm for emergent work is between 5 and 10%. From the PetroSA 2006 shutdown, the emergent was 23% of the original scope. The high rate of emergent work was mainly due to the poor work scope identification and validation process.
- **Contractors being allowed to mobilize on site while access to commence work is not available** – The standing costs charged by the contractors would be incurred by the client and this adds to the escalation of shutdown costs. The study of the PetroSA 2003 and 2006 shutdowns revealed that some contractors mobilized onto site while access to commence work was not yet granted.
- **Poor quality of workmanship** – The poor quality of workmanship leads to an increased costs as a result of reworks. The study of the PetroSA 2003 and 2006 shutdowns revealed that there were some reworks done on both shutdown periods, especially on welding jobs.
- **Safety incidents** – The medical costs resulting from any safety incidents contribute to increases on the shutdown or turnaround costs. From the 2006

PetroSA shutdown, two lost injuries occurred resulting in PetroSA incurring medical costs.

- **Industrial actions by the field labour, i.e. strike actions** – The study of the PetroSA 2003 and 2006 shutdowns revealed that industrial strike actions occurred during both shutdown periods resulting in costs being incurred by PetroSA.
- **Increase of the overall shutdown duration** – Additional costs get incurred by the client if execution period is extended. The additional expenses incurred include the payments for labour, site logistics and tools and equipment hire costs.
- **Poorly structured contracts** – If the contracts are poor structured, they leave room for manipulation by some contractors. The study of the PetroSA 2003 and 2006 shutdowns revealed that some of the major contracts had some flaws, which resulted in some contractors taking advantage and invoiced PetroSA more than more than their quotation values.
- **Poor pre-shutdown preparations** – The poor pre-shut preparations results in paying for additional resources to complete the jobs which should have been completed before the start of the execution phase. The study of the PetroSA 2006 shutdowns indicated that some of jobs done during the execution could have been done during the pre-shut preparation period.
- **Bad weather** – Because of safety considerations, any shutdown work is stopped in the event of rain and high wind speeds, unless the work is being performed in an enclosed environment. The suspension of work due to bad weather leads to an increase in costs as the client still pays for labour and other equipment standing costs. The study of the PetroSA 2003 and 2006 shutdowns revealed that a few bad weather days were experienced during both shutdown periods.

#### **4.3.2 The Contractors**

Contractors play major roles in the shutdown and turnaround execution processes. According to Singh (2000), the success of any turnaround will invariably depend upon the selection of the most qualified contractors and contractual arrangements to ensure the



highest contractor performance. At PetroSA, 70% of the respondents indicated that contractor management needs to be improved in order to get the highest benefits from the contractors. The following areas of concern regarding the contractors and contract management were raised:

- **Unclear scope of work for the contractor** – The scope of work for some contractors was not made very clear in the last two shutdowns (2003 & 2006). At PetroSA, major contractors were not consulted and involved during the work scope validation process. Hence, right from the start, there was no buy-in from the contractors on the scope of work.
- **The structure of the contract documents left room for exploitation by some contractors**
- **Poor planning and scheduling capabilities by some contractors** – Adherence to the shutdown schedules was made more difficult because some of the contractor lacked planning and scheduling capabilities
- **Poor quality control procedures by some contractors** – On the 2003 and 2006 shutdowns, some contractors did not have proper quality control procedures in their systems
- **Poor supervision of contractors by PetroSA staff** – During the last two shutdowns, the interview respondents indicated that proper field supervision of the contractors was lacking. The lack of proper field supervision would lead some contractors to stretching the duration of jobs, especially if they are being paid on rates basis.
- **Poor understanding of the vendor's contractual agreements by PetroSA field staff** – PetroSA field supervision tend to ask the contractors to do extra work, without really understanding the contractual implications of those actions.
- **Lack of ownership and commitment by some contractors**
- **Some contractors did not exercise proper control and discipline over their labour**

The two labour broker companies used on the 2006 shutdown at PetroSA lacked the capacity and capabilities to handle the huge volume of the labour contractors on site. A

lot of labour rated problems were picked up during the execution period which resulted in low productivity on site. 60% of the interview respondents felt that the labour broker companies did not do enough upfront planning and grossly under-estimated the labour issues that could arise during shutdowns.

#### **4.4 Shutdown Execution Phase**

This is the most resource intensive phase of the shutdown or turnaround with major involvement from several groups such as operations, safety, inspection, turnaround team, etc. The biggest challenge for the turnaround management team is to keep all participants focused and follow the established shutdown or turnaround plans. (Singh 2000)

As indicated above, following the established shutdown plans is the main focus of all the teams during the execution stage. The responses from the interview sessions indicated that during the 2006 shutdown at PetroSA, the coordination and communication of the shutdown activities was mainly done through meetings, both area specific and central shutdown meetings. The meetings resulted in good exchange of information on work progress, as well as identifying any imminent problem areas. However, the tracking of physical shutdown documentation (e.g. inspection requests, pipe & vessel repair approvals, pressure test & box up certificates, etc.) was not well coordinated and this resulted in some progress delays.

Various key performance indicators were used during the PetroSA 2006 shutdown to track progress and to highlight any imminent problem areas. From planning, the actual shutdown activities were tracked versus the plan, with major focus placed on the critical path activities for each respective area. The float on all the near-critical activities was measured, and consumption of this float would send a trigger to highlight that certain activities have become critical. Progress S-curves were also drawn up and tracked per area. The statistics for the 2006 shutdown at PetroSA are shown in table 4.1 below.

Refinery Shutdown Year	Shutdown Duration		Size of Shutdown		Emergent Work	
	Planned	Actual	Activities	Manhours	Manhours	Percent
PetroSA 2006	32 Days	39 Days	33777	189655	43500	23%

Table 4.1 – Shutdown Statistics

The base scope for the 2006 shutdown at PetroSA was 189 655 manhours, which was a total of 33 777 activities on the schedule. A total of 43 500 manhours of work were picked up as emergent work during the execution phase, which was 23% of the base scope of work. According to Lenahan (1999), the internationally acceptable rate of emergent work is between 5 – 10%. The actual duration of the shutdown was 39 days, with an overrun of 7 days on the original plan.

A study conducted at PetroSA in 2002 revealed that the spares and material costs were 46.2% of the total shutdown or turnaround costs at PetroSA. At the same time, the South African peer industries spent 26.7% of their total shutdown or turnaround costs on materials and spares, whereas the international petrochemical industries spent 33% on average. In South Africa, one reason for the major difference between PetroSA and its peers could be due to the geographical location of PetroSA, being situated far from the major industrial centres in the country. Banerji & Gopalakrishnan (2006) say that the total cost of the shutdown or turnaround tend to be exorbitant due to the cost of labour and materials in carrying out the overhaul and the cost of production loss due to idle plant.

#### 4.4.1 The Execution Challenges

The interview respondents indicated that the following were the challenges experienced during the shutdown execution phase at PetroSA 2003 & 2006 shutdowns:

- **Huge volumes of people on site with diverse backgrounds, behaviours and cultures** – This is one of the major challenges experienced by the management team during the execution phase of any shutdown or turnaround. Because of the diverse backgrounds and behaviours of individuals, it is quite difficult to develop

a common culture in the short space of time. The huge volumes make the control of labour quite difficult. This is also exacerbated by the lack of discipline by some individuals and contractors.

- **Poor mobilisation strategies of labour onto site** – Most of the interview respondents indicated that mobilisation of labour and contractors was a serious challenge for both the 2003 and 2006 shutdowns at PetroSA. The site induction and mobilisation programs were poorly managed, leading to frustrations even before the labour and contractors got onto site. The labour brokers, who were handling the recruitment of all the field labour, lacked the capacity and strategies to handle the huge volumes of the work force. The mobilisation processes caused some notable delays to the start of the execution, and also lead to some frustrations amongst the work force as it took a long time before they could eventually get onto site.
- **Shortage of critical skills** – The shortage of certain critical skills required for the shutdown execution has been highlighted as affecting the whole industry in the country. The study of the PetroSA 2003 and 2006 shutdowns revealed that specialized welders, instrument mechanics, riggers, planners and experienced supervisors are the critical skills in short supply in the industry. The skills' situation is even made worse if two or more refineries are shut down during the same period. Some refineries tend to offer higher packages to attract the scarce skills, hence creating competition in the industry.
- **Poor quality of shutdown labour and supervisors** – The study of the PetroSA 2003 and 2006 shutdowns also revealed that the competency levels of most supervisors and the work force were quite low. This had a direct effect on the quality of the work done, as well as the duration of executing the various tasks. Poor supervision also leads to an increase in safety incidents and costs. Hawkins & Kister (2006) say that plant shutdowns to perform maintenance work are the most expensive of all maintenance projects. This is due to the fact that labour costs are higher during shutdowns than normal operations.
- **Poor management and supervision of contractors** – One of the challenges faced by the execution teams is to ensure the efficient execution of all the work

done by contractors. According to the study of the PetroSA 2003 and 2006 shutdowns, the poor supervision of contractors in the field lead to low productivity levels by the contractors. If contractors are being paid on rates basis, they would naturally try to work longer durations in order to achieve maximum benefits.

- **Industrial action (strikes) by the labour force** – Both PetroSA 2003 and 2006 shutdowns had industrial strikes by the labour force. The shutdown execution schedules were seriously disrupted as a result of the industrial strikes. In both instances, the strike actions were caused by labour rates, i.e. that some categories of the labour were unfairly paid more than the others.
- **Delays in issuing of work permits from operations** – The study of the PetroSA 2003 and 2006 shutdowns revealed that the issuing of permits-to-work authorisations was a challenge experienced in both periods. The delays in issuing the permits were due to lack of pre-planning and organizing from the operations side, which resulted in execution delays on site. This, together with poor supervision and allowing the workforce to leave site without control, resulted in a loss of many manhours. Wireman (1994) says that on average, 2 hours are lost every time a worker is pulled off the job for any reason.
- **People taking short-cuts in executing their jobs** – On a number of occasions, some field personnel tried to use block permits in executing their jobs instead of individual, job-specific permits. This is a serious violation, which could lead to safety incidents.
- **Poor progress feedback from the field supervisors and contractors** – The study of the PetroSA 2003 and 2006 shutdowns revealed that some field supervisors were not consistent in providing progress feedback to the area planning teams. This created a huge challenge for the planning teams in communicating the accurate status of the execution phase. It was also noted that certain people were waiting for meeting times to report problems and concerns, instead of communicating these problems or concerns immediately they occurred.

- **Poor communication** – The study of the PetroSA 2003 and 2006 shutdowns indicated that communication was a big challenge experienced during the execution period. The communication channels were established for both shutdown periods, but the various participants were not well aligned with the procedures. Poor communication hampered the efficient decision making processes and also caused delays in the field execution.
- **Poor adherence to bar charts and schedules** – The study of the PetroSA 2003 and 2006 shutdowns revealed that most field personnel do not strive to adhere to the established bar charts and schedules for the execution. The study showed that the field supervisors need to be motivated and aligned to the required outcomes of the bar charts and schedules.
- **Emergent work** – Emergent work is one of the serious challenges experienced by the shutdown teams during the execution phase. To some degree, emergent work is a result of the poor work scope identification and validation process. The study of the PetroSA 2006 shutdown revealed that 23% of emergent work was picked up during the execution phase. Emergent work has a huge impact on the currently available shutdown resources, and if not well managed would cause an extension to the duration of the shutdown.
- **Poor cost management structures** – The study of the PetroSA 2003 and 2006 shutdowns revealed that the focus of trying to complete the shutdown execution period within the planned duration over-shadowed the importance of achieving the shutdown within costs. During the execution period, most supervisors concentrate their efforts on completing tasks and neglect the costs incurred in completing those tasks. Cost management in the shutdown management process has recently been highlighted as a major competitive tool in the petrochemical industry.
- **Poor coordination of shutdown documentation** – The study of the PetroSA 2003 and 2006 shutdowns revealed that lack of an established document control centre resulted in the poor coordination of documentation, especially during the execution period. Delays experienced in the processing of shutdown documentation resulted in the execution delays on site.

#### 4.4.2 The Safety Challenges

The study of the PetroSA 2003 and 2006 shutdowns revealed that one of the major challenges to safety was the ability to create a culture of high safety awareness among the huge numbers of the new employees on site. The large numbers of people created congestion on site, resulting in a lot of different activities being performed in close proximity to each other at the same time. Table 4.2 below outlines some safety statistics for the 2003 and 2006 shutdowns at PetroSA.

Refinery Shutdown Year	Number of People		Safety Statistics			
	People on Site	Safety Officers	Unsafe Acts	Minor Injuries	Lost Time Injuries	Fatal Injuries
PetroSA 2003	2500	8	*N/A	196	7	0
PetroSA 2006	4908	23	1366	104	2	0

\*N/A – Information not available for the 2003 shutdown

Table 4.2 – Comparative Safety Statistics

The number of employees during the 2006 shutdown almost doubled as compared to the 2003 shutdown, 4908 versus 2500. The total number of safety officers for the 2006 shutdown was 23, with a ratio of one safety officer for every 212 employees. On comparison, the 2003 shutdown had only 8 safety officers, with a ratio of one safety officer for every 312 employees. The unsafe acts and unsafe conditions was a new initiative introduced during the 2006 shutdown to highlight any situations that could lead to incidents. There were a total of 1366 unsafe acts and unsafe conditions identified in the 2006 shutdown. The number of minor and lost time injuries was lower for the 2006 period as compared to the 2003 period; this could be due to the higher ratio of safety officers to employees during the 2006 period.

The safety challenges highlighted from the study of the PetroSA 2003 and 2006 shutdowns were:

- **Poor adherence to the use of PPE** – The inconsistent use of PPE by the general work force was one of the major safety violations picked up during the two

directly to all the unsafe acts and minor injuries, as shown in table 4.2 – Comparative Safety Statistics. The most common PPE violations involved some employees not using their ear plugs, goggles and safety gloves. The other serious violations included some employees not following the laid down shutdown procedures, as well as not adhering to the conditions as shown on the issued permit-to-work authorisations. Poor house keeping, unsafe scaffolding and falling objects were the other serious safety incidents highlighted for the 2006 shutdown at PetroSA.

#### **4.5 Summary**

The response from the qualitative interviews indicated that a lot of challenges are faced in the shutdown management process, especially in the area of planning and preparation. Poor budgeting procedures result in the formulation of fragile cost estimates, which are further weakened by the absence of proper cost control structures. The execution period experiences challenges ranging from the mobilisation of employees onto site right up to the supervision of these employees on site. The poor supervisory skills experienced during the execution periods contribute to low levels of productivity from the field employees.

The management of contracts and contractors was another issue raised as directly contributing to the poor performance of most shutdowns and turnarounds. The lack of involvement of contractors during the work scope validation processes, as well as with the other shutdown preparation activities, contributes to the contractors not taking full ownership for the jobs under their responsibility.

The comparative data shows the performance of PetroSA between the two shutdown periods in consideration. The data shows that improper use of the personal protective equipment (PPE) and the violations to the shutdown procedures are the most common safety incidents picked up during the execution period.



## **Chapter 5. CONCLUSIONS AND RECOMMENDATIONS**

### **5.0 Introduction**

The recommendations highlighted in this chapter are based on the case study analyses of the PetroSA 2003 and 2006 shutdowns. In the planning process, improvements could be made in the area of work scope identification and validation, getting the contractors involved in the scope development process, carrying out scope challenge and workability review sessions and establishing shutdown documentation control centres. A model depicting the relevance and functioning of a document control centre is shown.

Improvements in the budgeting process are mainly focussed on establishing the budget formulation procedures that are similar to those of the work scope identification procedures. The budgeting process could also be streamlined by establishing proper cost management structures for the execution period, as well as by effectively managing contracts and contractors.

For the shutdown execution process, improvements could be achieved in the efficient mobilisation of resources, timely issuance of permit-to-work authorisations and the handling of emergent and additional work scope.

### **5.1 Recommendations and Conclusions**

The shutdown management process should follow the outlined phases and deliverables as outlined in chapter 4.2.1 (The shutdown Phases). However, to ensure that an organisation survives in the competitive commodities market, the shutdown management process must be executed efficiently so that the established milestones and deliverables are achieved in time and within the desired specifications.

### **5.1.1 Planning Process**

#### **Work scope Identification & Development:**

The success of any shutdown or turnaround depends upon the success of the planning and preparation phase. The work scope identification and development process forms the foundation of the entire planning process, and indeed the entire shutdown or turnaround management process. The results of a poor work scope identification and development process could lead to the late submissions of work requests, as well as to a lot of emergent work coming up during the execution phase. As mentioned in chapter 4, the PetroSA 2006 shutdown had 23% of emergent work as compared to the standard of 5 – 10% by pacesetter companies.

Shutdown work requests are normally submitted by operations, maintenance, inspection and projects departments. To ensure that only the essential work is done during the shutdown, the model shown in figure 2.1 (chapter 2) should be used to validate the work scope. This exercise must be done thoroughly, involving all the stakeholder departments and participants, with the main focus of generating a solid base for the shutdown or turnaround work scope.

In order to achieve higher efficiencies and effectiveness, the work scope must then be properly resourced using standard and acceptable norms. In the planning process, one of the gaps identified during the PetroSA 2006 shutdown was the resourcing of the various activities based on a supervisor's own experience (which could not be accurate at times). In order to avoid any inconveniences and to allow for any eventualities, most maintenance supervisors tend to over-resource. Standard and acceptable estimating norms should be distributed by the PetroSA shutdown team to avoid under and over-resourcing of activities. By taking a holistic picture of the entire shutdown or turnaround work scope, one could easily see that an organisation would lose millions of rands due to the over resourcing of activities.

The work scope management process should be meticulously done to ensure that all the relevant scope is identified and properly resourced in order to achieve the highest productivity. This exercise should be done early, preferably 12 – 18 months before the execution, to avoid any delays to the other phases of the shutdown management process. April & Gorelick (2004) say that achieving and sustaining competitive advantage requires organisations to learn better and faster from their success and failures.

**Incorporate the Contractor's Plans into the Master schedule:**

In order to ensure a total buy-in from the major contractors, the contractors must be involved in most of the shutdown management activities, especially the detailed scoping process. The major contractors must get involved immediately after the shutdown work scope has been identified and frozen. The contractors should be allowed to develop the detailed requirements and schedules for their portion of the work, and these should be verified and accepted by the company.

One of the gaps identified during the PetroSA 2006 shutdown was that some of the major contractors were not involved in the detailed scoping process. The work scope and the execution schedules were developed by the PetroSA shutdown and maintenance teams, and were passed onto the contractors for tender and execution purposes only. During the execution phase, the contractors highlighted a great deal of additional work which was not included in the tender documents and execution schedules that were given to them.

The benefits of involving the major contractors in the detailed scoping process can be seen in the minimal or lack of contractual disagreements at the end of the execution. The detailed scoping done by the contractors should be verified and accepted by the client, and their plans must be incorporated into the overall shutdown schedule in order to optimize the use of labour and other resources.

**Conduct the work scope challenge sessions:**

After the detailed scoping and the shutdown schedules have been drawn up, the scope challenge sessions involving all the stakeholders and participants must be conducted. The scope challenge sessions can be conducted during the pre-shut preparation phase and should preferably be done according to the defined areas. The participants from the following departments must be involved:

- Shutdown Planning team
- Operations or Production
- Process
- Maintenance personnel
- Inspection personnel
- Services personnel, e.g. scaffolding & insulation, etc.
- Projects
- The relevant major contractor in the area

The scoping challenge sessions are a good forum to re-check and ensure that the detailed scoping and resourcing have been correctly and optimally done. The sequencing and linking of the various activities are the other major activities accomplished during these sessions. Discrepancies, in terms of scope detail and resource quantities, will normally be picked up and corrected during these sessions. The scope challenge sessions must be championed by respective area planners and would normally take between 4 – 7 days for each area. If properly conducted, these sessions would ensure full buy-in from all the stakeholders and participants involved.

The scope challenge sessions were not done for the PetroSA 2003 and 2006 shutdowns. Some scope review sessions were done for both shutdown periods but were not well structured and did not involve the key participants, such as the major contractors.

### **Conduct workability review sessions:**

To ensure efficient execution of tasks, the workability review sessions are normally done on selected, highly complex jobs to be performed in the execution phase and must be conducted during the pre-shut preparation period. The workability reviews would involve complex tasks like the removal of an old vessel and installation of a new one during the execution period, using high tonnage cranes and equipment. Other activities include the dumping and re-loading of catalyst in huge vessels, including other heavy and dangerous operations involving the use of high tonnage cranes and huge equipment. The workability review sessions should be structured according to the following procedures (see Appendix B):

- Identify the high risk, high tonnage jobs according to the shutdown work scope
- Identify the material type and any hazardous substances to be handled
- Identify cranes and other major equipment required for the operation
- Identify all the participants and stakeholders in executing those jobs
- Identify the steps to be followed in executing the job
- Identify the exact positioning of the crane, clearly specifying the crane's allowable operating conditions, e.g. the maximum allowable wind speed, etc.
- Identify and highlight any possible safety hazards and what measures can be taken to mitigate such hazards
- The key participants should sign off the procedure, and this should finally be approved by the shutdown manager

The benefit of conducting effective workability reviews can be seen in the efficient execution of all major and hazardous operations during the execution period. The expensive shutdown resources, e.g. cranes and other major equipment, are efficiently optimised and congestion at the work sites is well managed.

**Define start-up plans by systems:**

In order to ensure a smooth start up, it is important to define the different systems or units or pieces of equipment that must be completed at the same time so that the respective sections of the refinery could be commissioned. The idea is to ensure that all the pieces of equipment that form a system should be made available as and when required to commission that system. The operations or production department must identify the different pieces of equipment that form the different systems and this information must be communicated to the planners to incorporate into the main schedule.

The different systems should be identified early enough during the planning process so as to avoid any rush or confusion during the commissioning phase. The field execution teams should in turn ensure that all the pieces of equipment that forms part of the various systems get completed in time just before the proposed commissioning time. The whole exercise requires good communication and coordination by all the parties involved.

**Make pre-shut preparation schedules:**

Systematic planning and accomplishment of pre-shutdown activities lays the foundation for a successful turnaround. In many ways, efficient execution of the pre-shutdown phase activities is critical to the success of plant shutdowns and turnarounds. Pacesetter companies treat this phase as an integral part of the shutdown execution, especially since it concerns issues such as safety and management controls. The pre-shutdown phase provides an excellent opportunity to fine tune field logistics and management controls. If some of these functions do not work as effectively as intended, one would bet that they would experience the same problems during the shutdown execution phase. (Singh 2000)

The pre-shutdown preparation phase, like the execution phase, must have a detailed schedule outlining all the activities and milestone dates. This phase allows the shutdown team to test the effectiveness of all the procedures and policies drawn up for the execution period. It gives an opportunity to alter the procedures that are found to be defective. The pre-shutdown phase must also ensure that all the preparations, i.e. prefabrication and site logistics, are in place before the execution starts. Hence, a detailed

schedule must be drawn up and tracked with the same level of attention as that intended for the main execution schedule.

**Set up the shutdown documentation control systems:**

There are so many requests and approval documents raised during the execution period such that the absence of an established document control system leads to poor coordination of these documents, resulting in execution delays on site. The PetroSA 2003 and 2006 shutdowns did not have formalised procedures for the routing of the various documents. The poor coordination of documents between the field execution teams, contractors, inspectors and the fabrication crews caused notable execution delays on site.

The document control centres should be custodians of all the individual equipment packs, and indeed the defined system packs, for each respective area. Information on the work progress for each piece of equipment should be communicated to the document control centres by the planners and the execution supervisors so that the equipment packs are continuously updated to reflect the current status. All the other shutdown documents, like the pipe repair approvals (PRA's), vessel repair approvals (VRA's), pressure test certificates and emergent work requests must be registered and routed through the document control centres. Figure 5.1 below, shows that the document control centre plays a central role in the coordination of all shutdown or turnaround documentation.

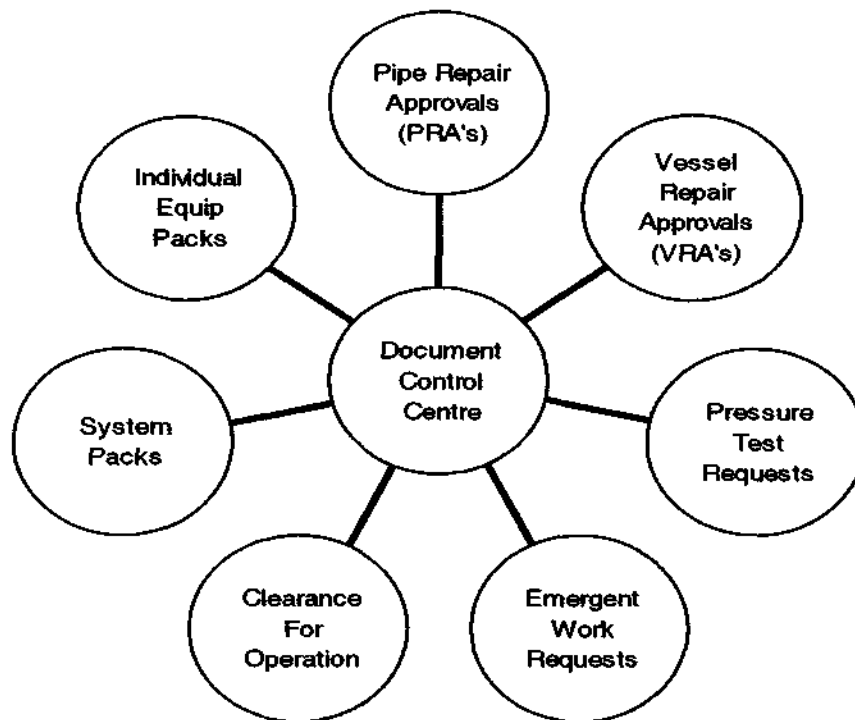


Fig. 5.1 – Document Control Model

The document control centres will play an even bigger role during the commissioning stage. As the equipment packs are updated and signed off on a continuous basis, the centres would be better positioned to advise which systems are ready for commissioning. The document control centres should keep track of all the documents required to issue a clearance for operation certificate (CFO).

### 5.1.2 Budgeting Process

#### **Budget formulation process based on actual work scope:**

The process of formulating the shutdown budget should be based on similar procedures as those for generating the shutdown work scope. The budgeting process must be inclusive and should be broken down into various work breakdown structures, up to the lowest inputs in each structure. The model shown below, in figure 5.2, highlights the process of identifying the preliminary budget estimate for the shutdown or turnaround.



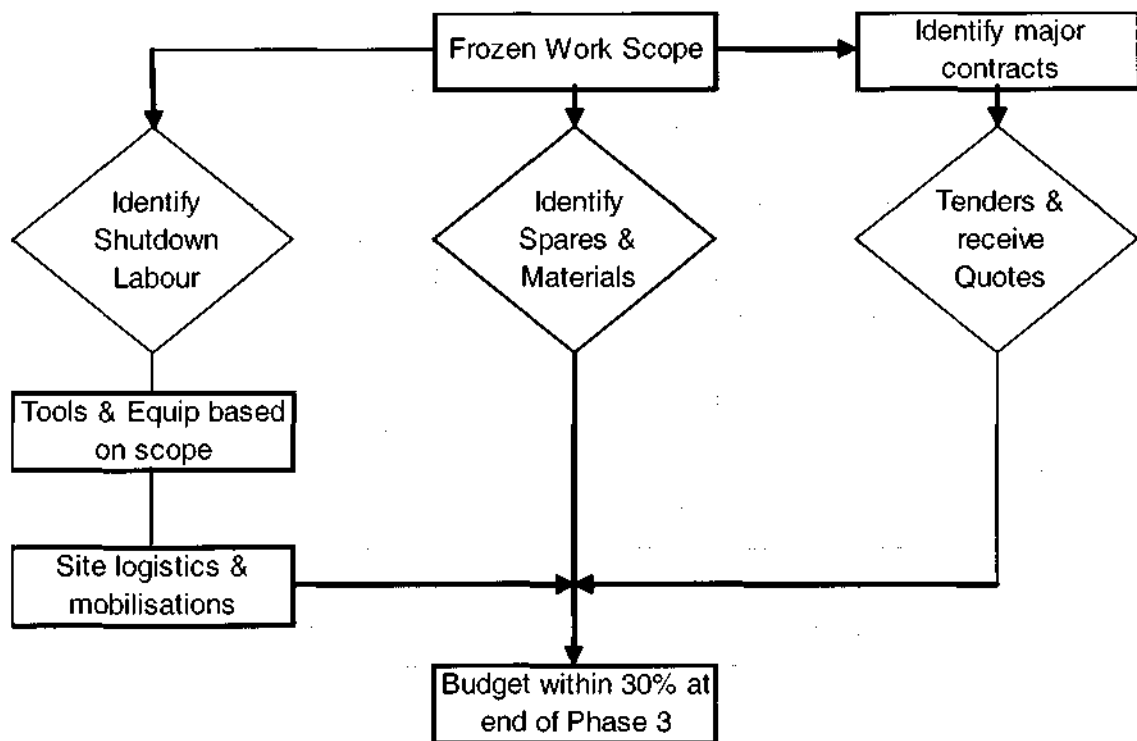


Fig. 5.2 – Preliminary Budget estimation Model

### **Cost Management Structures:**

The lack of proper cost management structures in most shutdowns or turnarounds lead to the poor cost controls. According to Singh (2000), the cost control system should be designed to not only track cost commitments, but also to provide data to analyse cost performance to date and to forecast costs at shutdown completion. These structures should be built up early in the shutdown management process so that their effectiveness could be tested as the preparations proceed. The cost management structures should include the following:

- Well defined cost breakdown structures for each area
- Cost commitment and expenditure curves for each area
- Performance tracking systems to monitor the contractors' expenditure
- A well defined approval system for expenditures on emergent or additional work requests for each area
- A system to trigger any cost deviations during the execution

### **Contracts and contractors:**

The structure of the contract documents must be carefully worded to ensure that the interests of both the client and the contractor are taken care of. The scope of work for the contractor must be clearly defined, including any special conditions or requirements, and should be accompanied with the relevant drawings or specifications. It is important to mention that the structure and contents of the contract documents must be done properly to avoid any claims at the end of the execution:

- The work scope and all specifications should be clearly stated in the contract document
- The contract document should clearly state the procedure to be followed by both the client and the contractor in the case of emergent or additional work being picked up during the execution period
- The expected performance from the contractor should be clearly stated in the contract document. The definition of performance should also include the quality of workmanship expected from the contractor
- Penalty clauses should be clearly stated in the contract document and must be communicated to the contractors
- The procedure of handling any conflicts between the client and the contractor must be clearly documented
- The contract document should also state the type of causes and reasons why a contractor would be asked to leave site. The document should clearly state the procedure to be followed in doing that.
- Incentive bonuses, where applicable, should also be clearly stated in the contract document
- The state of cleanliness in which the site must be left after the execution should also be stated in the contract document
- The rules of engaging sub-contractors, where applicable, should be clearly stated

In order to achieve good performance from the contractors, they must be engaged early enough to ensure that they participate in the work scope validation processes. By doing

this, the major contractors will develop a sense of ownership and responsibility. The shutdown management team should strive to involve the contractors in the various activities of the shutdown management process so that they develop a total buy-in.

### **5.1.3 Shutdown Execution**

#### **Mobilisation of labour resources onto site :**

The mobilisation of labour resources onto site must be well planned and managed to avoid any delays on the start date of the execution process. The planning and organising for labour resources is neglected during the preparation phases of most shutdowns and turnarounds. In most cases, when it is too late, last minute efforts are put in to try and ensure a smooth start to the execution process. The shutdown management team soon realises that the planning for the resource mobilisation should have been started long ago.

The planning and organising for labour resource mobilisations should be started early enough to ensure that all systems are developed and implemented before the actual mobilisation starts. Some of the South Africa refineries employ the shutdown labour force through labour brokers, whilst others prefer the major contractors to be directly responsible for all the hired employees. Both systems have advantages and disadvantages, but whichever option is preferred, the company must ensure that the labour brokers or the contractors have the capacity and systems to handle the huge volume of employees.

Poor mobilisation strategies create frustrations among the employees, leading to low morale just before the start of the shutdown. The shutdown management team must ensure that the labour brokers or the contractors have the capacity and structures to handle the huge volumes of employees in a short space of time, and should also create sound plans and procedures for carrying out the mobilisations. The best time to check and test the effectiveness of these procedures is during the pre-shutdown preparation phase, and any flaws identified should be corrected immediately.

### **Issuing of permits-to-work authorisations:**

As part of the turnaround planning, permit requirements should be identified for all approved work orders. In the past, field performances have been adversely affected by the late issuance of shutdown permits. Since the majority of safety permits are required at the beginning of each shift, any delays slow down the field work. We have seen many shutdowns where permit delays of 1 – 2 hours are very frequent and, in some cases, these delays are expected and are considered normal. (Singh 2000)

In most South African refineries, the late issuance of permit authorisations is very common. This invariably leads to low morale among the field execution teams, and affects the productivity of the whole execution process quite significantly. This directly translates into the poor competitiveness of the refinery among its peers and contributes to the increase in the shutdown costs. Hence, the permit issuance process must be well thought out and planned, as a refinery could gain a competitive advantage in this area.

### **Safety:**

The most common incidents during shutdowns or turnarounds are related to the improper use of personal protective equipment (PPE) and the violations of shutdown procedures like permit-to-work systems. The other serious incidents include falling objects, the use of unsafe scaffolding and unauthorised entry into vessels. Most of these incidents could be avoided, but the challenge on the shutdown management team lies in establishing a safe working culture in a short space of time among employees coming from diverse backgrounds, cultures and beliefs. The shutdown or turnaround safety policies and procedures should be developed early enough during the preparation period. Wells (1997) says that maintenance operations require careful consideration if they are to be undertaken without undue risk.

One of the most effective ways of establishing a safe working culture among the diverse groups of employees is through communication and incentive systems. The safety communication system should be efficient ensuring that all employees are timeously well-informed, and incentives must be given to people working safely or promoting a

safe working culture. A culture of doing the daily toolbox talks should be entrenched among all the field execution teams. The employees must be encouraged to think about safety all the time whilst working, and to look out for things that could go wrong in their surroundings.

#### **Handling of emergent and additional work:**

To some degree, emergent work always comes up during the execution phase in most refineries around the world. The distinguishing factor is the amount of emergent work that a particular refinery picks up during the execution period, and this contributes to classifying the refinery as a pacesetter, an average or a laggard amongst its peers. The amount of emergent or additional work scope that gets picked up during the execution phase is largely determined by the level and quality of work done during the work scope identification and validation phase.

When it does arise, emergent work should be handled in the most efficient and cost effective way to ensure minimal disruption to the overall shutdown schedule. Structures and procedures of dealing with emergent work must be designed and implemented during the preparation stages of the shutdown process. The procedures for approving emergent work should be clearly communicated to all, especially the field supervisors, in order to avoid the uncontrollable escalation of shutdown costs. The considerations for approving the emergent work should first be based on safety implications, then costs and finally the impact on the schedule.

Schedules of all emergent work should be drawn up by the planners with input from all the relevant parties, and these must then be incorporated into the overall shutdown schedule. The planners must work out the resources requirements for the emergent work, as well as the impact it has on the overall schedule. As far as practical, the current resources should be utilised to address the emergent or additional work scope, and only in special circumstances should the extra resources be mobilised.

### **Shortage of critical skills:**

The current shortage of critical skills, i.e. planners, supervisors, instrument mechanics, specialised welders and riggers, is affecting the entire petrochemical industry in South Africa as a whole. The shortage of these critical skills is affecting the shutdown process through poor quality of workmanship, resulting in increased shutdown costs and durations. The situation is exacerbated when two or more refineries shut down during the same period, and having to recruit from the same pool of resources.

In their shutdown business models, refineries should make allowances to upgrade or re-skill some of the employees to be used on their shutdowns. From past experiences, it can be observed that the costs of poor workmanship far out-strip the costs that could be invested in training certain categories of the labour market in the petrochemical industry. The benefits of training some of the skills for the shutdown or turnaround would contribute to increasing the shutdown or turnaround productivity, as well as the quality of the workmanship.

## **5.2 Summary**

The planning and preparations for shutdowns and turnarounds should be well structured to ensure that all the key milestones get achieved before the execution could start. Kenyon (2004) says pacesetters typically have multiple gates or phases in their shutdown or turnaround planning, scheduling and implementation processes. One of the major areas of focus is the planning process, where the identification and validation of the work scope lays a solid foundation. Nyman & Levitt (2001) say that each dollar invested in planning typically saves three to five dollars during work execution and that the duration of a planned job is commonly only half as long as that of an unplanned job.

In order to be competitive, the formulation of the budgets should be meticulously done ensuring that the process is based on similar procedures as those for generating the work scope.

To ensure high productivity during the execution period, the supervision of the employees and the contractors should be of a high quality. Refineries should ensure that the issuance of permit-to-work authorisations at the start of each shift is done with minimal delays. The emergent and additional work that comes up during the execution period must be handled in the most efficient and cost effective way to ensure minimal disruption to the schedule and costs.

## Appendix A – The Planning Process Template

Shutdown Phase	Planning Activities & Milestones achieved during each Phase	PetroSA			Pacesetter Companies		
<b>Phase 1</b> <i>Initiation</i>	1. Align Business & Equipment integrity plans		✓			✓	
	2. Establish execution time frame		✓			✓	
	3. Issue the initial budget target		✓			✓	
<b>Phase 2</b> <i>Conceptual Development</i>	1. Develop shutdown philosophy & objectives		✓			✓	
	2. Define success criteria & KPI's		X			✓	
	3. Develop shutdown organogram and milestones		✓			✓	
	4. Define shutdown documentation system		X			✓	
	5. Define the preliminary contracting strategies		✓			✓	
<b>Phase 3</b> <i>Scope Detail</i>	1. Carry out detailed scope identification		✓			✓	
	2. Identify labour & contractor requirements		✓			✓	
	3. Submit tasks lists/routings for tender process		✓			✓	
	4. Produce an initial budget proposal (within 30%)		X			✓	
	5. Create work orders and initiate ordering of spares		✓			✓	
<b>Phase 4</b> <i>Detailed Planning &amp; Scheduling</i>	1. Create planning/scheduling work orders		✓			✓	
	2. Incorporate contractors' plans into master plan		X			✓	
	4. Define Resource requirements		✓			✓	
	5. Schedule & produce execution barcharts		✓			✓	
	6. Produce a pre-shut pre-fabrication plan		X			✓	
	7. Define shutdown & startup plans by systems		X			✓	
	8. Produce cost estimates within 10% accuracy		X			✓	
<b>Phase 5</b> <i>Pre-shut Preparations</i>	1. Do scope challenge sessions		X			✓	
	2. Do workability review sessions		X			✓	
	3. Complete all pre-shut prefabrication work		✓			✓	
	4. Mobilise contractors, support services & logistics		✓			✓	
	5. Establish the costs tracking systems		X			✓	
	6. Set up the document control offices & systems		X			✓	
	7. Produce cost estimates within 5% accuracy		X			✓	
<b>Phase 6</b> <i>Shut Execution</i>	1. Issue look-ahead plans		✓			✓	
	2. Track progress (actual versus plan)		✓			✓	
	3. Make plans for all emergent work		X			✓	
	4. Use KPI's to highlight the shut performance		✓			✓	
	5. Keep daily records of actual performance		✓			✓	
<b>Phase 7</b> <i>Post-shut Close out</i>	1. Final completion reports		✓			✓	
	2. Review details of actual versus plan		X			✓	
	3. Conduct post-mortem review sessions		✓			✓	
	4. Update & improve task lists in the CMMS		X			✓	



## Appendix B – Workability Reviews Template

<b>WORKABILITY REVIEW SESSION</b>			
<b>DATE OF REVIEW:</b>		<b>SECTION:</b>	
<b>EQUIPMENT NO. &amp; DESCRIPTION:</b>		<b>APPROVED BY:</b>	
<b>Work Description:</b> _____ _____ _____			
<b>Departments involved in the Study</b> 1. Safety _____ 2. Operations _____ 3. Maintenance _____ 4. Environmental _____ 5. Services _____ 6. Projects _____ 7. Contractors _____ 8. Other _____			
<b>Dimensions of Equipment:</b>		<b>Material of Construction:</b> _____	
Length, m	Dia., m	Height, m	Wt., kg
		<b>Hazardous Material: Yes or No</b>	
		<b>Possibility of Hazardous Spill: Yes or No</b>	
<b>Craneage Requirements:</b>		<b>Position of Equipment from Crane:</b>	
Size	Boom sections	Horizontal Distance	
		Vertical Distance	
<b>Procedure to be followed in Executing the Job:</b> 1 _____ 3 _____ 2 _____ 4 _____			
<b>Mitigating Measures: What incidents can happen with this operation:</b> 1 _____ 3 _____ 2 _____ 4 _____			
<b>Mitigating Measures: What can cause these incidents to happen:</b> 1 _____ 3 _____ 2 _____ 4 _____			
<b>Mitigating Measures: What can be done to prevent these incidents happening:</b> 1 _____ 3 _____ 2 _____ 4 _____			
<b>Approvals:</b>  <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <span>_____ Safety</span> <span>_____ Operations</span> <span>_____ Mechanical</span> <span>_____ Environmental</span> </div>			

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6. Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.

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7. How far before the shutdown execution does your department start the planning process?

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8. At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?

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9. How is the information required for the shutdown plan gathered?

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10. How are the activity resources and durations on the plan worked out?

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11. What factors are considered when formulating a preliminary budget estimate for the shutdown?
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12. At what stage of the process can an accurate budget forecast presented?

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13. Give a list of the causes of budget over-runs for the shutdown in your department.

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14. What conflicts or areas of concern do you experience with the contracting companies in your department?

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15. How do you quantify the work to be contracted out, and are the contractors involved in this process?

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16. What critical skills' shortages do you experience during the shutdown execution?

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17. How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?

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18. What key performance indicators do you use during the shut execution phase and how effective are they?

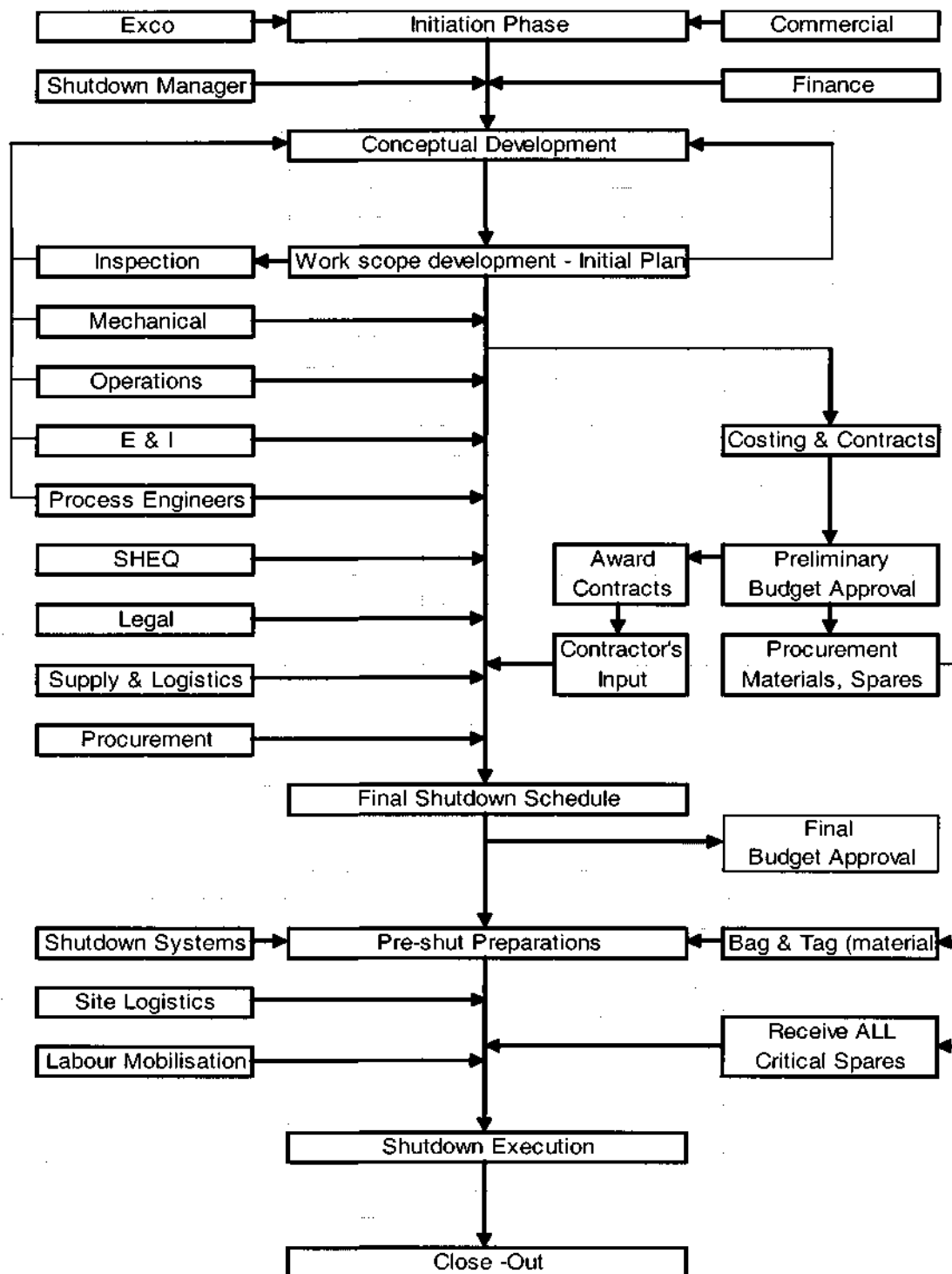
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19. What feedback control mechanisms do you use during shut execution phase and how effective are they?

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20. How is the emergent work handled during the shutdown execution phase?

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21. Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.

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- 
22. What challenges, in relation to safety, does your organization experience during the shut execution?

## Appendix D – The Shutdown Management Workflow Model



## Appendix E – The Responses from the Interview Sessions

No.	Question	Respondent #1	Respondent #2
1	What is your specific role in the whole shutdown management process?	<ul style="list-style-type: none"> <li>• SHEQ Plans – To ensure that Safety, Security, Health &amp; Environment (SSHE) plans are in place</li> </ul>	<ul style="list-style-type: none"> <li>• Collecting work scope, Detailed execution planning, Detailed scheduling, direct resource quantity determination, Assistance with execution coordination &amp; monitoring &amp; reporting execution progress</li> </ul>
2	Could you describe the planning philosophy used by your department for the shutdown management process?	<ul style="list-style-type: none"> <li>• Determine Safety Requirements Area (Top 5 Risks)</li> <li>• Identifying unsafe Acts &amp; Conditions</li> <li>• Identifying Safety Resources Required</li> </ul>	<ul style="list-style-type: none"> <li>• 7-Phase Project Planning</li> </ul>
3	Which other functional disciplines are involved or contribute to the whole shutdown management process?	<ul style="list-style-type: none"> <li>• All Depts - Operations, Process, Mech, elect &amp; Control Systems Reliability, Inspection Dept, SHEQ Dept, Commercial &amp; Finance Depts, Projects, HR &amp; IR Depts, Contracts &amp; Procurement.</li> </ul>	<ul style="list-style-type: none"> <li>• All Depts - SD Mgr with SD team, All reliability groups, All services groups, Production, Inspection, Commercial, SHEQ, Logistics, Procurement &amp; Warehousing &amp; Process</li> </ul>
4	How does your department communicate with the other functional disciplines or departments?	<ul style="list-style-type: none"> <li>• Flash Reports</li> <li>• Central safety meetings</li> <li>• During Shutdown, small teams attend area meeting &amp; report to central safety</li> </ul>	<ul style="list-style-type: none"> <li>• Via SD forum; SD meetings (central &amp; Area)</li> <li>• E-mail</li> <li>• Centralized documents on network server</li> <li>• Centralized documents on SAP</li> </ul>
5	What activities does the planning department achieve in each phase of the shutdown management process?	<ul style="list-style-type: none"> <li>• 7 - Phase approach - SHEQ is catered for at every stage (Identify safety requirements in some phases)</li> </ul>	<ul style="list-style-type: none"> <li>• PH 1 - Project Plan</li> <li>• PH 2 - Scope Summary</li> <li>• PH 3 - Scope Detail</li> <li>• PH 4 - Task lists, schedules, resources</li> <li>• PH 6 - Progress Reports</li> <li>• PH 7 - Closure of all jobs</li> </ul>

No.	Question	Respondent #3	Respondent #4
1	What is your specific role in the whole shutdown management process?	<ul style="list-style-type: none"> <li>• Planning, Support function to SD Mgr</li> </ul>	<ul style="list-style-type: none"> <li>• SD Mgr; Planning, budget estimate, SHEQ, &amp; execution</li> </ul>
2	Could you describe the planning philosophy used by your department for the shutdown management process?	<ul style="list-style-type: none"> <li>• 7 PH methodology</li> </ul>	<ul style="list-style-type: none"> <li>• 7 PH methodology; PH1 – Initiation, PH2 – Conceptual Development, PH3 – Scope &amp; Commercial Development; PH4 – Detailed planning, PH5 – Pre-shut, PH6 – Execution, PH7 – Close-out</li> </ul>
3	Which other functional disciplines are involved or contribute to the whole shutdown management process?	<ul style="list-style-type: none"> <li>• <u>All Depts</u> - Operations, Process, Mech, elect &amp; Control Systems Reliability, Inspection Dept, SHEQ Dept, Commercial &amp; Finance Depts, Projects, HR &amp; IR Depts, Contracts &amp; Procurement.</li> <li>• Commercial should get more involved</li> </ul>	<ul style="list-style-type: none"> <li>• <u>All Depts</u> - Exco, Operations, Process, Mech, elect &amp; Control Systems Reliability, Inspection Dept, SHEQ Dept, Commercial &amp; Finance Depts., Projects, HR &amp; IR Depts., Contracts &amp; Procurement, Legal, Logistics, TS &amp; L.</li> <li>• Commercial should get more involved</li> </ul>
4	How does your department communicate with the other functional disciplines or departments?	<ul style="list-style-type: none"> <li>• Area Planners should have area meetings</li> <li>• Centralized documents on network server (quite successful - G /Drive)</li> </ul>	<ul style="list-style-type: none"> <li>• Internal meetings - Generic plan of how &amp; what feedback are in place</li> <li>• Internet &amp; Intranet; newspapers &amp; industry information - Plans in place</li> <li>• Challenge - is tracking of physical documents!!</li> </ul>
5	What activities does the planning department achieve in each phase of the shutdown management process?	<ul style="list-style-type: none"> <li>• PH 1 - Overall Project Plan</li> <li>• PH 2 - Identify scope summary by discipline (Can estimate a rough Budget cost at this stage)</li> <li>• PH3 - Scope Detail</li> <li>• PH 4 - Detailed Planning</li> <li>• PH 5 Pre-shut preparations</li> <li>• PH 6 - Execution (Daily reports, progress per area &amp; identify threats</li> <li>• PH 7 - Close out work orders; Reports</li> </ul>	<ul style="list-style-type: none"> <li>• PH 1 - Dates &amp; Budgets, roles &amp; Responsibilities</li> <li>• PH2 - Conceptual development</li> <li>• PH3 - Scope optimisation</li> <li>• PH 4 - Detailed Planning</li> <li>• PH 5 - Preshut &amp; mobilisation of resources</li> <li>• PH 6 - Execution</li> <li>• PH 7 - Close out &amp; Reports</li> </ul>

No.	Question	Respondent #5	Respondent #6
1	What is your specific role in the whole shutdown management process?	<ul style="list-style-type: none"> <li>• SD Eng – Responsible for all area SDs &amp; T/As</li> </ul>	<ul style="list-style-type: none"> <li>• SD Eng – Responsible for all area SDs &amp; T/As</li> </ul>
2	Could you describe the planning philosophy used by your department for the shutdown management process?	<ul style="list-style-type: none"> <li>• 7 PH methodology</li> </ul>	<ul style="list-style-type: none"> <li>• 7 PH methodology</li> </ul>
3	Which other functional disciplines are involved or contribute to the whole shutdown management process?	<ul style="list-style-type: none"> <li>• <u>All Depts</u></li> </ul>	<ul style="list-style-type: none"> <li>• SHEQ</li> <li>• Procurement</li> <li>• Services</li> <li>• HR</li> <li>• Commercial should get more involved (in 2006 commercial were not very involved)</li> </ul>
4	How does your department communicate with the other functional disciplines or departments?	<ul style="list-style-type: none"> <li>• Via E-mails &amp; meetings ; central document Control is NOT available</li> <li>• Procedures are in place BUT are not properly communicated</li> </ul>	<ul style="list-style-type: none"> <li>• Meetings</li> <li>• E-mail &amp; through the shared database</li> </ul>
5	What activities does the planning department achieve in each phase of the shutdown management process?	<ul style="list-style-type: none"> <li>• 7 PH approach - obtain a lot of information from the area teams</li> </ul>	<ul style="list-style-type: none"> <li>• Identify the process in the planning</li> </ul>



No.	Question	Respondent #7	Respondent #8
1	What is your specific role in the whole shutdown management process?	<ul style="list-style-type: none"> <li>• PetroSA SD IR specialist - Ensure fairness, handle disciplinary grievances &amp; industrial strikes</li> </ul>	<ul style="list-style-type: none"> <li>• Project Mgt - Developing of scope &amp; planning</li> </ul>
2	Could you describe the planning philosophy used by your department for the shutdown management process?	<ul style="list-style-type: none"> <li>• No disquiet contractors on site</li> <li>• Team meetings &amp; toolbox talks</li> </ul>	<ul style="list-style-type: none"> <li>• 7 PH approach</li> </ul>
3	Which other functional disciplines are involved or contribute to the whole shutdown management process?	<ul style="list-style-type: none"> <li>• <u>All PetroSA depts</u></li> </ul>	<ul style="list-style-type: none"> <li>• All Depts. - Support function - financial &amp; commercial</li> <li>• SD dept, procurement &amp; central planning</li> <li>• Inspection, Mech, Production</li> <li>• Process</li> <li>• Services</li> <li>• Commercial should get more involved</li> </ul>
4	How does your department communicate with the other functional disciplines or departments?	<ul style="list-style-type: none"> <li>• Daily meetings &amp; e-mails</li> <li>• Challenge - Big meetings are not effective, as people don't fully express themselves!!</li> </ul>	<ul style="list-style-type: none"> <li>• Meeting which are accurately minuted, as well as face-to-face meetings</li> <li>• Central database</li> <li>• Electronic means - e-mails</li> </ul>
5	What activities does the planning department achieve in each phase of the shutdown management process?	<ul style="list-style-type: none"> <li>• SKIP! [No Response]</li> </ul>	<ul style="list-style-type: none"> <li>• PH 1 - Initiation, kick off &amp; rough time lines</li> <li>• PH 2 - SD policy</li> <li>• PH 3 - Detailed scope</li> <li>• PH 4 - - VRA's, PRA's creating work orders &amp; finalizing task lists</li> <li>• PH 5 - Mobilizing logistics &amp; mgt structures</li> <li>• PH 6 - execution</li> <li>• PH 7 - Close out documentation</li> </ul>

No.	Question	Respondent #9	Respondent #10
1	What is your specific role in the whole shutdown management process?	<ul style="list-style-type: none"> <li>• Fabrication &amp; Services Mgr – Responsible for all fabrication &amp; services, i.e. scaffolding, insulation, High Pressure cleaning, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Lead, Manage &amp; coordinate the whole shutdown or Turnaround project (SD Manager PetroSA 2006 shutdown)</li> </ul>
2	Could you describe the planning philosophy used by your department for the shutdown management process?	<ul style="list-style-type: none"> <li>• Determine Fab &amp; Services requirements for the SD</li> </ul>	<ul style="list-style-type: none"> <li>• Defn SD as offline maintenance of GTL units, commons plus all refinery units. (Incl synthol units)</li> <li>• LPO opportunity ~ R65M, 19 mech days</li> <li>• Total GTL budget ~ R204M</li> </ul>
3	Which other functional disciplines are involved or contribute to the whole shutdown management process?	<ul style="list-style-type: none"> <li>• Planning dept, Procurement/contracts, Purchasing/warehousing, production, engineering, service dept IR &amp; external logistics</li> <li>• Commercial should get more involved</li> </ul>	<ul style="list-style-type: none"> <li>• All Depts. - Exco, Operations, Process, Mech, elect &amp; Control Systems Reliability, Inspection Dept, SHEQ Dept, Commercial &amp; Finance Depts., Projects, HR &amp; IR Depts., Contracts &amp; Procurement, Legal, Logistics, TS &amp; L.</li> </ul>
4	How does your department communicate with the other functional disciplines or departments?	<ul style="list-style-type: none"> <li>• Meeting</li> <li>• Central database</li> <li>• Electronic means - e-mails</li> </ul>	<ul style="list-style-type: none"> <li>• Meeting structures</li> <li>• Memos</li> <li>• Electronic means - e-mails</li> <li>• telephone</li> </ul>
5	What activities does the planning department achieve in each phase of the shutdown management process?	<ul style="list-style-type: none"> <li>• SOW - prelim phases, including budget estimate</li> <li>• Challenge SOW</li> <li>• More accurate</li> <li>• Pre-shut phase; prefabs; contracts</li> <li>• Execution</li> </ul>	<ul style="list-style-type: none"> <li>• Firm up all the work items related to work lists that have been submitted by functional experts</li> </ul>

No.	Question	Respondent #11	Respondent #12
1	What is your specific role in the whole shutdown management process?	<ul style="list-style-type: none"> <li>• Central labour control</li> <li>• Cost optimization, investigate &amp; implement methods of reducing costs</li> </ul>	<ul style="list-style-type: none"> <li>• Planning &amp; Execution of Project Work</li> <li>• Time &amp; Attendance mgt</li> </ul>
2	Could you describe the planning philosophy used by your department for the shutdown management process?	<ul style="list-style-type: none"> <li>• 7 PH approach</li> </ul>	<ul style="list-style-type: none"> <li>• MS Projects</li> <li>• Aligned with main SD Plan</li> </ul>
3	Which other functional disciplines are involved or contribute to the whole shutdown management process?	<ul style="list-style-type: none"> <li>• <u>All depts</u></li> <li>• Concern: HC &amp; Services depts should be more involved!</li> </ul>	<ul style="list-style-type: none"> <li>• <u>All depts</u></li> <li>• Concern: Commercial &amp; Finance should get more involved!</li> </ul>
4	How does your department communicate with the other functional disciplines or departments?	<ul style="list-style-type: none"> <li>• Centralised documents on the central server</li> </ul>	<ul style="list-style-type: none"> <li>• Daily Meetings</li> <li>• Internal meeting attended by fab</li> </ul>
5	What activities does the planning department achieve in each phase of the shutdown management process?	<ul style="list-style-type: none"> <li>• Could do better: The handling of additional work / emergent work</li> </ul>	<ul style="list-style-type: none"> <li>• Initial plan</li> <li>• as scope is made available a detailed plan is done</li> </ul>

No.	Question	Respondent #13	Respondent #14
1	What is your specific role in the whole shutdown management process?	<ul style="list-style-type: none"> <li>• Area Production Manager (operations)</li> <li>• Making equip available for inspection &amp; maintenance</li> <li>• Providing safety standby's</li> </ul>	<ul style="list-style-type: none"> <li>• Site Manager for Kentz (at Engen Refinery site)</li> <li>• To coordinate all the work from planning, to preparation &amp; through to execution and close-out</li> </ul>
2	Could you describe the planning philosophy used by your department for the shutdown management process?	<ul style="list-style-type: none"> <li>• Part of a multi-disciplinary team: Identify equipment that requires maintenance</li> </ul>	<ul style="list-style-type: none"> <li>• 5 - phase approach; 1. cost estimation 2. Planning &amp; preps 3. Detailed planning 4. Execution 5. Close out</li> </ul>
3	Which other functional disciplines are involved or contribute to the whole shutdown management process?	<ul style="list-style-type: none"> <li>• <u>All depts</u></li> <li>• Commercial should get more involved</li> </ul>	<ul style="list-style-type: none"> <li>• Inspection, Process, Operations &amp; safety</li> </ul>
4	How does your department communicate with the other functional disciplines or departments?	<ul style="list-style-type: none"> <li>• Daily Meetings</li> <li>• Via area allocated people/persons</li> </ul>	<ul style="list-style-type: none"> <li>• Daily Meetings</li> <li>• written communication, by radio, verbal &amp; no emails encouraged during the execution</li> </ul>
5	What activities does the planning department achieve in each phase of the shutdown management process?	<ul style="list-style-type: none"> <li>• Getting information from all the other disciplines</li> <li>• Compiling of schedules, activities &amp; durations</li> </ul>	<ul style="list-style-type: none"> <li>• High level plan; plan for plan; work scope identification; progress; learnings</li> </ul>

No.	Question	Respondent #15
1	What is your specific role in the whole shutdown management process?	<ul style="list-style-type: none"> <li>• QA/QC Manager for Kentz (at Engen Refinery site)</li> <li>• To coordinate all the work inspection, quality &amp; handover documentation</li> </ul>
2	Could you describe the planning philosophy used by your department for the shutdown management process?	<ul style="list-style-type: none"> <li>• Using Packages; All work to be packaged, logged and handed to relevant disciplines</li> </ul>
3	Which other functional disciplines are involved or contribute to the whole shutdown management process?	<ul style="list-style-type: none"> <li>• All different disciplines of the client (<u>All Depts.</u>); Inspection, Process, Operations &amp; safety, QA, Painting contractors</li> </ul>
4	How does your department communicate with the other functional disciplines or departments?	<ul style="list-style-type: none"> <li>• Daily Meetings; Formal documents</li> <li>• written communication, by radio, verbal &amp; no emails encouraged during the execution</li> </ul>
5	What activities does the planning department achieve in each phase of the shutdown management process?	<ul style="list-style-type: none"> <li>• Various deliverables; High level plan; Lead times on delivery; progress; learnings</li> </ul>

No.	Question	Respondent #1	Respondent #2
6	Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.	<ul style="list-style-type: none"> <li>• Safety Resources were not enough (2006 shutdown) esp. safety watchers &amp; environ officers</li> <li>• Budgets &amp; completion of tasks in time -Planners were not following up on tasks in every area (to understand &amp; report the status quo)</li> </ul>	<ul style="list-style-type: none"> <li>• Project Plan - virtually ignored by most parties involved</li> <li>• Scope - Areas not cooperating in submitting scope &amp; details</li> <li>• Schedules - Poor input from end users</li> <li>• Progress reports - a lot of difficulty in receiving feedback from respective supervisors</li> </ul>
7	How far before the shutdown execution does your department start the planning process?	<ul style="list-style-type: none"> <li>• For SHEQ - Ideally 1 year in advance</li> </ul>	<ul style="list-style-type: none"> <li>• 2 years</li> </ul>
8	At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?	<ul style="list-style-type: none"> <li>• Identification of some scope was delayed &amp; this resulted in late orders</li> <li>• Delayed risk assessments also delayed the procurement process</li> <li>• Spares &amp; Materials management should be improved</li> </ul>	<ul style="list-style-type: none"> <li>• Spares &amp; Materials management should be improved</li> </ul>
9	How is the information required for the shutdown plan gathered?	<ul style="list-style-type: none"> <li>• Methodologies &amp; guidelines in place - structured according to phases</li> <li>• Challenge - Response time from the areas was poor &amp; Scope process was not properly done</li> </ul>	<ul style="list-style-type: none"> <li>• During PH 2 - Information from the area execution teams</li> </ul>
10	How are the activity resources and durations on the plan worked out?	<ul style="list-style-type: none"> <li>• Foremen &amp; Engineers estimate the resources &amp; durations</li> <li>• Challenge - People bringing in work late, as well as last minute emergent work</li> </ul>	<ul style="list-style-type: none"> <li>• Scope process for past shutdown was not properly done</li> </ul>

No.	Question	Respondent #3	Respondent #4
6	Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.	<ul style="list-style-type: none"> <li>• Lack of proper input (drive) from the area teams</li> <li>• Area Engineers &amp; subordinates don't take ownership</li> </ul>	<ul style="list-style-type: none"> <li>• Poor identification of work scope; Lack of involvement of area teams; Inexperienced supervisors</li> <li>• The inspection scope not properly reviewed &amp; challenged by the area teams (Supervisors &amp; Engineers)</li> <li>• Conflict in priorities - area teams concentrating on running plants</li> </ul>
7	How far before the shutdown execution does your department start the planning process?	<ul style="list-style-type: none"> <li>• 2 years</li> </ul>	<ul style="list-style-type: none"> <li>• Depends on the size &amp; complexity of the SD - at least 24 months</li> <li>• Highly complex - 36 months</li> <li>• Medium - 24 to 18 months</li> <li>• Less Complex - 8 to 12 months</li> </ul>
8	At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?	<ul style="list-style-type: none"> <li>• At the start of PH 3, but also depends on the criticality of the spares; approx. 12 - 18 months before</li> <li>• Spares &amp; Materials management should be improved</li> </ul>	<ul style="list-style-type: none"> <li>• PH 3 - Scope &amp; commercial development (18 - 24 months)</li> <li>• Spares &amp; Materials management should be improved</li> </ul>
9	How is the information required for the shutdown plan gathered?	<ul style="list-style-type: none"> <li>• During PH 2 - Information from the area execution teams</li> </ul>	<ul style="list-style-type: none"> <li>• Inspection &amp; RBI</li> <li>• Maintenance - defects</li> <li>• Operators - pick up defects</li> <li>• Structured systems in place</li> </ul>
10	How are the activity resources and durations on the plan worked out?	<ul style="list-style-type: none"> <li>• Detailed Information from the area execution teams (foremen &amp; engineers)</li> <li>• Scope process for past shutdown was not properly done</li> </ul>	<ul style="list-style-type: none"> <li>• From a high, looking at the size of the SD, we determine the number of people required &amp; duration</li> <li>• From a second level, Task specific - use historical information</li> <li>• Scope process for past shutdown was not properly done</li> </ul>

No.	Question	Respondent #5	Respondent #6
6	Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.	<ul style="list-style-type: none"> <li>• Getting the right information early is a big challenge for the planning department</li> </ul>	<ul style="list-style-type: none"> <li>• Identification of work scope</li> <li>• Planning for emergent work</li> </ul>
7	How far before the shutdown execution does your department start the planning process?	<ul style="list-style-type: none"> <li>• At least 12 months</li> </ul>	<ul style="list-style-type: none"> <li>• 10 months</li> </ul>
8	At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?	<ul style="list-style-type: none"> <li>• The initial kick off meeting should identify the critical spares</li> </ul>	<ul style="list-style-type: none"> <li>• At the initiation phase</li> <li>• Spares &amp; Materials management should be improved</li> </ul>
9	How is the information required for the shutdown plan gathered?	<ul style="list-style-type: none"> <li>• Task lists are printed</li> </ul>	<ul style="list-style-type: none"> <li>• Task lists are printed through the SAP system</li> </ul>
10	How are the activity resources and durations on the plan worked out?	<ul style="list-style-type: none"> <li>• No standard norms are available; they use experience</li> <li>• Scope process for past shutdown was not properly done</li> </ul>	<ul style="list-style-type: none"> <li>• Standard norms &amp; Experience</li> </ul>



No.	Question	Respondent #7	Respondent #8
6	Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.	<ul style="list-style-type: none"> <li>• Type of tool used by planning dept - SMS - was not linked to SAP</li> </ul>	<ul style="list-style-type: none"> <li>• Buy - in from other disciplines is difficult; quality of plan relies on info from mech &amp; prod</li> <li>• SMS barcharts are difficult to read</li> </ul>
7	How far before the shutdown execution does your department start the planning process?	<ul style="list-style-type: none"> <li>• 12 months - from the IR perspective</li> </ul>	<ul style="list-style-type: none"> <li>• 3 years; at least 8 months for a full SD</li> </ul>
8	At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?	<ul style="list-style-type: none"> <li>• SKIP! [No Response]</li> </ul>	<ul style="list-style-type: none"> <li>• PH 2 - conceptual development</li> <li>• Spares &amp; Materials management should be improved</li> </ul>
9	How is the information required for the shutdown plan gathered?	<ul style="list-style-type: none"> <li>• SKIP! [No Response]</li> </ul>	<ul style="list-style-type: none"> <li>• Stat &amp; RBI requirements</li> <li>• SAP system</li> <li>• Specific requirements from prod &amp; mech</li> <li>• Defects</li> <li>• projects</li> </ul>
10	How are the activity resources and durations on the plan worked out?	<ul style="list-style-type: none"> <li>• No Response</li> </ul>	<ul style="list-style-type: none"> <li>• Stds are available??</li> <li>• estimates &amp; from experience</li> <li>• Info from other T/As &amp; outages</li> <li>• Scope process for past shutdown was not properly done</li> </ul>

No.	Question	Respondent #9	Respondent #10
6	Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.	<ul style="list-style-type: none"> <li>• Defining definite scope of work</li> <li>• Putting control measures in place to track plan vs actual; Emergent work is a challenge</li> <li>• Capturing of completed work, there is a time delay</li> <li>• expediting of spares - no proper system</li> </ul>	<ul style="list-style-type: none"> <li>• Review of task lists</li> <li>• Signing off by functional areas</li> </ul>
7	How far before the shutdown execution does your department start the planning process?	<ul style="list-style-type: none"> <li>• 2 yrs</li> </ul>	<ul style="list-style-type: none"> <li>• 2 yrs</li> </ul>
8	At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?	<ul style="list-style-type: none"> <li>• During the initial phases after identifying the scope of work</li> <li>• Spares &amp; Materials management should be improved</li> </ul>	<ul style="list-style-type: none"> <li>• At the work development stage - identify long lead items</li> <li>• Spares &amp; Materials management should be improved</li> </ul>
9	How is the information required for the shutdown plan gathered?	<ul style="list-style-type: none"> <li>• From previous SD records, Inspection reports &amp; SAP</li> <li>• From experienced personnel</li> </ul>	<ul style="list-style-type: none"> <li>• Based on equipment list - core team then does impact assessment</li> <li>• Compliance, RBI, reliability, maintainability, ops requirements, etc.</li> </ul>
10	How are the activity resources and durations on the plan worked out?	<ul style="list-style-type: none"> <li>• Use historical info &amp; SAP info</li> <li>• Make allowance for the unforeseen</li> <li>• By resource leveling</li> <li>• Scope process for past shutdown was not properly done</li> </ul>	<ul style="list-style-type: none"> <li>• Through work scope that is used to generate an integrated plan</li> <li>• Generate alternative methods of execution (Fat Rat)</li> <li>• Cost effectiveness - minimal downtime</li> <li>• Scope process for past shutdown was not properly done</li> </ul>

No.	Question	Respondent #11	Respondent #12
6	Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.	<ul style="list-style-type: none"> <li>• On postmortem report</li> </ul>	<ul style="list-style-type: none"> <li>• Scope is not identified in time</li> <li>• Feedback from the units is not accurate</li> </ul>
7	How far before the shutdown execution does your department start the planning process?	<ul style="list-style-type: none"> <li>• 2 yrs</li> </ul>	<ul style="list-style-type: none"> <li>• 12 months &amp; finalized at least 6 months</li> </ul>
8	At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?	<ul style="list-style-type: none"> <li>• 12 months depending on the item's long lead time</li> <li>• Could improve: Expediting &amp; placing of contracts</li> </ul>	<ul style="list-style-type: none"> <li>• as scope becomes available</li> </ul>
9	How is the information required for the shutdown plan gathered?	<ul style="list-style-type: none"> <li>• RBI &amp; scope challenges</li> </ul>	<ul style="list-style-type: none"> <li>• Unit planners load work on SAP then central planning coordinates on SMS</li> </ul>
10	How are the activity resources and durations on the plan worked out?	<ul style="list-style-type: none"> <li>• Critical path, additional/emergent work</li> <li>• Scope process for past shutdown was not properly done</li> </ul>	<ul style="list-style-type: none"> <li>• Through the task lists</li> <li>• Scope process for past shutdown was not properly done</li> </ul>

No.	Question	Respondent #13	Respondent #14
6	Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.	<ul style="list-style-type: none"> <li>• Some scope can only be identified after inspection of the equipment</li> <li>• Under-estimation of duration &amp; manpower</li> <li>• Poor signing off of completed tasks by the field supervisors</li> <li>• Late work submissions</li> </ul>	<ul style="list-style-type: none"> <li>• Learnings from experience (past)</li> <li>• Efforts of comparing past performances</li> <li>• Expectation to produce plan in time</li> </ul>
7	How far before the shutdown execution does your department start the planning process?	<ul style="list-style-type: none"> <li>• 18 months</li> </ul>	<ul style="list-style-type: none"> <li>• 12 months</li> </ul>
8	At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?	<ul style="list-style-type: none"> <li>• 18 - 12 Months</li> <li>• Spares &amp; Materials management should be improved</li> </ul>	<ul style="list-style-type: none"> <li>• 2 - 3 Months from execution</li> </ul>
9	How is the information required for the shutdown plan gathered?	<ul style="list-style-type: none"> <li>• Each section to gather the scope required</li> </ul>	<ul style="list-style-type: none"> <li>• Through a work scope identification sheet</li> </ul>
10	How are the activity resources and durations on the plan worked out?	<ul style="list-style-type: none"> <li>• Past experience and records used as reference</li> <li>• Scope process for past shutdown was not properly done</li> </ul>	<ul style="list-style-type: none"> <li>• By using norms; scientific approach; compare between shutdowns</li> </ul>

No.	Question	Respondent #15
6	Give a list of challenges experienced by the planning department in the whole process. Explain the cause of each challenge listed.	<ul style="list-style-type: none"> <li>• Planners are not aware of some inspection durations</li> <li>• Planning does not give milestones for QA/QC</li> <li>• Shutdowns should be planned around packages</li> </ul>
7	How far before the shutdown execution does your department start the planning process?	<ul style="list-style-type: none"> <li>• 18 - 6 months</li> </ul>
8	At what stage of the planning process are the critical materials and spares required for the shutdown identified and ordered?	<ul style="list-style-type: none"> <li>• 1 year - 3 Months from execution</li> </ul>
9	How is the information required for the shutdown plan gathered?	<ul style="list-style-type: none"> <li>• Through a work scope identification sheet</li> </ul>
10	How are the activity resources and durations on the plan worked out?	<ul style="list-style-type: none"> <li>• Norms</li> <li>• One Challenge is obtaining scope from the client</li> </ul>

No.	Question	Respondent #1	Respondent #2
11	What factors are considered when formulating a preliminary budget estimate for the shutdown?	<ul style="list-style-type: none"> <li>• Previous shutdown budget (actuals) is the starting point, look at the present work scope &amp; then apply factors</li> <li>• Challenge - is if previous budget was poorly planned</li> </ul>	<ul style="list-style-type: none"> <li>• Previous shutdown budget (actuals) is the starting point, look at the present work scope &amp; then apply factors</li> </ul>
12	At what stage of the process can an accurate budget forecast presented?	<ul style="list-style-type: none"> <li>• 1 month before execution</li> <li>• Challenge - is any delays in obtaining the detailed scope, as well as late submissions from contractors</li> </ul>	<ul style="list-style-type: none"> <li>• PH 4</li> </ul>
13	Give a list of the causes of budget over-runs for the shutdown in your department.	<ul style="list-style-type: none"> <li>• Emergent work</li> <li>• Scope creep - the known work increasing</li> <li>• Re-work ; Quality issues</li> <li>• Lack of proper supervision for the labour &amp; contractors - they take longer to complete jobs</li> <li>• Poor planning &amp; scheduling of work - the work not being broken into smaller manageable chunks results in STANDING time</li> <li>• Contractors being allowed to come onto site when the access to start their work is NOT available</li> <li>• Good cost control measures need to be implemented</li> </ul>	<ul style="list-style-type: none"> <li>• Low productivity - people not completing work on time</li> <li>• Poor control of service contractors &amp; lack of good costs controls</li> <li>• Poor budgeting - Not basing budget on actual scope</li> </ul>
14	What conflicts or areas of concern do you experience with the contracting companies in your department?	<ul style="list-style-type: none"> <li>• Labour issues - Problem in RSA in general</li> <li>• If scope of work for the contractors is not clear at the start</li> <li>• Contracts for the past shutdown have not been optimally done</li> <li>• Labour brokers lack the capacity and plans to handle large numbers of people</li> </ul>	<ul style="list-style-type: none"> <li>• Our contract are not set optimally, leaving room for exploitation</li> <li>• Our contractor controls are not set up optimally, leaving room for exploitation</li> <li>• Labour brokers lack the capacity and plans to handle large numbers of people</li> </ul>

No.	Question	Respondent #3	Respondent #4
11	What factors are considered when formulating a preliminary budget estimate for the shutdown?	<ul style="list-style-type: none"> <li>• Information from previous budgets, &amp; then add inflation</li> </ul>	<ul style="list-style-type: none"> <li>• Historical budgets - then apply indices &amp; order of magnitude</li> <li>• Industry norms - comparing to similar size SD's &amp; seeing how much they are spending</li> <li>• Area of Improvement - Creating a detailed estimate at task level!!</li> </ul>
12	At what stage of the process can an accurate budget forecast presented?	<ul style="list-style-type: none"> <li>• PH 3 - Just before detailed planning (within 20% accuracy)</li> <li>• PH 4 - During course of ph 4 within 5%</li> </ul>	<ul style="list-style-type: none"> <li>• PH 4 - (3 months before SD)</li> </ul>
13	Give a list of the causes of budget over-runs for the shutdown in your department.	<ul style="list-style-type: none"> <li>• Safety - safety incidents can influence the budget if not properly planned for</li> <li>• Schedule - slippages</li> <li>• Quality - Reworks</li> </ul>	<ul style="list-style-type: none"> <li>• Industrial action - strikes</li> <li>• Low productivity - lower than the norm (compare with international productivity!)</li> <li>• Inability to accurately determine define scope of work</li> <li>• Emergent work</li> <li>• If skills/competence level of Engineer are low - inability to challenge any work that is brought forward by esp. Inspectors</li> <li>• Good cost control measures need to be implemented</li> </ul>
14	What conflicts or areas of concern do you experience with the contracting companies in your department?	<ul style="list-style-type: none"> <li>• If the contractors don't have a good knowledge of the planning procedures</li> <li>• Execution - if the contractors don't report accurately</li> </ul>	<ul style="list-style-type: none"> <li>• Labour Brokers - always pushing for longer to earn more money (Broker could even encourage the labour to go on strike), Brokers also lack capacity</li> <li>• Paying higher than the norm</li> <li>• Supervisors/Engineers - not challenging the contractors</li> <li>• Contracts for the past shutdown have not been optimally done</li> </ul>

No.	Question	Respondent #5	Respondent #6
11	What factors are considered when formulating a preliminary budget estimate for the shutdown?	<ul style="list-style-type: none"> <li>• Use the previous budget (actual) - then identify the gaps</li> </ul>	<ul style="list-style-type: none"> <li>• formulation of contracts (Rates &amp; conditions)</li> <li>• Labour</li> <li>• Plan for emergent work (contributes to budget over runs)</li> </ul>
12	At what stage of the process can an accurate budget forecast presented?	<ul style="list-style-type: none"> <li>• Month &amp; a half before execution</li> </ul>	<ul style="list-style-type: none"> <li>• At phase 3</li> </ul>
13	Give a list of the causes of budget over-runs for the shutdown in your department.	<ul style="list-style-type: none"> <li>• Preparation time not enough</li> <li>- Not sufficient planning time</li> <li>• Emergent work</li> <li>• Industrial action - strikes</li> <li>• Major safety incident</li> <li>• Good cost control measures need to be implemented</li> </ul>	<ul style="list-style-type: none"> <li>• Rework on poor workmanship</li> <li>• Good cost control measures need to be implemented</li> </ul>
14	What conflicts or areas of concern do you experience with the contracting companies in your department?	<ul style="list-style-type: none"> <li>• Contracts - Lack of understanding of the contracts on the PetroSA execution teams (could be asking for more work to be done without understanding the cost implications)</li> <li>• Asking the contractors to do reworks because of poor quality - e.g. the inspectors asking the contractors to re-clean the bundles</li> <li>• Labour brokers lack the capacity and plans to handle large numbers of people</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of commitment from the contractors</li> <li>• Contracts poorly drawn up - contractors should be made more responsible</li> </ul>



No.	Question	Respondent #7	Respondent #8
11	What factors are considered when formulating a preliminary budget estimate for the shutdown?	<ul style="list-style-type: none"> <li>• Work scope to done, including statutory work</li> <li>• Scarcity of skill, considering PetroSA is situated remotely from major centres</li> <li>• Accommodation &amp; transport for labour</li> </ul>	<ul style="list-style-type: none"> <li>• Duration of SD</li> <li>• Resources requirements</li> <li>• Contracts requirements</li> <li>• Completion incentives within contracts</li> </ul>
12	At what stage of the process can an accurate budget forecast presented?	<ul style="list-style-type: none"> <li>• When a scope freeze is declare</li> </ul>	<ul style="list-style-type: none"> <li>• Beginning of PH 4</li> </ul>
13	Give a list of the causes of budget over-runs for the shutdown in your department.	<ul style="list-style-type: none"> <li>• Labour rates</li> <li>• Strikes &amp; Go-slows</li> <li>• People dragging jobs</li> <li>• Reworks</li> </ul>	<ul style="list-style-type: none"> <li>• Poor cost mgt (no cost engineers)</li> <li>• If duration increases</li> <li>• Structure of contracts - loopholes in contracts (Use fixed prices than rates)</li> <li>• Good cost control measures need to be implemented</li> </ul>
14	What conflicts or areas of concern do you experience with the contracting companies in your department?	<ul style="list-style-type: none"> <li>• Lack of ownership from the contractors</li> <li>• Quality of workmanship</li> <li>• contractors lacking control over their labour</li> <li>• Contracts for the past shutdown have not been optimally done</li> <li>• Labour brokers lack the capacity and plans to handle large numbers of people</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of ownership</li> <li>• BEE co.s lack experience</li> </ul>

No.	Question	Respondent #9	Respondent #10
11	What factors are considered when formulating a preliminary budget estimate for the shutdown?	<ul style="list-style-type: none"> <li>• work scope</li> <li>• Previous history</li> </ul>	<ul style="list-style-type: none"> <li>• work scope - Capital works, compliance, RBI, SHEQ, maintenance, ops requirements</li> <li>• Previous history</li> <li>• SD philosophy</li> <li>• Major procurement requirements</li> </ul>
12	At what stage of the process can an accurate budget forecast presented?	<ul style="list-style-type: none"> <li>• Scope must be fixed just before the execution - obtain 80% accuracy</li> <li>• During execution - do a forecasting exercise</li> </ul>	<ul style="list-style-type: none"> <li>• At detailed planning stage - final work lists, what if scenarios, Equip &amp; tools ; within 5%</li> </ul>
13	Give a list of the causes of budget over-runs for the shutdown in your department.	<ul style="list-style-type: none"> <li>• Under - scoping</li> <li>• additional work</li> <li>• Opportunity work</li> <li>• Not prioritizing the work</li> </ul>	<ul style="list-style-type: none"> <li>• Emergent work</li> <li>• Poor scope control</li> <li>• Poor pre-shut work</li> <li>• Bad cost forecast</li> <li>• Good cost control measures need to be implemented</li> </ul>
14	What conflicts or areas of concern do you experience with the contracting companies in your department?	<ul style="list-style-type: none"> <li>• If the set up of the contract document has left out critical clauses (Not optimally done)</li> <li>• There is no direct control on the contractors if there is deviations</li> <li>• Labour rates should be standardized nationally &amp; Labour brokers lack the capacity</li> <li>• Mgt of contractors is a challenge</li> </ul>	<ul style="list-style-type: none"> <li>• Control of scope; time based contracting - the longer the more money for the contractors</li> <li>• No good look at quality issues from the contractor's side</li> <li>• Contracts for the past shutdown have not been optimally done</li> </ul>

No.	Question	Respondent #11	Respondent #12
11	What factors are considered when formulating a preliminary budget estimate for the shutdown?	<ul style="list-style-type: none"> <li>• History</li> <li>• CIEFSA index</li> </ul>	<ul style="list-style-type: none"> <li>• History &amp; add escalation</li> <li>• Scope</li> </ul>
12	At what stage of the process can an accurate budget forecast presented?	<ul style="list-style-type: none"> <li>• Once scope is finalized</li> </ul>	<ul style="list-style-type: none"> <li>• Once scope is finalized - just before execution</li> </ul>
13	Give a list of the causes of budget over-runs for the shutdown in your department.	<ul style="list-style-type: none"> <li>• Emergent work</li> <li>• Strikes</li> <li>• Changing the rules of the project, e.g. mgt deciding to pay overtime</li> <li>• Contracts not reviewed properly</li> <li>• Weather</li> <li>• Good cost control measures need to be implemented</li> </ul>	<ul style="list-style-type: none"> <li>• Heat treatment - lack of control</li> <li>• Lack of scope</li> <li>• IR problems</li> <li>• Should improve on cost controls</li> </ul>
14	What conflicts or areas of concern do you experience with the contracting companies in your department?	<ul style="list-style-type: none"> <li>• Labour brokers cannot handle high volumes</li> <li>• Quality of skills; no apprenticeships</li> <li>• No quotation before the start of the job</li> <li>• Contracts for the past shutdown have not been optimally done</li> </ul>	<ul style="list-style-type: none"> <li>• Supervisors - lack of commitment &amp; transparency</li> <li>• Brokers &amp; site agents are incompetent</li> </ul>

No.	Question	Respondent #13	Respondent #14
11	What factors are considered when formulating a preliminary budget estimate for the shutdown?	<ul style="list-style-type: none"> <li>• Past SAP records</li> <li>• Use market rates to estimate</li> </ul>	<ul style="list-style-type: none"> <li>• Use norms</li> </ul>
12	At what stage of the process can an accurate budget forecast presented?	<ul style="list-style-type: none"> <li>• 6 months before execution</li> </ul>	<ul style="list-style-type: none"> <li>• During planning &amp; prep stage</li> </ul>
13	Give a list of the causes of budget over-runs for the shutdown in your department.	<ul style="list-style-type: none"> <li>• Under-estimation of duration</li> <li>• Plant aging over time</li> <li>• Process upsets</li> <li>• Re-negotiations of contractors wages</li> <li>• Tighter controls of costs are required</li> </ul>	<ul style="list-style-type: none"> <li>• Under-estimation of duration</li> <li>• Emergent work</li> </ul>
14	What conflicts or areas of concern do you experience with the contracting companies in your department?	<ul style="list-style-type: none"> <li>• Contractors not bringing qualified personnel</li> <li>• Labour brokers lack the capacity and plans to handle large numbers of people</li> <li>• Poor equipment used by contractors</li> <li>• Contracts for the past shutdown have not been optimally done</li> </ul>	<ul style="list-style-type: none"> <li>• Under-estimation of scope by client</li> </ul>

No.	Question	Respondent #15
11	What factors are considered when formulating a preliminary budget estimate for the shutdown?	<ul style="list-style-type: none"> <li>• Manhours</li> </ul>
12	At what stage of the process can an accurate budget forecast presented?	<ul style="list-style-type: none"> <li>• From contractor's side - off a tender document</li> </ul>
13	Give a list of the causes of budget over-runs for the shutdown in your department.	<ul style="list-style-type: none"> <li>• From contractor's side - off a tender document</li> </ul>
14	What conflicts or areas of concern do you experience with the contracting companies in your department?	<ul style="list-style-type: none"> <li>• Getting a clear scope of work from the client - Contract Document not being clear on the scope of work</li> </ul>

No.	Question	Respondent #1	Respondent #2
15	How do you quantify the work to be contracted out, and are the contractors involved in this process?	<ul style="list-style-type: none"> <li>• PetroSA should agree hourly rates with contractors - But the challenges is to ensure proper supervision to closely monitor them during execution</li> </ul>	<ul style="list-style-type: none"> <li>• From estimation manuals &amp; discussions with responsible foremen/service coordinators</li> <li>• Contractors not involved</li> </ul>
16	What critical skills' shortages do you experience during the shutdown execution?	<ul style="list-style-type: none"> <li>• Rigging &amp; Welding (specialized skills)</li> <li>• Challenge - Other refineries &amp; related industries in the country fighting for similar skills at the same time</li> </ul>	<ul style="list-style-type: none"> <li>• Riggers, welders, Planners &amp; Supervisors</li> </ul>
17	How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?	<ul style="list-style-type: none"> <li>• Communication through meetings</li> <li>• Challenge - area Planners were not very proactive in identifying the status quo of their areas in terms of progress (were solely dependent on information given by field supervisors)</li> <li>• Challenge - Lack of document control centres to track the movements of physical paperwork (PRA's, VRA's &amp; SRA's)!!</li> </ul>	<ul style="list-style-type: none"> <li>• 2 daily SD meetings using bar charts &amp; task books</li> <li>• Verbal/Radio communication</li> </ul>
18	What key performance indicators do you use during the shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• DIFR (Disabling Injuries Frequency Rate)</li> <li>• Unsafe acts &amp; unsafe conditions</li> </ul>	<ul style="list-style-type: none"> <li>• S-Curve &amp; measure Actual vs. Plan; very efficient if sufficient feedback is obtained from supervisors/engineers</li> </ul>
19	What feedback control mechanisms do you use during shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Deliverables that were controlled by planning</li> <li>• Two-weekly meetings that were used to identify shortfalls</li> </ul>	<ul style="list-style-type: none"> <li>• S-Curve &amp; reports of outstanding work; efficient if sufficient feedback is obtained from supervisors/engineers</li> </ul>
20	How is the emergent work handled during the shutdown execution phase?	<ul style="list-style-type: none"> <li>• Area Engineer verifies &amp; then Shutdown Mgr to approve</li> <li>• Challenge - Not properly screened &amp; assessed by Area Engineers leads to increase in costs and duration</li> </ul>	<ul style="list-style-type: none"> <li>• Approved by Area Engineers</li> </ul>

No.	Question	Respondent #3	Respondent #4
15	How do you quantify the work to be contracted out, and are the contractors involved in this process?	<ul style="list-style-type: none"> <li>• PetroSA's services coordinator should estimate the work. Contractors are not involved</li> </ul>	<ul style="list-style-type: none"> <li>• Currently, contractors are not involved (something that PetroSA should look at - After PH 2 , 12 months before execution)</li> </ul>
16	What critical skills' shortages do you experience during the shutdown execution?	<ul style="list-style-type: none"> <li>• Experienced &amp; Qualified Planners</li> </ul>	<ul style="list-style-type: none"> <li>• Supervision skills</li> </ul>
17	How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?	<ul style="list-style-type: none"> <li>• Area execution level - through bar charts</li> <li>• Look aheads forward managing of the plan</li> <li>• Communication through meetings</li> </ul>	<ul style="list-style-type: none"> <li>• E-mail system (intranet)</li> <li>• Satellite planning offices (meetings)</li> </ul>
18	What key performance indicators do you use during the shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Percentage of work done per day</li> <li>• Threats that can be seen for the coming days</li> <li>• Challenge - Planning requires accurate information from the field</li> </ul>	<ul style="list-style-type: none"> <li>• Safety indicators</li> <li>• Planning &amp; schedule indicators</li> <li>• Scope growth</li> <li>• Quality issues</li> <li>• Number of activities</li> </ul>
19	What feedback control mechanisms do you use during shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Above information triggers feedback</li> </ul>	<ul style="list-style-type: none"> <li>• Progress reports - if float is consumed then it acts as a trigger</li> </ul>
20	How is the emergent work handled during the shutdown execution phase?	<ul style="list-style-type: none"> <li>• Emergent work register should be made available - to record all emergent work - ERP system</li> <li>• Proper cost mgt should be done</li> </ul>	<ul style="list-style-type: none"> <li>• Inspection raises, area Engineer should challenge &amp; verify; then SD mgr approves</li> </ul>

No.	Question	Respondent #5	Respondent #6
15	How do you quantify the work to be contracted out, and are the contractors involved in this process?	<ul style="list-style-type: none"> <li>Involved to a lesser degree</li> </ul>	<ul style="list-style-type: none"> <li>The contractors should be involved</li> <li>Also plan for the unexpected</li> </ul>
16	What critical skills' shortages do you experience during the shutdown execution?	<ul style="list-style-type: none"> <li>Quality of artisans is poor; Mech, instrument, boilermakers, welders &amp; pipe fitters</li> </ul>	<ul style="list-style-type: none"> <li>Welders, painting contractors &amp; inspectors</li> </ul>
17	How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?	<ul style="list-style-type: none"> <li>Daily meetings</li> <li>Radio communication</li> </ul>	<ul style="list-style-type: none"> <li>Daily meetings</li> </ul>
18	What key performance indicators do you use during the shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>Plan vs actual</li> <li>Tasks, manhours/activities</li> </ul>	<ul style="list-style-type: none"> <li>Quality of work, signing off of box-ups</li> <li>safety &amp; start up</li> </ul>
19	What feedback control mechanisms do you use during shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>Decisions are made on site starting with the artisan, then foreman and if the problem can't be resolved it goes to the engineer</li> </ul>	<ul style="list-style-type: none"> <li>SD mgr's meeting</li> </ul>
20	How is the emergent work handled during the shutdown execution phase?	<ul style="list-style-type: none"> <li>Using the additional work forms</li> </ul>	<ul style="list-style-type: none"> <li>Approved by SD mgr</li> </ul>



No.	Question	Respondent #7	Respondent #8
15	How do you quantify the work to be contracted out, and are the contractors involved in this process?	<ul style="list-style-type: none"> <li>• Depends on SD philosophy</li> </ul>	<ul style="list-style-type: none"> <li>• During execution - e.g. HP cleaning &amp; scaffolding; advisable to use day rates, but contractors always try to extend duration</li> </ul>
16	What critical skills' shortages do you experience during the shutdown execution?	<ul style="list-style-type: none"> <li>• Instrument mechs &amp; techs</li> <li>• Inspectors</li> <li>• Specialized welders</li> </ul>	<ul style="list-style-type: none"> <li>• Welders</li> <li>• skills levels are poor in general</li> </ul>
17	How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?	<ul style="list-style-type: none"> <li>• Daily meetings &amp; e-mails</li> </ul>	<ul style="list-style-type: none"> <li>• Daily meetings (morning &amp; afternoon)</li> </ul>
18	What key performance indicators do you use during the shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Amount of IR/ER (Industrial Relations / Employee Related) queries &amp; safety incidents</li> </ul>	<ul style="list-style-type: none"> <li>• Track tasks on a daily basis</li> <li>• safety stats (injuries, fires &amp; spills)</li> </ul>
19	What feedback control mechanisms do you use during shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• From IR perspective - people on the ground</li> </ul>	<ul style="list-style-type: none"> <li>• Identify critical path before execution &amp; track on daily basis</li> </ul>
20	How is the emergent work handled during the shutdown execution phase?	<ul style="list-style-type: none"> <li>• Approved by SD mgr</li> </ul>	<ul style="list-style-type: none"> <li>• Try &amp; make estimates for emergent work &amp; make provisions</li> </ul>

No.	Question	Respondent #9	Respondent #10
15	How do you quantify the work to be contracted out, and are the contractors involved in this process?	<ul style="list-style-type: none"> <li>• Areas where PetroSA has no experience - specialist contractors are used</li> </ul>	<ul style="list-style-type: none"> <li>• Through scope definition - depending on complexity mixture</li> <li>• Best practice is to involve the contractors in the scope definition</li> </ul>
16	What critical skills' shortages do you experience during the shutdown execution?	<ul style="list-style-type: none"> <li>• General labour force; Welders, fitters &amp; turners</li> <li>• Supervisors</li> <li>• Experienced planners</li> </ul>	<ul style="list-style-type: none"> <li>• General labour force; Welders, fitters, turners &amp; riggers</li> </ul>
17	How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?	<ul style="list-style-type: none"> <li>• Daily meetings (morning &amp; afternoon)</li> </ul>	<ul style="list-style-type: none"> <li>• Daily meetings (morning &amp; afternoon)</li> <li>• Road / safety shows</li> <li>• Flyers &amp; bulletins</li> </ul>
18	What key performance indicators do you use during the shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Percentage completion of planned work</li> </ul>	<ul style="list-style-type: none"> <li>• Cost, Duration, PTW adherence, LTI injuries, Quality of work (Rework), ER issues, Productivity, Safety</li> </ul>
19	What feedback control mechanisms do you use during shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Identify critical path before execution &amp; track on daily basis</li> <li>• Analyse non-critical path activities</li> </ul>	<ul style="list-style-type: none"> <li>• Formal meetings</li> <li>• Walkabouts - give prompt recognition to people doing the right things</li> </ul>
20	How is the emergent work handled during the shutdown execution phase?	<ul style="list-style-type: none"> <li>• Assess costs &amp; then allocate resources</li> </ul>	<ul style="list-style-type: none"> <li>• Additional work requests</li> <li>• Change order</li> </ul>

No.	Question	Respondent #11	Respondent #12
15	How do you quantify the work to be contracted out, and are the contractors involved in this process?	<ul style="list-style-type: none"> <li>• Important to review contracts before paying per hour</li> <li>• Review current SD / TA procedures</li> </ul>	<ul style="list-style-type: none"> <li>• Not major problems; except for lack of supervisor commitment</li> </ul>
16	What critical skills' shortages do you experience during the shutdown execution?	<ul style="list-style-type: none"> <li>• General labour force; Welders, fitters, electrical, instruments &amp; B/makers</li> </ul>	<ul style="list-style-type: none"> <li>• Welders &amp; B/makers</li> </ul>
17	How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?	<ul style="list-style-type: none"> <li>• Shared server</li> </ul>	<ul style="list-style-type: none"> <li>• Daily Meetings - quality of feedback was poor</li> </ul>
18	What key performance indicators do you use during the shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Progress vs plan</li> </ul>	<ul style="list-style-type: none"> <li>• Schedule - marking up daily</li> </ul>
19	What feedback control mechanisms do you use during shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Daily meetings</li> </ul>	<ul style="list-style-type: none"> <li>• Percentage of work complete gave a good indication</li> </ul>
20	How is the emergent work handled during the shutdown execution phase?	<ul style="list-style-type: none"> <li>• Procedure in place to be approved by SD mgr</li> </ul>	<ul style="list-style-type: none"> <li>• Area Engineers determine priorities</li> </ul>

No.	Question	Respondent #13	Respondent #14
15	How do you quantify the work to be contracted out, and are the contractors involved in this process?	<ul style="list-style-type: none"> <li>• No, contractors are not utilized</li> </ul>	<ul style="list-style-type: none"> <li>• As contractors, we use a Contracting model</li> </ul>
16	What critical skills' shortages do you experience during the shutdown execution?	<ul style="list-style-type: none"> <li>• Welders, Inspectors &amp; artisans</li> </ul>	<ul style="list-style-type: none"> <li>• Welders, E &amp; I mechs, riggers</li> </ul>
17	How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?	<ul style="list-style-type: none"> <li>• Daily Meetings (area Meeting) - chaired by the area planner</li> </ul>	<ul style="list-style-type: none"> <li>• Daily Meetings; by radio; handover meetings</li> </ul>
18	What key performance indicators do you use during the shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Plan versus actual</li> </ul>	<ul style="list-style-type: none"> <li>• Weld inches; Quality sign off's; S-curves</li> </ul>
19	What feedback control mechanisms do you use during shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Critical path</li> </ul>	<ul style="list-style-type: none"> <li>• S-curves; percentage manhours achieved versus plan</li> </ul>
20	How is the emergent work handled during the shutdown execution phase?	<ul style="list-style-type: none"> <li>• Special forms; shutdown manager to approve</li> </ul>	<ul style="list-style-type: none"> <li>• Emergent work should be planned; Special forms; shutdown manager to approve</li> </ul>

No.	Question	Respondent #15
15	How do you quantify the work to be contracted out, and are the contractors involved in this process?	<ul style="list-style-type: none"> <li>• Using Packages; All work to be packaged; Packages can be used extensively</li> </ul>
16	What critical skills' shortages do you experience during the shutdown execution?	<ul style="list-style-type: none"> <li>• Welders</li> </ul>
17	How are the shutdown's activities coordinated and communicated among all the parties involved in the shut execution?	<ul style="list-style-type: none"> <li>• Daily Meetings; by radio; handover meetings</li> </ul>
18	What key performance indicators do you use during the shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Weld inches; Weld reject rate; Pack hand over status; S-curves</li> </ul>
19	What feedback control mechanisms do you use during shut execution phase and how effective are they?	<ul style="list-style-type: none"> <li>• Hand over status; punch lists</li> </ul>
20	How is the emergent work handled during the shutdown execution phase?	<ul style="list-style-type: none"> <li>• Using a deviation system; Inspection to advise; Emergent work should be planned; Special forms; shutdown manager to approve</li> </ul>

No.	Question	Respondent #1	Respondent #2
21	Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.	<ul style="list-style-type: none"> <li>• Unsafe Acts &amp; Conditions - being repeated everyday</li> <li>• Too many people on site - diverse backgrounds, behaviours &amp; cultures</li> <li>• People taking short-cuts in executing their jobs; trying to use a block permit instead of individual smaller permits</li> <li>• No learnings from the previous 2003 shutdown - similar problems were experienced in 2006. Lack of a consistent shutdown team</li> </ul>	<ul style="list-style-type: none"> <li>• Poor feedback on progress from supervisors</li> <li>• Poor adherence to bar charts &amp; schedules</li> </ul>
22	What challenges, in relation to safety, does your organization experience during the shut execution?	<ul style="list-style-type: none"> <li>• Safety watchers - not experts &amp; lacked confidence at the jobs they were asked to oversee</li> </ul>	<ul style="list-style-type: none"> <li>• Poor adherence to the use of PPE</li> </ul>

No.	Question	Respondent #3	Respondent #4
21	Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.	<ul style="list-style-type: none"> <li>• Non-adherence to the schedule; people don't have to wait for the meeting to report a delay - it should be communicated immediately</li> <li>• People not reporting accurately - just to get through with the meeting</li> </ul>	<ul style="list-style-type: none"> <li>• People &amp; labour on site; some of these could have other work arrangements already waiting for them - we need to make alternative replacements if comes to the worst</li> <li>• Bad weather</li> <li>• Criticality of skills, like engineers</li> <li>• Inspection reports</li> <li>• Improve on contracting strategies</li> <li>• Limited skills - hence maximize utilization</li> <li>• Supervisor</li> <li>• Labour brokers - labour issues on site &amp; people not being paid consistently</li> </ul>
22	What challenges, in relation to safety, does your organization experience during the shut execution?	<ul style="list-style-type: none"> <li>• PPE, especially ear plugs</li> <li>• People disregarding the rule of not using cell phones on site</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of adherence to procedures - use of PPE</li> <li>• Lack of adherence to Permit to work systems &amp; risk assessments</li> <li>• Poor communication</li> </ul>

No.	Question	Respondent #5	Respondent #6
21	Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.	<ul style="list-style-type: none"> <li>• Unforeseen problems - each day is very different</li> <li>• Shutting down / Decommissioning of the units has high safety risks</li> <li>• Congestion on site is also a high safety risk</li> <li>• Poor communication</li> <li>• Keeping mgt happy</li> </ul>	<ul style="list-style-type: none"> <li>• Quality of SD labour &amp; supervisors in South Africa</li> <li>• Scope growth</li> <li>• Requests from the inspectors (e.g. 100% x-rays on open ended lines)</li> <li>• Shortage of skills, especially at artisan levels</li> </ul>
22	What challenges, in relation to safety, does your organization experience during the shut execution?	<ul style="list-style-type: none"> <li>• PPE</li> <li>• scaffold incidents</li> <li>• Communicating &amp; reporting of injuries is not properly done</li> </ul>	<ul style="list-style-type: none"> <li>• People don't adhere to safety standards</li> <li>• Proper supervision is lacking</li> </ul>



No.	Question	Respondent #7	Respondent #8
21	Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.	<ul style="list-style-type: none"> <li>• Control of labour on site</li> <li>• Lack of discipline &amp; contractors who have no interest</li> <li>• Strikes</li> </ul>	<ul style="list-style-type: none"> <li>• Quality of skills</li> <li>• The tracking of inspection reports is very poor &amp; takes too long to communicate recommendations</li> </ul>
22	What challenges, in relation to safety, does your organization experience during the shut execution?	<ul style="list-style-type: none"> <li>• PPE issues</li> <li>• Permit violations</li> <li>• Lack of safety watchers</li> </ul>	<ul style="list-style-type: none"> <li>• Safety officers &amp; watchers who are not PetroSA staff lack responsibility &amp; ownership</li> <li>• large numbers of contract labour - difficult to develop a culture</li> </ul>

No.	Question	Respondent #9	Respondent #10
21	Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.	<ul style="list-style-type: none"> <li>• Poor skills levels, poor supervision, low productivity &amp; reworks</li> <li>• No proper control systems on emergent work</li> <li>• No proper structures for prioritizing jobs</li> </ul>	<ul style="list-style-type: none"> <li>• Failing on the basic initial philosophy</li> <li>• Lack of skills</li> </ul>
22	What challenges, in relation to safety, does your organization experience during the shut execution?	<ul style="list-style-type: none"> <li>• Contract labour is not safety conscious; a lot of unsafe acts</li> <li>• Working long hours - fatigue</li> <li>• Poor supervision</li> <li>• People not using common sense</li> </ul>	<ul style="list-style-type: none"> <li>• PPE</li> </ul>

No.	Question	Respondent #11	Respondent #12
21	Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.	<ul style="list-style-type: none"> <li>• Mobilisation of labour - internal process make it a centralized process</li> <li>• Cost mgt</li> <li>• Mgt of contracts; ownership of contract</li> </ul>	<ul style="list-style-type: none"> <li>• Scope</li> <li>• IR problems</li> <li>• Feedback confirmations</li> <li>• extension of contracts</li> <li>• Services &amp; inspectors not mobile</li> <li>• Inexperienced SD team</li> </ul>
22	What challenges, in relation to safety, does your organization experience during the shut execution?	<ul style="list-style-type: none"> <li>• Good SD 2006</li> <li>• Good culture of near hits/misses</li> </ul>	<ul style="list-style-type: none"> <li>• PPE</li> <li>• Falling objects</li> </ul>

No.	Question	Respondent #13	Respondent #14
21	Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.	<ul style="list-style-type: none"> <li>• Standby's</li> <li>• Poor communication</li> <li>• Feedback confirmations</li> <li>• Poor permit-to-work authorization system</li> </ul>	<ul style="list-style-type: none"> <li>• Inefficiencies</li> <li>• Not enough inspectors</li> <li>• poor interface between contractors, subcontractors and other disciplines</li> </ul>
22	What challenges, in relation to safety, does your organization experience during the shut execution?	<ul style="list-style-type: none"> <li>• Lack of supervision</li> </ul>	<ul style="list-style-type: none"> <li>• Poor safety culture in construction</li> </ul>

No.	Question	Respondent #15
21	Give a list of the challenges you experience in your area during the shutdown execution phase. Explain the cause of each challenge.	<ul style="list-style-type: none"> <li>• Inaccurate feedback report</li> <li>• Poor communication</li> </ul>
22	What challenges, in relation to safety, does your organization experience during the shut execution?	<ul style="list-style-type: none"> <li>• Minor injuries</li> </ul>

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25 MAY 2007

MR. PM BENAYA (205524393)  
GRADUATE SCHOOL OF BUSINESS

Dear Mr. Benaya

ETHICAL CLEARANCE APPROVAL NUMBER: HSS/0262/07M

I wish to confirm that ethical clearance has been granted for the following project:

"The challenges of shutdown management in the petrochemical refineries: A case study of PetroSA GTL Refinery"

Yours faithfully

*Phumelele Ximba*

MS. PHUMELELE XIMBA  
RESEARCH OFFICE

→ cc. Post-Graduate Office (Christel Haddon)  
cc. Supervisor (Dr. AS Gani)