Improving the turnaround maintenance of the Escravos gas plant

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Dedication

This work is dedicated to the loving memory of my angels; the late Johnson and Grace Ishekwene. I will always miss you both.

Acknowledgements

I thank God Almighty for all He has deposited in me.

My profound gratitude goes to my supervisor, Prof. Harry Wichers. I appreciate your understanding and patience.

Thank you Adeyemi for supporting this work, the knowledge that you always have my back all the time gave me great comfort especially when I lost both father and mother.

Finally my appreciation goes to my colleagues and friends whose names and contributions are too many to count here.

Abstract

According to Oliver (2002) the success of turnaround maintenances is measured in terms of the cost of completion, time, safety performance and the performance of the plant afterwards.

The Escravos gas plant (EGP) is a gas processing plant that converts associated gas from Chevron owned crude oil wells to liquefied petroleum gas, natural gas and gas condensate (Chevron intranet. Website assessed on September 14, 2007).

According to the EGP plant operations coordinator (See interview Appendix A), the plant undergoes a turnaround maintenance exercise once every two years. The major tasks done during these turnaround maintenances are

1. Change-out of three molecular sieve beds.
2. Servicing of three compressor turbines.
3. Servicing of expander turbo-machinery.
4. Clean-out of fired gas heater tubes and burners.
5. Tie-ins for major upgrades.

The EGP management does not involve the contractor personnel that carry out the tasks in the management of the turnaround maintenance. The contractor's personnel simply follow the work plans and instructions developed by the EGP management.

The EGP turnaround management team consists of the coordinator who is the head of the turnaround maintenance team, shift supervisors, maintenance supervisors (rotating equipment maintenance supervisor, instrumentation and electrical maintenance supervisor, and static equipment maintenance supervisors), safety supervisors, maintenance planners, process engineers and construction supervisors.

All these listed personnel in the preceding paragraph and the supervisors of the contractor teams participate in the pre-turnaround meetings which happen once a month for the first 10 months of the 12 months leading to the turnaround. The meeting frequency increases to once every two weeks during the last two months leading to the turnaround maintenance. The meeting is held

daily during the turnaround maintenance and once every two weeks for the first month after the turnaround maintenance.

During the preceding months to the turnaround maintenance, the work scope is defined, the job sequence outlined and schedules are developed. Resources requirements are detailed and procured. During the turnaround maintenance the focus of the turnaround meeting is to discuss potential deviations, observe at-risk behaviors and likely challenges. Plans are then made to address these deviations, challenges and at-risk behaviors. After the turnaround maintenance, "lessons learnt" are captured and the turnaround maintenance is closed out.

According to the EGP coordinator (see interview in appendix A), the success of its turnaround maintenance is measured by the time used to complete the turnaround maintenance, the total recordable incident rate during the turnaround maintenance, the days away from work, the lost time injury(LTI) and the cost incurred.

Poling et al noted that it is difficult to rate turnaround maintenance projects because no two turnaround maintenances strategies are exactly the same. They iterated that the most common tactics used is benchmarking and that benchmarking enables a company to measure and compare its performance against peer companies in a constructive and confidential manner. They pointed out that the quantitative differences computed between a plant and other similar plants using detailed data taxonomy can provide invaluable information regarding improvement opportunities. This is a way of effectively extending a "lessons learned" exercise across multiple companies. According to then however a critical attribute of effective reliability and maintenance benchmarking is the ability to compare disparate assets; but even small differences for similar plants can alter the value of the comparison.

Existing literature indicate that the parameters the gas plant management use to rate the safety of its turnaround maintenance (i.e. the total recordable incident rate, the days away from work and the lost time injury)are reactive in nature. They are otherwise called lagging indicators. Lagging indicators are safety performance metrics that are recorded after the accident or incidents has occurred. For example lost time injury is any work related injury or illness which prevents that person from doing any work day after accident (E&P Consultancy Associates. Website assessed on June 15, 2009). In contrast the other group of metrics called pro-active metrics or leading indicators such as at-risk behaviors, near misses and preventive maintenance not completed are parameters that measure safety performance before accident occurs.

Leading indicators gained popularity in the 1930's after Heinrich postulate his iceberg theory (Wright, 2004). Heinrich's used the iceberg analogy to explain reactive (lagging) and proactive (leading) indicators. Heinrich likened accident and at-risk behaviors to two parts of an Iceberg; the part you see above water and the part hidden under the water. The size of the iceberg above water is relatively small compared to that under water. The iceberg starts to grow under the water and only after they reach a certain size does part of the ice begin to appear above water. Heinrich believed that accidents are the result of root causes such as at-risk behaviors, inconsistencies, wrong policies, lack of training and lack of information. When the number of accidents that occur in an endeavor is measured you get relatively smaller numerical quantities when compared to the number of at-risk behaviors.

Heinrich suggested that to eliminate accidents that occur infrequently, organizations must make effort to eliminate the root causes which occur very frequently. This makes sense because imagine a member of personnel coming to work intoxicated every day. Binging intoxicated at work is an at-risk behavior. The employee is very likely to be involved in an accident at some time as a result of his drinking habit. The number of times he is intoxicated if counted will be huge when compared to the impact of the accident when it does occur.

The iceberg theory is supported by work from Bird (1980) and Ludwig (1980) who both attempted to establish the correct ratio of accidents to root causes in different industries. Heinrich suggested a ratio of three hundred incidents to twenty nine minor injuries to one major injury.

This researcher chose to use the number of at-risk behavior exhibited by the turnaround maintenance teams to rate the safety performance of tasks despite criticism from individuals like Robotham (2004) who said that from his experience minor incidents do not have the potential to become major accidents and Wright et al (2004).

Leading indicators are convenient to analysis because of their relative large quantity. In a turnaround environment, the numbers of accidents that occur are relatively few unlike the number of near misses (Bird, 1980). It is easy to statistically analyze thirty at-risk behaviors than four accidents. In addition Fleming et al (2001) noted that data from industry show much success by companies in the reduction of accidents by efforts at reducing the number of at-risk behaviors, increase the number of safety audits, and reduce the number of closed items from audits etc. Phimister et al made similar claims when they said Near miss programs improve corporate environmental, health and safety performance through the identification of near misses.

Existing literature also reveals many theories about management styles and their possible impact on performance. The theories are grouped into trait theories, situational theories and behavioral theories. The trait theories tries to explain management styles by traits of the managers like initiative, wisdom, compassion and ambitious. Situational theories suggest that there is no best management style and managers will need to determine which management style best suit the situation. Behavioral theories explain management success by what successful managers do. Behavioral theorists identify autocratic, benevolent, consultative and participatory management styles. Vroom and Yetton (1973) identified variables that will determine the best management style for any given situation. The variables are;

1. Nature of the problem. Is it simple, hard, complex or clear?
2. Requirements for accuracy. What is the consequence of mistakes?
3. Acceptance of an initiative. Do you want people to use their initiative or not?
4. Time-constraints. How much time do we have to finish the task?
5. Cost constraints. Do we have enough or excess to achieve the objective?

A decision model was developed by Vroom and Yago (1988)to help managers determine the best management style for different situations based on the variables listed above (See figure six).

They also defined five management style could adopt, namely the;

1. Autocratic I style
2. Autocratic II style.

3. Consultative I style
4. Consultative II style
5. Group II style

The autocratic I management style is a management style where the leader solves the problem alone using information that is readily available to him/her, is the normal management style of the Escravos gas plant management in all turnarounds prior to 2009. However the Vroom and Yago model recommends the Consultative II management style for the type of work done during the Escravos gas plant turnaround maintenance.

According to Coye et al (1995), participatory management or consultative style II creates a sense of ownership in organization. In this management style the leader shares problem with group members individually, and asks for information and evaluation. Group members do not meet collectively, and leader makes decision alone (Vroom and Yago, 1988). Coye et al believe that this management styles instills a sense of pride and motivate employees to increase productivity. In addition they stated that employees who participate in the decisions of the organization feel like they are a part of a team with a common goal, and find their sense of self-esteem and creative fulfillment heightened.

According to Filley et al (1961), Spector and Suttle did not find any significant difference in the output of employees under autocratic and participatory management style.

This research studies if and how the Escravos gas plant turnaround maintenance can be improved by changing the management style from autocratic I style to consultative II style. Two tasks in the turnaround were studied; namely the change out of the molecular sieve catalyst beds and the servicing of the turbine engines.

The turnaround contractor Techint Nigeria Limited divides the work group into teams responsible for specific tasks. Six teams (team A, B, C, D, E and F) were studied. EGP management will not allow the researcher to study more than these six teams for fear of the research disrupting the work. The tasks completed by these teams are amongst those not on the projects critical path so delays caused by the research will not impact the entire turnaround project provided the float on these activities were not exceeded. They also had the fewest number of personnel, so cost impact of the research work could be easier to manager.

Teams A, B and C are different maintenance teams comprising of eight personnel each. They were responsible for changing the EGP molecular sieve beds A, B and C respectively in the 2007 and 2009 turnaround. Their tasks are identical because the molecular sieve beds are identical.

Teams E, D and F are also maintenance teams comprising of six personnel each. They were responsible for servicing the EGP turbine engines A, B and C during the 2007 and 2009 turnaround maintenance. Their tasks are also identical because the turbine engines are identical.

Consultative management style II is exercised by involving team A and team D in the development of the procedures, processes and job safety analysis of all tasks that they were assigned to complete during the 2009 turnaround maintenance. They were also permitted to participate in the turnaround maintenance meetings and to make contributions in the meetings. In the 2007 turnaround maintenance team A and team D only carried out their tasks. They did not participate in the development of procedures and job safety analysis neither did they participate in the turnaround maintenance meetings.

The other four teams; team B, team C, team E and team F are used as experimental controls for the research. They did not participate in the development of the procedures, processes nor the job safety analysis for the tasks in either of the turnaround maintenance. They were also not permitted to attend the daily turnaround meetings. They only completed their tasks based on instructions given to them during the 2007 and 2009 turnaround maintenance.

It was necessary to study the experimental control teams as the researcher was not sure whether task repetition, increased knowledge or improved team cohesion would lead to a reduced time or a reduced numbers of at-risk behavior.

The research tested the hypothesis $1H_0$ and $1H_1$ and $2H_0$and $2H_1$ at the 0.025 and 0.05 level of significance as follows;

Null hypothesis, $1H_0$: There is no significant difference in the time spent by team A and team Din 2007 when they did not participate in the development of the procedures and processes with the time in 2009 when they did(μ_1- μ_2 =0).

Alternate hypothesis, $1H_1$: There is a significant difference in the time spent by the team A and Din 2007 when they did not participate in the development of the procedures and processes with the time in 2009 when they did (μ_1- $\mu_2 \neq 0$).

Null hypothesis, $2H_0$: There is no significant difference in the number of at-risk behaviors observed to have been exhibited by the team A and team D in 2007 when they did not participate in the development of the procedures and processes with the number in 2009 when they did (μ_1- μ_2 =0).

Alternate hypothesis, $2H_1$: There is a significant difference in the number of at-risk behaviors observed to have been exhibited by the team A and team D in 2007 when they did not participate in the development of the procedures and processes with the number in 2009 when they did (μ_1- $\mu_2 \neq 0$).

The student t test was used to analyze these times and number of at-risk behavior. At the 0.025 and the 0.05 level of significance, the data show that there is no difference in the times all the teams used to complete their task in 2007 and in 2009. The researcher concludes that a change in the management style from autocratic I style to consultative II style did not lead to a reduction in the time used by any team to complete their task.

However at the 0.025 and the 0.05 level of significance, there is a significant difference in the number of at-risk behaviors of the research team A and team D. There is however no significant difference in the number of at-risk behavior of the control team B, team C, team E and team F at the same level of significance. The researcher concludes that a change in the management style from autocratic I style to consultative II style lead to a reduction in the number of at-risk behavior of team A and team D.

In addition the reduction in the number of at-risk behavior of team A and team D could not have been because of task repetition, increased knowledge or improved team cohesion since there is no significant difference in the number of at-risk behavior exhibited by team B, team C, team E and team F.

The research can be used by the Escravos gas plant management and the management of any similar process plant to fashion out more cost effective, time effective and safer methods for carrying out their turnaround maintenance. A change in management styles may just be a better approach to improving productivity than giving financial incentives to contractors and personnel.

Changes in management style will have to be managed. The change must be gradual because sudden change can be detrimental as people may just need to understand and adapt to the change. The turnaround personnel must also understand the intent so as to prevent conflicts.

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Keywords and terms

1. At-risk Behavior- behaviors that key stakeholders sometimes engage in, knowing on some level that it could risk safety (E&P Consultancy Associates. Website assessed on June 15, 2009).

2. Autocratic I management style (AI) leader- A leader that solves the problem alone using information that is readily available to him/her (Vroom and Yago 1988).

3. Autocratic II management style (AII) leader- A leader that obtains additional information from group members, and then makes decision alone. Group members may or may not be informed.(Vroom and Yago 1988).

4. Autocratic manager-The autocratic manager is one who gives out instruction to his subordinates and expects them to complete it without questioning. He rarely seeks feedback from them and there is great punishment for failure (Lupindo, 2007).

5. Benevolent-autocratic manager-The benevolent-autocratic manager motivates employee with reward. He allows a little amount of decision making at the level directly next to his. He has full understanding of these decisions and they must be what he wants to hear (Lupindo 2007).

6. Consultative I management style (CI) - A leader that shares problem with group members individually, and asks for information and evaluation. Group members do not meet collectively, and leader makes decision alone (Vroom and Yago, 1988).

7. Consultative II management style (CII) leader- A leader that shares problem with group members collectively, but makes decision alone (Vroom and Yago, 1988).

8. Consultative manager-The consultative manager is somewhat democratic and partly participative in style. He makes big decision and form general policies that direct the organization. Feedback from the subordinate form a major part of the managers decision. He

asks for the feedback and encourages it. He does not get himself involved in the basics of the work (Lupindo, 2007).

9. Group II management style (GII) leader- She/he meets with group to discuss situation. The leader focuses and directs discussion, but does not impose will. Group makes final decision (Vroom and Yago, 1988).

10. Incident-An unplanned event or chain of events which has or could have caused injury or illness and / or damage or loss to environment, third parties or assets (E&P Consultancy Associates. Website assessed on June 15, 2009).

11. Job safety analysis- A process of systematically evaluating certain jobs, tasks, processes or procedures and eliminating or reducing the risks or hazards as low as practicable (ALARP) in order to protect workers from injury or illness. The JSA process is documented and the JSA document is used in the workplace or at the job site to guide workers in safe job performance. The JSA document is also a living document that is adjusted as conditions warrant (Wikipedia JSA. Website assessed on October 29, 2009).

12. Lost time injury-Any work related injury or illness which prevents that person from doing any work day after accident (E&P Consultancy Associates. Website assessed on June 15, 2009).

13. Management styles- The methods and means by which managers perform their function of directing, controlling and coordinating (Lupindo 2007).

14. Participatory manager- The participatory manager does not just ask for feedback from them but involve personnel in the formulation of policies, procedures and goals. In some cases participatory managers have allowed workers to partly own the business directly or indirectly (Lupindo 2007).

15. Performance-Process or manner of functioning or operating (The free dictionary. Website assessed on May 7, 2008).

16. Procedures-A way of doing something, especially the usual or correct way (Oxford Advance Learner's dictionary, 2010).

17. Recordable Injuries- They include occupational death, nonfatal occupational illness, and those nonfatal occupational injuries which involve one or more of the following: loss of consciousness, restriction of work or motion (Liberty Insurance Agency. Website assessed on August 27, 2011).

18. Standard Operating procedure-A Standard Operating Procedure (SOP) is a set of written instructions that document a routine or repetitive activity followed by an organization (United State Environmental Protection Agency 2009).

19. Total Recordable Incidence Rate (TRIR) - A measure of the rate of recordable workplace injuries, normalized per 100 workers per year. The factor is derived by multiplying the number of recordable injuries in a calendar year by 200,000 (100 employees working 2000 hours per year) and dividing this value by the total man-hours actually worked in the year (Liberty Insurance Agency. Website assessed on August 27, 2011).

20. Turnaround Maintenance- This is a periodic maintenance process by which a process plant is shut down for inspections, overhauling, modifications and tie-ins(American petroleum institute. Website assessed on December 11, 2007).

Acronyms

1. DAFW- Days away from work
2. EGP- Escravos Gas Plant
3. JSA- Job safety analysis
4. LPC-Least preferred co-worker
5. LPG- Liquefied petroleum gas
6. LTI- Lost time injury
7. LTIFR- Lost time injury frequency rate
8. MVC- Motor vehicle crash
9. NGC- Nigerian gas company
10. NNPC-Nigerian National Petroleum Corporation
11. OSHA-Occupational safety and health authority
12. SOP- Standard operating procedure
13. TRIR-Total recordable incident rate
14. RCA- root cause analysis
15. PI- Plant instruction.

Chapter 1

Introduction

This chapter introduces the research. The research context is described to provide background for the research undertaken. The goals of the research and the research methodology adopted are presented. Finally, the thesis structure is outlined.

1.1. Introduction.

A turnaround maintenance activity is a planned periodic maintenance activity in which process plants, which are normally always in operation except for emergencies, are shut down to carry out certain tasks. According Zulkipli et al (2009) examples of tasks carried out during turnaround maintenance are.

1. Inspections,
2. Tie-ins for plant expansions,
3. Modifications and upgrades,
4. Overhauls,
5. Replacements and
6. Maintenance.

Zulkipli et al (2009) also noted that turnaround must be completed in the shortest possible time because during the period of the turnaround, production opportunity is lost since the whole plant or at least a major portion of it is shut down.

The Escravos gas plant (EGP) is one of Chevron Corporation's joint venture investments in Nigeria with the Nigeria National Petroleum Company (NNPC). It is a multi billion naira investment that processes some of Nigeria gas reserves in the Niger delta to produce liquefied petroleum gas (LPG) and gas condensate(Escravos gas plant intranet. Website assessed on August 22, 2007).

The Escravos gas plant consist of a feed separation and filtration section, a dehydration section using molecular sieves, a cooling section using a cold box and turbo-expander, a fractionation section, a lean gas compression and metering section, a liquefied petroleum gas product storage and shipping section, and a condensate stabilization section (Escravos gas plant intranet. Website assessed on August 22, 2007).

Like any other process plant, EGP undergoes a turnaround maintenance activity every two years. The major tasks done during the turnaround maintenance are the change-out of the two molecular sieve beds, the servicing of the two compressor turbines, the servicing of the expander turbo-machinery, the clean-out of the fired gas heater tubes and burners and tie-ins for major upgrades.

According to Escravos gas plant operations coordinator (see interview in appendix A) who manages the EGP turnaround maintenance, it takes about two weeks to complete and 1.2 million U.S. dollars to complete the items that are repeated on every turnaround (the other costs are non reoccurring tasks) and there is an average of 0.33 total recordable incidents per turnaround (Interview with the EGP coordinator. See Appendix A).

Prior to the 2009 turnaround maintenance, only the gas plant operation coordinator (see interview in appendix A) with the shift supervisors, safety supervisors, process engineer, maintenance planner, construction supervisor and the maintenance (instrument and electrical, rotating equipment and fixed equipment) supervisors develops the procedures, processes and job safety documents for the turnaround maintenance. They do not normally involve the contractor personnel who directly perform the tasks in activities like the development of the procedures, Job safety and analysis and in the turnaround maintenance meetings.

1.2. Problem statement.

The cost incurred during turnaround maintenances can include;

1. The cost of tools and equipment,
2. The cost of paying contractors for work such as off loading catalysts from vessels, cleaning the reactors and reloading the catalyst,
3. The cost of any accident that arises during the process. This include the cost of treating injured personnel, the cost of investigating the incident, the cost of repairs of damaged assets, the cost of insurance payout, the cost of delays as a direct and indirect result of the accident and so on,
4. Loss of Revenue because the plant is not operational when the change-out is taking place and

5. Labor cost in the form of overtime payouts to employees.

Cost 4 and 5 above are directly dependent on time because;

1. The longer the plant is shut down for maintenance the more it loses income from sales of product.
2. Turnarounds are so labor intensive because of the amount of work to be done in the time which is usually short. Many turnaround manager use overtime to complete these task (G Gono (2001)). So the costs of turnaround maintenances will increase as the time taken to complete the turnaround increases.

Cost 3 depends on the knowledge and skill of workers and their behavior to safety. The researcher will think that the more people become trained to understand the impact of at-risk behaviors, the more they would work safe.

The Escravos gas plant coordinator (see interview in Appendix A) acknowledges that apart from cost and time, the number of incidents and accidents that occur in the plant as a whole normally increases during turnaround. According to Gono (2001) this is due to the intensity and nature of work during the turnaround.

For example, the cost of the 2005 gas plant turnaround was 1.2million dollars (see interview with gas plant coordinator). This is about 36% of the overall gas plant annual operating expense (see figure one). In addition the total recordable incident rate during the period where turnaround is taking place is between 2.5 to 3.5 times the rate when no turnaround work is occurring (see figure two).

The total recordable incidence rate (TRIR) is a measure of the rate of recordable workplace injuries, normalized per 100 workers per year. The factor is derived by multiplying the number of recordable injuries in a calendar year by 200,000 (100 employees working 2000 hours per year) and dividing this value by the total man-hours actually worked in the year (Liberty Insurance Agency. Website assessed on August 27, 2011).

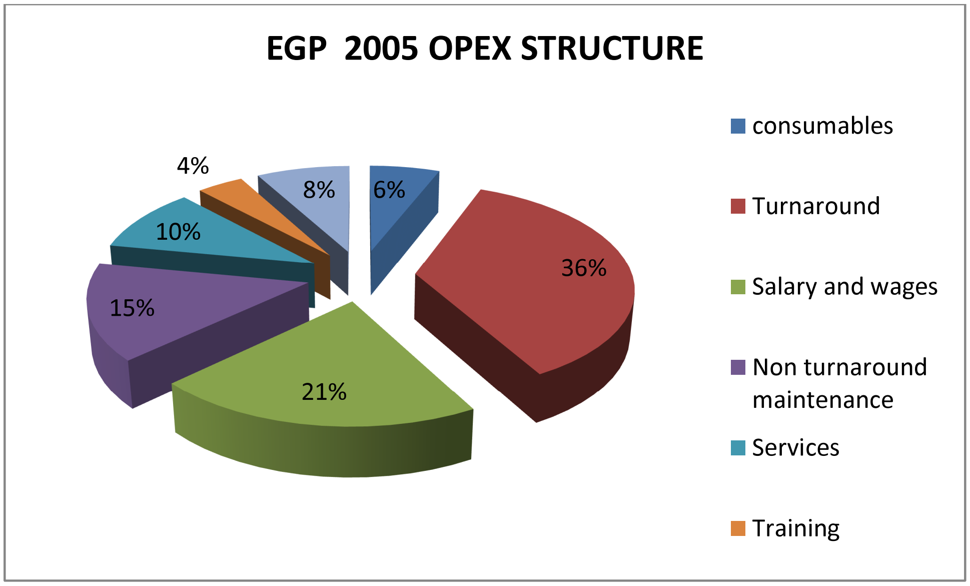

Figure one. Escravos gas plant operating expense structure (Reference EGP website)

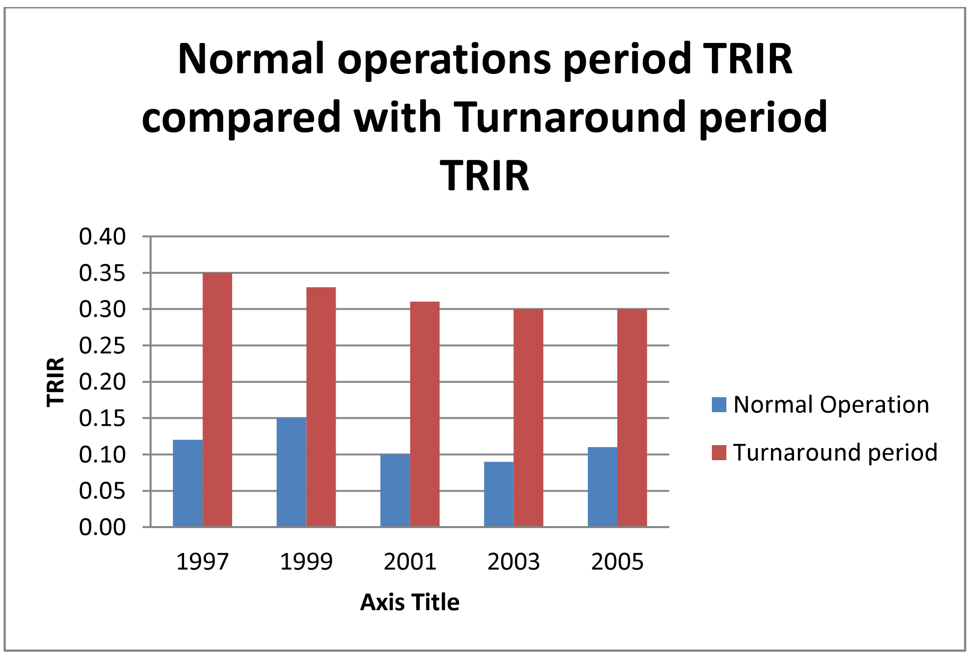

Figure two. Escravos gas plant comparison of TRIR (Reference EGP website)

Two problem statements of this research are:

1. Is it possible to reduce the cost of the Escravos gas plant turnaround maintenance?
2. Is it possible to reduce the number of incidents that occur during the Escravos gas plant turnaround maintenance?

The Escravos gas plant applies an autocratic management style for its turnaround maintenance but the researcher having studied the works of Vroom and Yago (1988) knows that there are other management styles. The researcher considers the following additional problem statements:

1. Will applying other management styles improve the times used to complete the turnaround maintenance, its cost and safety performances for this type of turnaround maintenance?
2. What type of management style do other researchers and experts proffer as the best management style for the type of work performed during the EGP turnaround maintenance?

1.3. Research Objectives.

The general aim of this research work is to

1. Understand the current EGP turnaround maintenance through the stages of planning, pre-shutdown, shutdown, execution and start up.
2. Conduct literature survey on different management styles and how to measure the success of turnaround maintenance in the processing industry.
3. Identify the management styles the EGP uses for its turnaround maintenance.
4. Determine the best management style the Escravos gas plant (EGP) should adopt based on the literature survey conducted.
5. Reach agreement with the EGP management on how to test the management style selected or the modification to improve the turnaround maintenance.
6. Conduct research and determine if the change of management style or the modification of the existing style will improve the turnaround maintenance.

The specific objectives of the project are as follows:

1. Determine if a change in management style could reduce the duration of activities in the EGP turnaround maintenance project.
2. Determine if a change in management style could reduce the safety performance of the EGP turnaround maintenance project.

1.4. Dissertation organization.

The thesis is organized into the following chapters:

Chapter 1: Research Introduction.

The research is introduced. The research context is described to provide a background for the research. The objective of the research and the organization of the dissertation are presented.

Chapter 2: Literature survey

The literature survey is conducted by the researcher to assess experts' opinion on how to measure the performance of turnaround maintenance like that of the EGP and on the managerial styles prescribed by expert for work like that performed during the Escravos gas plant turnaround maintenance.

Chapter 3: Empirical investigation.

The scientific method used in carrying out the research is enumerated.

Chapter 4: Results.

The data from the research is presented and statistically analyzed to determine the effect that a change in management style has on the time to complete the selected tasks and the number of at-risk behaviors exhibited by the teams while completing these tasks.

Chapter 5: Discussions and interpretations.

An interpretative discussion and outcomes of the research is made in this chapter.

Chapter 6: Conclusions and recommendations

The overall dissertation is concluded. Suggestions are made for any one conducting further research based on the findings and experience the researcher gained while conducting the study.

In the next chapter the experts' opinions on the turnaround maintenances, the dimensions of measuring performances of turnaround maintenances and the preferred method of managing turnaround maintenances will be discussed.

Chapter two

Literature survey

The literature survey is conducted by the researcher so as to assess experts' opinion on managerial styles and on how to measure the performance of turnaround maintenances.

2.1. Turnaround maintenance

Like conducting a regular service on a vehicle, turnaround maintenances are an essential activity of any process plants (Duffuaa, 2004). They have to be carried out because certain equipments or parts of equipments in the plant only have a limited life span in comparison to the plant. According to the Escravos gas plant operations coordinator (see interview in appendix A), the Escravos gas plant (EGP)molecular sieves are designed to last for 30 months based on the EGP feed rate and composition. It is around this limitation that the EGP turnaround maintenance is planned.

In their book "Handbook of Maintenance Management and Engineering", Ben-Daya et al (2009) purported that turnarounds management's potential for cost saving is drastic, and it directly contributes to the company's bottom line profits. They also wrote that controlling turnarounds cost and duration represents a definite challenge. According to Ben-Daya et al maintenance planning and scheduling is one of the most important elements in maintenance management and it can play a key role in managing complex turnarounds.

Ben-Daya et al listed six possible objectives of turnaround maintenances. They are;

1. To improve efficiency and throughput of plant by suitable modification,
2. To increase reliability of equipment during operation,
3. To make plants safe to operate till next turnaround,
4. To achieve the best quality of workmanship,
5. To reduce routine maintenance cost and
6. To upgrade technology by introducing modern equipment and techniques.

Lenahan (2006) in his book titled "Turnaround, shutdown and outage management: effective planning and step" identified the performance indices that can be used to rate the performance of turnaround maintenance as safety, cost, duration, efficiency and quality.

In his write up in the oil and gas journal of April 2002, Rod Oliver identified 12 performance criteria some of which are duration, total cost, safety, start-up incident, environmental incidents, unscheduled shutdowns etc. These criteria and their description are defined as

Criterion	Description
Duration	Oil out to on-spec product. Days or days/year
Total cost	Turnaround and routine maintenance
Turnaround costs	Actual and annualized by plant function
Frequency	Run length, months
Predictability	Actual vs. planned work hours, duration and cost
Safety	Accident number and rates
Start-up incidents	Days lost due to rework
Unscheduled shutdowns	Days lost during the run
Mechanical availability	Time available %
Additional work	Actual vs. contingency
Environmental incidents	Impact of incidents attributed to a shut down
Savings	Money saved resulting from changes to the above indices

He further iterated that the organization must measure turnaround performance and observe trends. As with all measurements, a single indicator can mislead. It is, therefore, necessary to design a number of criteria to provide a balanced indication of performance.

2.2. Safety during turnaround maintenance

There is a greater probability for incident and accidents to occur during turnaround than under normal operating circumstances largely for the following reasons.

1. Often the task carried out during turnarounds are none routine,
2. Personnel who are not always very familiar with the plant are often employed,
3. The intensity of the work carried out during turnarounds is high. So much to do so little time to do it and
4. The complexity of the work done.

According to keesing (2009), the cost, both direct and indirect that is incurred as a result of poor safety performance during a turnaround directly impacts the bottom line and can mean the difference between being under, or over estimated budget cost.

CAM (Website assessed on August 2, 2008) noted that although many maintenance planners are beginning to include critical support services that can keep turnarounds on schedule, many still do neglect them. CAM also argued that not including support services such as safety training and management, industrial hygiene monitoring, lead and asbestos testing, and environmental monitoring as part of turnarounds or maintenance project can have serious impact on scheduling activities, and unanticipated delays can push the completion dates out further and further. So any research into how safety can be improved during turnaround maintenances is beneficial to the managers of the turnaround maintenance.

Poling et al noted that it is difficult to rate turnaround maintenance projects because no two turnaround maintenances strategies are exactly the same. They iterated that the most common tactics used is benchmarking and that benchmarking enables a company to measure and compare its performance against peer companies in a constructive and confidential manner. They pointed out that the quantitative differences computed between a plant and other similar plants using detailed data taxonomy can provide invaluable information regarding improvement opportunities. This is a way of effectively extending a “lessons learned” exercise across multiple companies. According to then however a critical attribute of effective reliability and maintenance benchmarking is the ability to compare disparate assets; but even small differences for similar plants can alter the value of the comparison.

2.3. Measuring safety

According to Ben Daya et al (2004), safety is one of the key measures used to determine the success of turnaround maintenance. Jump (Website assessed in January 6, 2008) pointed out that measuring safety is a complex problem.

In his article posted on the web and titled “A Review of Commonly-Used Performance Indicators” Spear (Website assessed on February 1, 2008) identified the following classification of measures of safety; trailing or leading indicators, input or output, outcome or process oriented, results or activity-based measures, downstream factors or upstream factors, and/or qualitative or quantitative metrics. The researcher has particular interest in the first two classifications.

2.3.1. Proactive (leading) and Reactive (lagging or trailing)

Just like Spear, Jump (2008) identified two categories of measure of safety;

1. Proactive (Measurement of safety performance prior to loss or potential events. That is the accident has not happened but could have happened if conditions had been different). Examples include at-risk behaviors personnel exhibit and the number of audit completed.

2. Reactive (Measures that determine performance based on loss events. i.e. the accident has happened). For example measuring Total recordable incident rates, number of investigations completed, and lost time injuries.

Spear is in agreement with Baldauf (2008) who said that businesses use key performance indicators (KPIs) to measure progress toward specific health and safety goals or simply to monitor trends associated with corporate and facility activities or special projects. These KPIs he said are used as a means to collect data and communicate trends, which can then be used to indicate where further improvements and resources are required.

He further postulated that KPIs that represent what has already happened are referred to as “lagging indicators” and that lagging indicators are commonly used in company communications to provide an overview of performance, such as the tracking of injury statistics, exposure incidents, and regulatory fines. On the other hand Baldauf said that “Leading indicators” are more predictive of future performance results.

Leading indicators are viewed as proactive measurements. These might include, among other things:

1. Number of audits or inspections performed.
2. Number and types of findings and observations.

3. Time frame to close action items.
4. Training completed.
5. Near miss incidents.
6. Timely preventive maintenance tasks performed.
7. Safety committee meetings.

In either case, KPIs must be quantifiable and tied to specific targets.

The consultnet.ie (Website assessed in August 1, 2007) enumerated the advantages of these two methods over one another.

Advantages of lagging indicators (Reactive)

1. Motivate management. Management will respond to improve safety performance if the values of lagging indicators are high where they had previously been slow to respond.
2. An accepted standard. Many safety regulators and standards authorities still use the lagging indicators to rate performance.
3. Long history of use. These have been the earliest measure of safety performance
4. Used by government agencies, industry associations.
5. Easy to calculate. The numbers of actual incidents like injuries and death are small compared to the parameters they are measured against like total man hours and number of days. All these parameters are easy to obtain.
6. Indicate trends in performance.Measures like lost time injuries, total recordable injury rate and so on can be compared yearly to indicate a trend of performance.
7. Good for self comparison. They are good comparisons only when an organization or industries is ranking itself against itself because some organizations and industries are more prone to accidents and injuries than others. For example a refinery is more prone to accidents than a car manufacturing plant.

Advantages of leading indicators

1. Proactive.Leading indicators like number of at-risk behaviors, risk assessments recommendations that were not closed out, preventive maintenance not completed, delayed

inspections are measured before incidence happen. This means that trends can identify the root cause of accidents and manage them before it happens.

2. Not easily manipulated.The motivation to manipulate these parameters is not as much as that for lagging indicators.
3. Usually is unbiased (management attitude to restricted work, Doctor influence/worker attitude to light duties/compensation system/safety awards and competitions).
4. Easier to analyze statistically because of their relatively larger numbers.
5. Figures measured are typically high, making it easy to establish trends.
6. Unlike lagging indicators where the incident occurs and then managers/safety specialists put it down to a ‘once off/freak’ event, leading indicators are records of possible events that could lead to the ‘once off/freak event’.

2.3.2. Output against input

Gittleman et al (2006) proffered a quite different approach from the usual method of measuring safety against the inputs of labor (the number of workers and hours worked) but rather related to labor outputs (the amount of production generated by workers.)

In their article titled “A Different Approach to Measuring Workplace Safety: Injuries and Fatalities Relative to Output”, they enumerated the latter approach, calculating trends in injury and fatality rates using a "value-added" measure of output as the denominator.

The article describes the derivation of output data that can be used for this approach and points out some of the related issues and caveats. Analyses of work-related injury and fatality risks may differ, depending on whether the measure is injuries per hour worked or injuries per unit of output.

The article also showed a possibility that some industries or sectors that appear to be relatively safer by one measure may appear to be less so by other measures.

According to Furst (2006), in general, there is no single reliable measure of safety and health performance. It is not a one-size-fits-all proposition. One may decide on three, four, five, six, or even more perspectives for measurement purposes. A mixture of both outcome-oriented and process-oriented measures are needed to effectively evaluate performance. Furst suggested that the type of metrics used should be different for evaluating different levels of the organization.

Petersen (1996) postulated that only process-oriented metrics be used at the lower management or unit levels and activity measures (with some outcome measures) primarily used for the middle-upper management levels. Pure outcome measures should be reserved for the executive level.

This researcher is of the opinion that it is arguable that the inputs and output of any two turnarounds are the same. Although the task may be the same their quality which on its own is an output are most likely not to be the same, even in the presence of standardization by procedures, tools, processes and so on. The output of no two individual can exactly be the same. The output of an individual on two separate occasions cannot be the same.

2.4. Iceberg theory and accident triangle

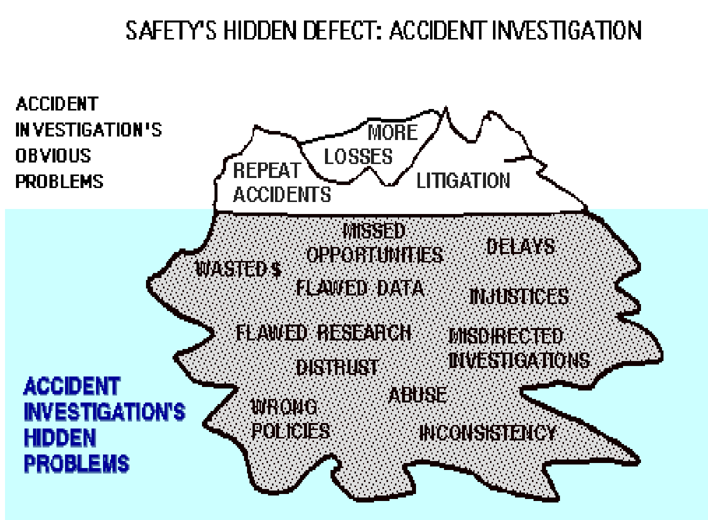

Figure three: Iceberg effect. B. Ludwig (1980)

The iceberg effect is a common analogy that has been used to describe the root cause of many accidents. Proponents of the iceberg effect like Benner, Jr. (1980) say the real causes or what is commonly called root causes of major accidents are engrained in the organization and often like the big chunk of ice under the sea it not very visible when compared with the relatively smaller number of accidents that occur. They believe that the small chunk of ice (accidents) is the result of the large number of factors hidden in the organizations and repeated so much that they become cultures and accepted norms.

The root causes include at-risk behaviors, inconsistencies, wrong policies, lack of training, lack of information, improper management of change procedures etc. These root causes are not readily visible to most people. The subtle ones are like the bottom of an iceberg. They are there, and they create lots of difficulties, but they are hidden. Benner especially argued that inadequate investigations or investigation failures are included in the hidden factors.

L. Wright et al (2004) linked the idea of a common cause hypothesis to Heinrich (1931) in his seminal book “Industrial Accident Prevention”.

The implication of this analogy today is that it has become a widely accepted way of thinking that if you prevent minor damage, you will automatically prevent major ones. Accident ratio studies (insisting on set ratios between near misses, minor accidents and serious accidents based on Heinrich’s hypothesis) are common like Bird (1980) and Ludwig (1980).

Another implication of Heinrich’s theory according to Fleming et al (2001) many companies invest heavily on programs aimed at eliminating lost time injuries so as to prevent major accidents. Phimister et al in the Risk Analysis Journal, Volume 23, No. 3 of 2003 made similar claims when they said Near miss programs improve corporate environmental, health and safety performance through the identification of near misses. According to Robotham (2004), George McDonald believes the iceberg analogy and Heinrich’s ratio hypothesis are flawed.

Robatham argued that from his personal experience the majority of minor damage incidents do not have this potential. He made his conclusion by analyzing the nature of the energy that was available to be exchanged in the incident.

Robatham highlighted that all organizations have limited resources to devote to safety, it seems more efficient to him to prevent one incident resulting in paraplegia than to prevent twenty incidents where people have a couple of days off work. He said that somewhere in the push to reduce L.T.I's (Lost time injury), reduce the LTIFR (Lost time injury frequency rate) and consequently achieve good ratings in safety program audits the focus on serious personal damage tends to be lost. He said he knew of companies that have made great reductions in LTIFR, yet they are still seriously injuring their people. He however did not mention the names of the company.

McDonald's opinion is that the vast majority of the mishaps can never get to be minor occurrences and which in turn can never get to be major occurrences. According to him minor incidents and mishaps can form part, but only a part, of a predictive base. He warned that concentrating on them in the past seriously misdirected safety efforts and resources and has been instrumental in bringing safety into disrepute. This he furthered buttressed by saying "the common cold is not indicative of heart, stroke, cancer or AIDS deaths."

Finally he believed that the iceberg theory and the belief there are set ratios between incidents of various types are responsible for the concentration on Class 11 and Class 111 occurrences in many companies in Australia today.

Wright et al (2004) analyzed many of the research work that linked minor incidents to major accidents and three cases analyzed in their research work confounded the iceberg theory and four did not.

They pointed to the fact that two of the cases that confounded the theory confuses ratio of minor to major incidents as being the same as causal mechanisms of major and minor incidents. They said another showed confusion over activity being performed prior to incident and the causes of incident. They did not give explanation about the three that did not confound the iceberg theory.

Wright et al (2004) enumerated that it appeared that researchers have not differentiated between the causes of severity and frequency and the causes of accidents and incidents. Thus, if a ratio is established and the data follow the pattern of the ratio found by Heinrich (1931) or Bird (1980), it is suggested that the similar cause hypothesis is validated. Where the ratio is invalidated i.e. severe incidents do not occur at the expected frequency when compared with minor or no injury incidents the similar “cause hypothesis” is discounted. These positions fail to take into account the fact that the ratio model (whether validated or not) has no bearing on the similar “cause hypothesis”. A valid test of the common “cause hypothesis” should be based solely on causal patterns and not ratio data. Such a test should be determined by using data that has been analyzed for “causal factors” and not be based simply on frequencies of accident severity. Causality has no bearing on the ratio relationship propounded by the iceberg model and vice versa.

There has not been real concession about the actual ratio but studies by some other researchers that support the ratio theory show there is some kind of mathematical relation.

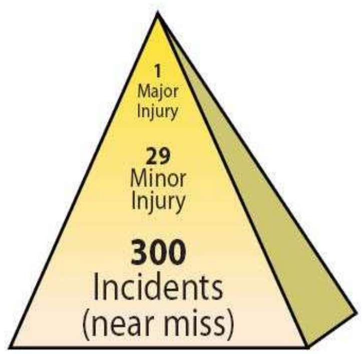

Figure four: Heinrich safety pyramid

Heinrich initial study showed a ratio of one major injury to twenty nine minor injuries to three hundred cases analyzed. In 2003, ConocoPhillips Marine conducted a similar study. They found that for every single fatality there are at least three hundred thousand at-risk behaviors, defined as activities that are not consistent with safety programs, training and components on machinery.

Bird (1980) determined the actual reporting relationship of accidents for the entire average population of workers. He conducted a survey of 1,700,000 accidents and devised his "accident ratio" which, although not identical to Heinrich's, showed that the same pattern applied. His study indicated a ratio of approximately 600 incidents for every reported major injury.

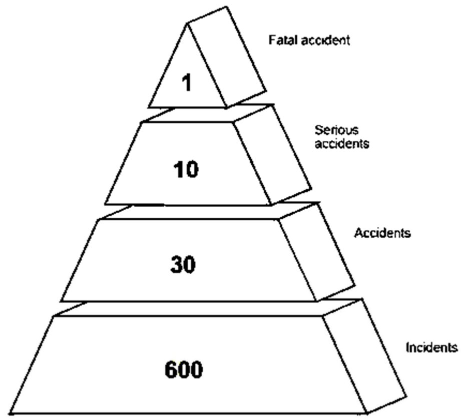

Figure five: Bird's safety Pyramid

In the internet write up on Preventing Serious Accidents with the Human Performance Philosophy in the Nuclear Weapons Journal, Issue 1, 2007 (Website assessed on August 1, 2007), it was enumerated that near misses or at-risk behaviors as they are sometimes called are probably the best data that industries receive on the reliability of safety systems.

The safety performance of the EGP turnaround maintenances will be rated by the number of at-risk behaviors the workers are observed to exhibit while completing their tasks instead of the usual lagging indicators like the TRIR and the DAFW because of the following reasons:

1. Leading indicators like at-risk are statistically easier to analyze because of their relatively larger numerical quantity than lagging indicators. Only a few accidents or incidents occur for each task in comparison to the numerous at-risk behaviors.
2. Based on my experience in the oil and gas industry spanning over 17 years, the iceberg and pyramids model which forms the basis for recording and analyzing leading indicators are generally accepted theories.
3. According to Fleming et al's many organizations have successfully reduced the number of incidents and accident by making efforts to reduce the at-risk behaviors.
4. The advantages of leading indicators listed in section 2.3.1. above
5. The fact that EGP management already captures data of the at-risk behaviors exhibited during its turnaround maintenance.

2.5. Standard operating procedures

Standard operating procedures are organizational documents that enumerate the companies approved method for carrying out tasks. They are developed out of the fact that different people have different ways of doing things. Also different people have different ways they like to do things. SOPs standardize the way organizations want their activities to be conducted. From the researchers experience the factors they consider to develop SOPs include:

1. The one which is most efficient,
2. The one which is most effective,
3. The safest methods,
4. The most convenient and
5. Restrictions by regulatory organizations.

Writers on SOPs like Edelson and Bennett, (1998); Imai, (1986); Monden, (1983); and Suzuki (1993) agree that SOPs are developed in line with some other developed standards and regulations for the purpose of;

1. Improving output,
2. Obtaining consistency,
3. Removing chances of errors,
4. Removing the chances of injury or accidents,
5. Designing work to fit some other work structure.

Adler (1993) believes that SOPs can lead workers into to a feeling of being controlled like machines or not being empowered depending on how they are developed and adopted. According to Adler (1993) and Klein (1991), when workers participate in the development of SOPs they are motivated to accept and use them. This is because workers get a feeling of making an impact which they are willing to pursue positively to whatever end. Klein is of the opinion that when SOPs are shoved upon workers, they get a feeling of being controlled and that workers will generally resist this feeling of control or at least find hard to follow.

In their paper on SOPs and motivation, De Treville at al (2005) suggested that the impact of SOPs will be positive as long as the SOPs are accurate and generate workers' competency.

Conversely in the event that SOPs are inaccurate, their required use will be negative. In addition they made the following conclusions on the impact of the use of SOPs on intrinsic motivations:

1. The availability of accurate SOPs moderate the relation between SOP use and the sense of competence experienced by workers,
2. Required SOP use will be positively related to worker sense of competence and self efficacy belief,
3. Workers participation in SOP development and refinement moderates the relationship between SOP use and the sense of impact experienced by workers,
4. Required SOP use will be positively related to the sense of impact experienced by workers,
5. Workers participation in SOP development and refinement moderates the relation between required SOP use and the sense of meaning experienced by workers,
6. Required SOP will be positively related to the sense of meaning experienced by workers,
7. Workers participation in SOP development and refinement moderates the relation between required SOP use and the sense of self-determination experienced by workers,
8. Required SOP use will be positively related to the sense of self determination experienced by workers and
9. Effective leadership behaviors are positively related to workers intrinsic motivation.

If 3, 5, 6, 7 and 8 above may be true for the workers involved in the EGP turnaround maintenance. The time the workers spend on activities and the number of at-risk behavior they are observed to exhibit may greatly reduce when they participate in the development of the procedures needed for the turnaround maintenance.

Chevron has developed plant instructions (PI) which are SOPs on their own to guide operations personnel on working safe (Chevron intranet). They include plant instruction for;

1. Bypassing critical equipment such as safety switches, shutdown switches and alarms. Shutdown switches, safety switches and alarm are protective devices for the process plant equipment. They notify operators of the plant of dangerous levels of process parameters such as pressures and temperatures. They should be active at all times to protect personnel, the equipment and the environment in the case of an emergency. Bypassing switches are necessary only for maintenance work and start-up purposes. This PI establishes processes for

ensuring bypasses are recorded, communicated and returned back after maintenance work is completed and after start-up.

2. Isolation of energy sources. (Lock out and tag out). The intent is to ensure electrical energy, mechanical rotation, stored spring energy or energy from falling objects are completely removed from the equipment before work is performed on it.
3. Incident and near miss reporting. The intent is to identify the root cause of all accident, ensure the accident causes and lessons are communicated to others and to prevent reoccurrence.
4. Confined space entry. This PI provides guidelines for entry into environments that are not normally designed for continuous occupancy or have dangerous atmosphere such as oxygen deficient atmospheres where oxygen level is lesser than 18.5%. At this level human beings cannot breathe. It requires personnel to use are artificial respirators or self contained breathing apparatus when working in dangerous atmospheres. It also specifies how long one can work in such an atmosphere and who authorizes entry into such atmosphere amongst others restrictions.
5. Connection to live plant utility. Utilities include instrument air, fire water line, portable water and nitrogen. The intent of this plant instruction is to maintain the integrity of the utility. It will be dangerous to connect a gasoline line to a fire water line for example so the PI specifies what must be done before workers and contractors can connect their equipment to the utilities.
6. Waste reduction and management. The intent of this PI is to enumerate the guidelines for waste reduction, monitor waste generation and ensure the safe disposal of waste.
7. Handling hazardous chemicals. The PI specifies the requirement for communicating the hazards associated with the use of certain chemical and how these hazards can be controlled.
8. Plant entry procedure. It specifies what contractors, maintenance personnel and people who do not normally operate the plant need to do before they can enter the facility.
9. Permit to Work System. It specifies the kinds of permit like hot work permit, confined space entry permits etc, that workers must obtain before commencing work. It defines role and responsibilities for all parties involved in the work.
10. Hot work. It specifies what must be done before any work that generates heat such as welding and cutting may commence.

11. Excavation. This PI describes what must be done before digging more than half a meter into the ground to prevent excavating live pipe network, live electrical cables etc. It also specifies what must be done to prevent people falling into dug trenches and preventing the collapse of trenches.
12. Lifting and rigging. Prescribes what must be done to safely lift objects over live plants. Lifts involving cranes, and objects heavier that 100kg is considered a critical lift.

These plant instruction cover the most frequent and fatal causes of accidents in the industry. These are mostly based on data and information provided by regulatory authority like OSHA (Occupational health and safety authority data, Department of petroleum resources (DPR) (Chevron. Website assessed on September 14, 2007)

2.6. Management styles

Management style describes how managers perform their functions. Henry Fayol (1930) stated the function of managers are forecasting, planning, organizing, commanding, coordinating, and controlling. Managers have to perform many roles in an organization and how they handle various situations will depend on their style of management. Management styles belong to a group of management theory called the behavioral theory of management, the other being the classical theory and the open system theory.

Tannenbaum et al (1958) first muted the idea of style of management in their article in the Harvard Business review of 1958 titled “How to choose a Leadership Pattern”. They argued that the style of management is dependent upon the prevailing circumstance and that a manager’s performance is dependent on the selection of the right management style to the right situation. They linked earlier work such as the “Great man” theory by Thomas Carlyle (1888) and trait theory by Gordon Allport (1937)

The work done by Tannenbaum et al led to the development of many other theoretical models about management styles. These models can be grouped into the trait theory, the behavior theory and the situation theory.

2.6.1. Trait theory

The trait theory is one area in the study of personality. The trait theory suggests that individual personalities are composed of broad dispositions called traits. Saul Kassin (2003) defined traits as habitual patterns of behavior, thought, and emotion. She further went on to impress that these traits are relatively stable over time; they differ across individuals; and also influence behavior. The trait theory studied the difference between individuals and uses traits to explain their behaviors. They conclude that these differences were the result of the complex interactions between the finite amounts of traits.

Trait theory is the successor of the Thomas Carlyle's "Great Man" theory of leadership (1888). The "Great Man" theory supposes that great men are born with innate abilities that make them great leader. In contrast, the trait theory follows the belief that leadership traits can be learned and developed through experience and learning (Krietner, 2000).

Edwin Ghiselli et al (1981) listed the traits of initiative, self-assurance, individuality, supervisory ability, and intelligence. He suggests that the probability that managers are successful will depend largely on the individual's intelligence.

Allport (1937) cited 4500 trait like words and organized them into three concentric levels namely:

1. Cardinal traits
2. Central traits
3. Secondary traits

Eysenck (1992) enumerated that the most common criticisms of trait theory are that traits are often poor predictors of behavior because some people have a certain trait but they still behave differently under different circumstance. He also pointed out that critics say trait theories do not address how or why individual differences in personality develop or emerge. Stogdill (1948) found little or no positive relationship between a manager's traits and his success. Eugene Jennings (1961) concurred with this conclusion.

Delmar (2000) argues that the bulk of the subject used for the research on traits theories are US based. He also argued that management attributes are culture dependent and that the trait theory is obsolete. McCrae et al (1989) states that five factors are enough to describe human trait but Saucier et al (1998) proffered that more factor are needed to completely describe human behavior. The factors McCrae referred to are:

- Openness – Emotion, adventure, diversity, variety unusual ideas, curiosity.
- Conscientiousness – Self-discipline, act dutifully, self projection, respect for others, seeking relevance, seeking achievement, planned rather than spontaneous behavior, beauty, pays attention to detail, orderliness.
- Extraversion –Energy, positive emotions, vibrancy, outgoing, urgency, and the tendency to seek stimulation in the company of others.
- Agreeableness- Friendly, loving, helpful, compassionate and cooperative rather than suspicious and antagonistic towards others.
- Neuroticism – Anger, moody, suicidal, anxiety, depression, disturbed or vulnerability.

Supporters of trait theory believe that it does play a role in predicting human behavior. In fact Fagenson (1987) calls for more research to further delineate the traits for the theories to give constructive information about leadership. Supporter postulate that the trait theory can be applied by people at all levels in all types of organizations. They believe that managers can use the theory to evaluate their position in the organization and determine how it can be made stronger. The trait theory is a very good reference for performing SWOT (strength, weaknesses, opportunity and strength) analysis on managers.

2.6.2. Situational theory

Situational theory presupposes that behaviors and decision of managers are dependent on the circumstances surrounding a situation. This means that there are no real right answers to the question “what is the best way for manager?” Hershey and Blanchard (1972) see the manager's leadership process as a function of the leader, the subordinates, and the situation. According to them, behavior becomes a function not only of the characteristics of the leader, but of the characteristics of followers as well (the follower being the situation). Herbert Spencer (1884) said that the times make the person and not the other way around obviously confirming his belief that we are constantly changing based on our experiences and knowledge. D. Katz and R. L. Kahn (1966) feel that leadership acts are all different for different organizations, management levels, and situations.

Situational theory includes Fred Fiedler's contingency model and Martin Evans and Robert House's path-goal model.

The model of Hershey and Blanchard (1972) describes the manager's behavior as dependent not only on his abilities and personality but also on those of the subordinates. They stated that effective management style must match the appropriate level of followership development. They postulated four management-styles and four stages of subordinates-development. The stages are numbered stage one to stages four, and stage one is the lowest level and stage four the highest level.

They described the stages of subordinate development as follows:

Stage one: Followers are unwilling and unable to take responsibility for performing tasks.
Stage two: Followers are unwilling and unable to perform tasks.
Stage three: Followers are able but unwilling to perform tasks.
Stage four: Followers are willing and able to perform tasks.

They described the management styles as follows; telling management style for stage one, selling for stage two, participatory for stage three and delegating for stage four.

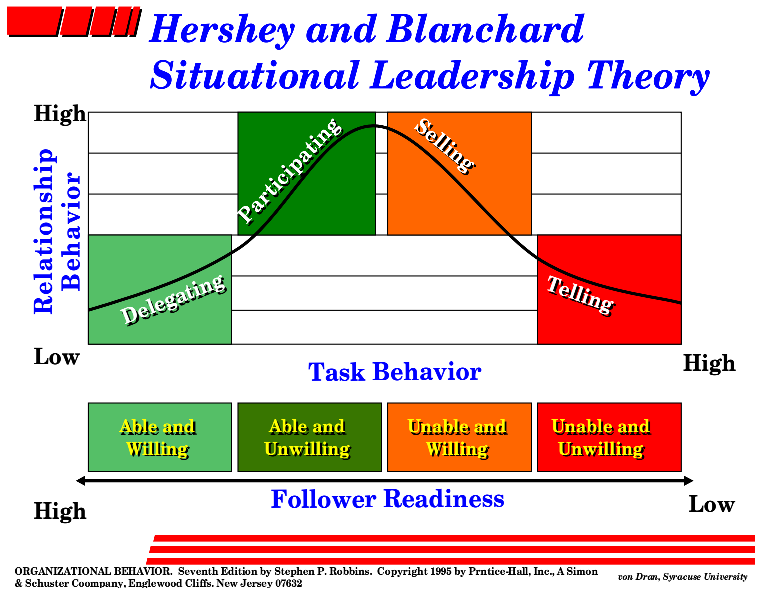

Figure six: Hershey and Blanchard situational theory reference from Kasch associate [online] (2008)

Victor Vroom in collaboration with Yetton (1973) considered more situational variables to develop a decision model shown in figure two below. Vroom and Yago (1988) developing this theory further by defining five styles of management and eight different processes that can be used for decision. Vroom and Yago's management styles are:

The autocratic I (AI) leader who solves the problem alone using information that is readily available to him/her,

The Autocratic II (AII) leader who obtains additional information from group members, then makes decision alone. Group members may or may not be informed,

The consultative I (CI) leader who shares problem with group members individually, and asks for information and evaluation. Group members do not meet collectively, and the leader makes decision alone,

The consultative II (CII) leader who shares problem with group members collectively, but makes decision alone and

The group II (GII) leader who meets with group to discuss situations before making decision. Leader focuses and directs discussion, but does not impose will. Group makes final decision.

The eight criteria and the questions asked for each criterion are:

1. Quality Requirement (QR) - How important is the technical quality of the decision?
2. Commitment Requirement (CR) - How important is subordinate commitment to the decision?
3. Leader's Information (LI) - Do (the leader) have sufficient information to make a high quality decision on her/his own?
4. Problem Structure (ST) - Is the problem well structured (e.g. defined, clear, organized, lend itself to solution, time limited, etc.)?
5. Commitment Probability (CP) - If you the leader was to make the decision by yourself, is it reasonably certain that your subordinates would be committed to the decision?
6. Goal Congruence (GC) - Do subordinates share the organizations goals to be attained in solving the problem?
7. Subordinate conflict (CO) - Is conflict among subordinates over preferred solutions likely?
8. Subordinate information (SI) - Do subordinates have sufficient information to make a high quality decision?

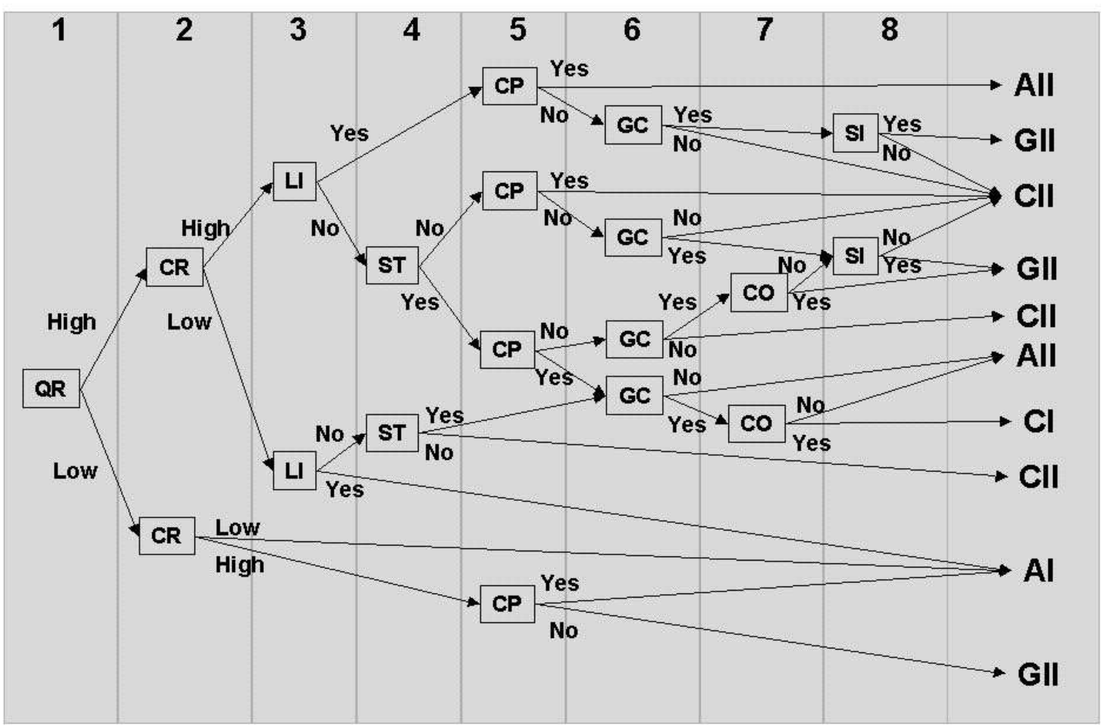

Figure seven: Vroom and Yago deterministic model for management style Vroom et al (1988)

2.6.3. Behavioral theory

The behavioral theory which was prominent in the 1950s and 1960 came as a result of the criticism of trait theory. These theories focused on what leaders do by attempting to observe and describe the leader's style of behavior and linking that style to their level of success. Wilfred Sellars (1963) noted that a person may qualify as a behaviorist, loosely or attitudinally speaking, if they insist on confirming “hypotheses about psychological events in terms of behavioral criteria”.

Graham (2010) inferred that the doctrine of behaviorism is committed in its fullest and most complete sense to the truth of the following three sets of claims:

1. Psychology is the science of behavior. Psychology is not the science of mind,
2. Behavior can be described and explained without making ultimate reference to mental events or to internal psychological processes. The sources of behavior are external (in the environment), not internal (in the mind, in the head) and
3. In the course of theory development in psychology, if, somehow, mental terms or concepts are deployed in describing or explaining behavior, then either (a) these terms or concepts should be eliminated and replaced by behavioral terms or (b) they can and should be translated or paraphrased into behavioral concepts.

Behavioral theories comprise several approaches: a continuum of styles, independent styles, and two-dimensional models of styles.

Continuum of Styles-Robert Tannenbaum and Warren Schmidt (1958)developed a continuum of leadership behavior to describe a range of behavioral patterns available to a manager. They defined two extreme ends of a continuum of management styles namely the boss centered management and the subordinate centered management. In this continuum they related the leader's actions to the degree of authority used by him and the amount of freedom he gives his subordinates. They advised managers not to operate at either end of the spectrum but to apply a combination of the two extremes dependent on the situation at hand.

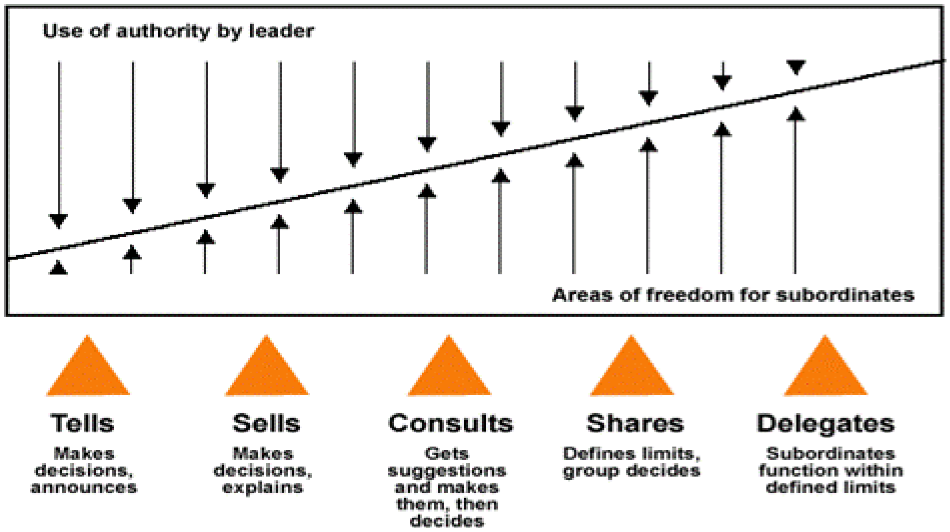

Figure eight: Tannenbaum and Schmidt continuum of leadership behavior. (1958)

Two-Dimensional Styles-These theories focuses on defining manager’s behaviors and success based on two dimensions. Roger M. Stogdill et al (1948) management model is based on the dimensions of "consideration" and "initiating structure." According to them, a leader with a high degree of "consideration" created a work environment of mutual trust, respect for subordinates' ideas, and consideration of their feelings. However a leader with a high degree of "initiating structure" was one who established unit goals, structured his role and those of his subordinates, planned and scheduled work activities, and communicate pertinent information.

Blanchard and Hershey (1972) concluded those whose behavior was high in both "consideration" and "initiating structure," is the most effective one.

Moulton and Blake (1964) developed a managerial grid in which they classified manager into 5 types depending on their relative concern for work and concern for people.

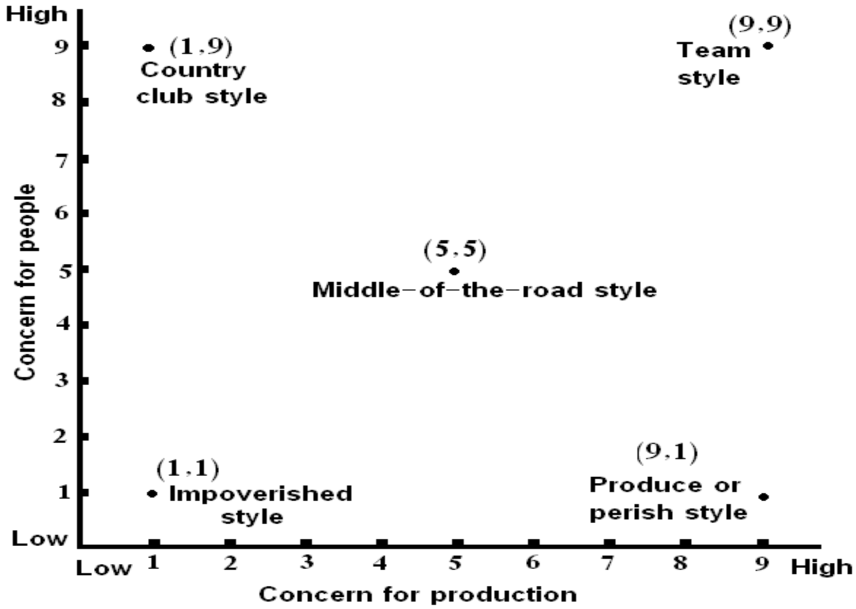

Figure nine: Moulton and Blake managerial grid. Blake et al (1965)

They ranked managers on a horizontal grid from one to nine to represent the varying degree of their concern for production and did same on a vertical grid for their concern for people. The result is the managerial grid. On the grid they marked out five points (see figure nine above) to define five types of managers namely:

1. Point 1, 1 on the scale is the “Impoverished manager” who has a very low degree of concern for people and a low degree of concern for production.
2. Point 1, 9 on the scale is the “Country club manager” who has a high degree of concern for people but a low degree of concern for production.
3. Point 5, 5 on the scale is the “Middle of the road manager” who has an average concern for people and an average concern for production.
4. Point 9, 1 on the scale is the “Produce or perish manager” who has a low degree of concern for people and a high degree of concern for production.
5. Point 9, 9 on the scale is the “Team manger” that has a high degree of people and a high degree of concern for production.

Mouton and Blake argued that the best manager would be the one who couples the two concerns to provide the highest level of contribution and accomplishment.

Critics of their model points out that concern does not necessary define behavior. However it's the researcher opinion that the accuracy of Moulton and Blake survey is further validated by the fact that the both superiors and subordinates of the manager participated in it.

Independent Styles Many researchers over the years have studied and generated a list of independent styles. Kurt Lewin (1939) led a team of researchers to identify three styles namely autocratic, democratic and Laissez-Faire. Rensis Likert (1967) examined different types of organization and management styles and he concluded that to maximize profit and productivity there must be highly effective work groups linked together in an overlapping pattern by similar effective groups. He identified four management styles from these organizations namely the autocratic, the benevolent-autocratic, consultative and participative.

The autocratic manager is one who gives out instruction to his subordinates and expects them to complete it without questioning. He rarely seeks feedback from them and there is great punishment for failure. He is only concerned about production and has no interest in people's problems. He uses threat to get his workers to perform their job and he does not expect workers personal challenges to affect their work. Many people hate autocratic leaders and see them as slave drivers but M. E. Shaw (1955) iterated that, in problem-solving situations, autocratically supervised persons used less time and made fewer errors than did democratically supervised subjects.

The benevolent-autocratic manager motivates employee with reward. He allows a little amount of decision making at the level directly next to his. He has full understanding of these decisions and they must be what he wants to hear and not necessarily the truth.

The consultative manager is somewhat democratic and partly participative in style. He makes big decisions and form general policies that directs the organization. Feedback from the subordinate form a major part of the managers decision. He asks for the feedback and encourages it. He does not get himself involved in the basics of the work. He is only interested in the overall performance of the organization and does not dictate how it is achieved specifically as long as they are in line with the general philosophies and over bearing principles he has chosen for the organization.

The participatory manager takes it up a notch over the consultative managers. He does not just ask for feedback from the subordinate but involve personnel in the formulation of policies, procedures and goals. In some cases participatory managers have allowed workers to partly own the business directly or indirectly. Sometimes he creates a feeling of ownership. This on its own can motivate the employees to higher performance.

Chris Doucouliuagos (1995), an industrial relations researcher, analyzed the results of 43 published studies to investigate the effects on productivity of various forms of worker participation: Workers participation is decision-making, profit sharing, worker's ownership and so on. Not surprisingly, he found out that all of these factors were positively associated with productivity, quality, and employees' morale and satisfaction.

Squelch and Lemmer (1994) argue that people who have been allowed a voice in the decision that affect them are more likely to accept and adhere to these decisions. Noncemba (2007) suggests that a team that is allowed to participate in management makes a far better decision than one that does not have a say. This researcher believes that better decision may have a positive impact on the time spent on tasks and the number of at-risk behaviors observed to have been exhibited by the worker. Likert (1967) believes that employee centered supervisors tend to have higher producing groups than job-centered supervisors, a submission that Stogdill (1948) agreed with.

Challenge (1995) pointed to data from recent focus-group interviews by the Princeton Survey Research Center which show hourly workers, professional and technical employees, and supervisors consistently stated that among the things they value most in a job are variety and freedom to decide how to do their work without close supervision. In addition they valued information and communication regarding things that affect their work, and evidence that their employers seek value and act on their suggestions for improving the workplace.

However Filley et al (1967) stated that Spector and Suttle found no significant difference in output between autocratic and participatory styles. Patchen (1962) noted close supervision does not necessarily reduce a subordinate's freedom because the subordinate may perceive close supervision as interest in his welfare.

According to Filley et al (1967), varying ideas within and between these three independent approaches to leader behavior were never reconciled. However, independent approaches such as these did help to provide the groundwork for the development of subsequent two-dimensional behavioral models.

2.7. Causes of deviations Chevron Nigeria found from it incident study

2.7.1. Causes of at-risk behaviors

Records from Jan. 2007 to June 2009 shown in chart one below show that not following SOPs and safe work practices are the two most frequent cause of accident in Chevron Nigeria.

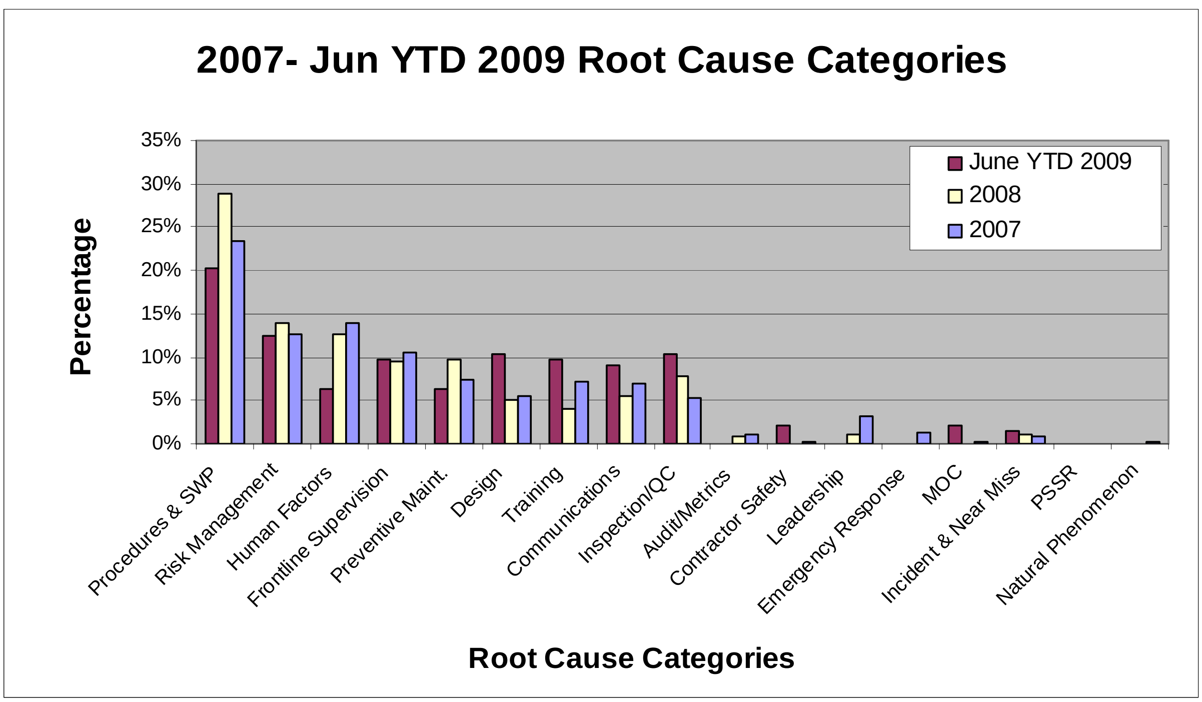

Chart one: Chevron 2007 June year to date root cause categories (Chevron intranet. Website assessed on September 12, 2009)

In addition to the plant instruction listed in section 2.5., Chevron administers an “Operational Excellence” program in which its employees are trained to always obey ten tenets as they carry out their work. The ten tenets are:

1. Always Operate within design and environmental limits,
2. Always operate in a safe and controlled condition,
3. Always ensure safety devices are in place and functioning,
4. Always follow safe work practices and procedures,
5. Always meet or exceed customer’s requirement,
6. Always maintain the integrity of dedicated systems,
7. Always comply with applicable rules and regulations,
8. Always address abnormal conditions,
9. Always follow written procedures for high risk or unusual situations and
10. Always involve the right people in decisions that affect procedures and equipment (Chevron intranet. Website assessed on September 14, 2007).

Chart two below shows that the operational excellence tenet most violated is “follow safe work practices and SOPs”. One question that this research can answer is, “will involving employees who do the actual work in the development of SOPs and processes help reduce at-risk behaviors?”

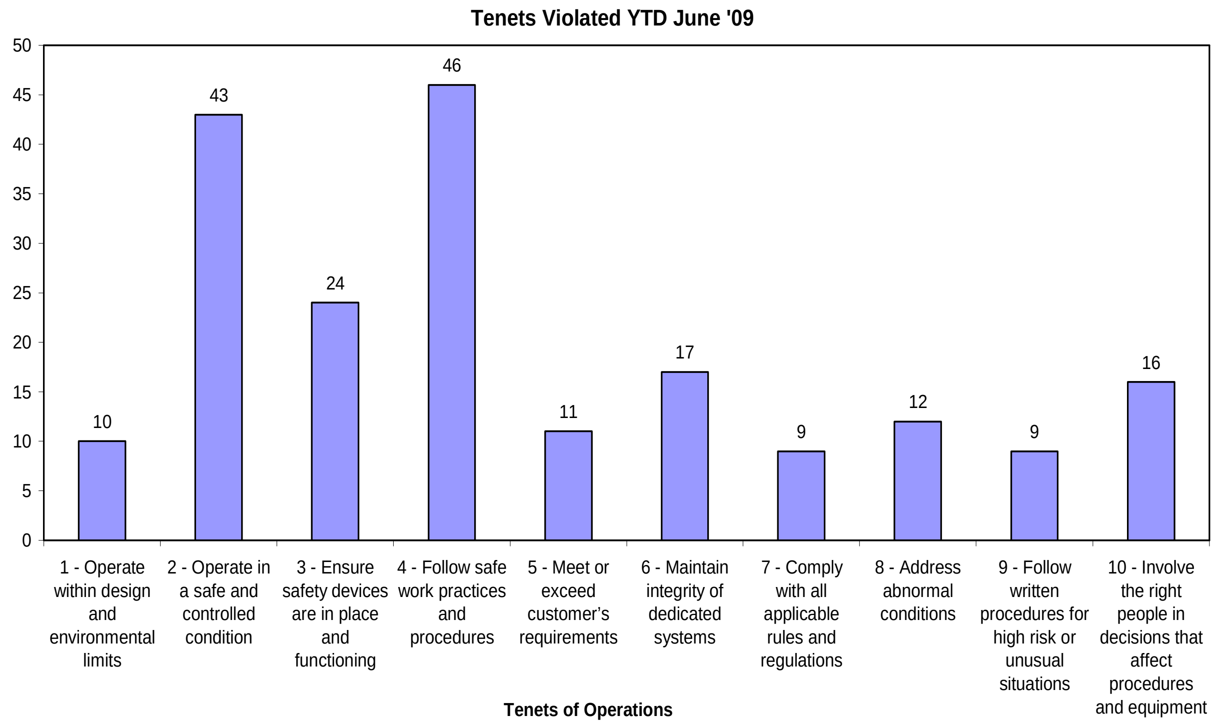

Chart two: Tenets of operations violated year to date June 2009(Chevron intranet. Website assessed on September 12,2009)

2.7.2. Causes for delays

The researcher is of the opinion that the time that employees spend on tasks may depend on how much they understand the task. A time and motion study conducted by the researcher on the 2007 turnaround identified the reason for delays in work task. Insufficient knowledge of the work ranked the highest cause of delay followed by unavailability of tools or spares in both the number of times it caused delays (chart three). This research may answer the question "would a change in the management style reduce the time to complete task during the EGP turnaround maintenance"

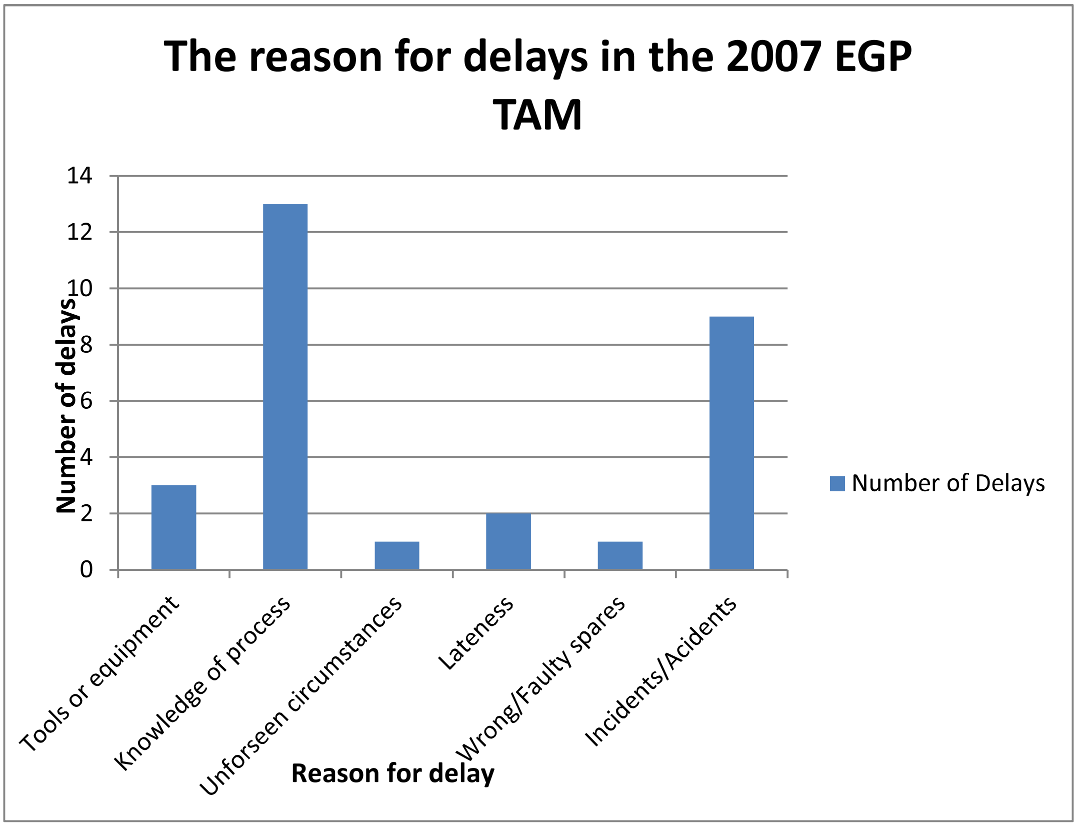

Chart three: Reason for delays in the 2007 EGP turnaround maintenance

If the conclusions of De Treville et al (2005) and others about how involving people in the development of SOPs improves their performances, a change of the management style used by the Escravos gas plant management for its turnaround maintenance to a consultative II or participatory management style can lead to an improvement in the time and the number of at-risk behavior exhibited by the teams in the Escravos gas plant turnaround maintenance.

2.8. Summary of the Chapter

Analysis of existing literature studies how to measure the performance of turnaround maintenance. It indicates that no two turnaround maintenances are the same. However the dimensions of time, cost and quality are typically used to match turnaround maintenances against each other. One factor that can affect the two other dimensions is the safety performance of the turnaround. In order words accidents have their own cost and time implications.

Existing literature shows safety performance are measured using namely leading and or lagging indicators. The advantages of both methods were described and the researcher indicated his preference for rating the safety performance of the EGP turnaround maintenances using the number of at-risk behaviors the workers exhibited while completing their task instead of the usual Total recordable incident rate and Days away from work because:

1. Leading indicators like are statistically easier to analyze because of their relatively larger numerical quantity than lagging indicators. Only a few accidents or incidents occur for each task in comparison to the numerous at-risk behaviors.
2. Based on my experience in the oil and gas industry spanning over 17 years, the iceberg and pyramids model which forms the basis for recording and analyzing leading indicators are generally accepted theories.
3. According to Fleming et al(2001) many organizations have successfully reduced the number of incidents and accidents by making efforts to reduce the at-risk behaviors.
4. The advantages of leading indicators listed in section 2.3.1. above
5. The fact that EGP management already takes data of the at-risk behaviors exhibited during its turnaround maintenance.

Existing literature on the management styles and their impact of performance are also discussed. The classification of management style by different theorist is fairly the same. They include autocratic, democratic, participatory and benevolent managerial styles.

There is no agreement between different schools of management on which type of management style is the best. Scientific theorists believe that there is one best way of doing things but situational theorists believe that the best management style will depend on the situation that surrounds the work.

One group of situational theorist Vroom and Yago (1988) developed a deterministic model that can be used to determine which is the best management style based on factors such as the nature of work and the quality required, the amount of information available to the leader and the workers, to mention a few. They identified the following type of management styles, autocratic I, autocratic II, consultative I, consultative II and Group II.

In the next chapter the investigative methods adopted for this research and the reason for adopting them will be described. The research hypothesis will also be defined and the method of presenting data and the tools and technique of analysis will be described.

CHAPTER THREE

Empirical investigation

Research methodology describes the approach employed to systematically solve a research problem.
"It is the science of studying how research is done scientifically" (*Kothari, 2005).*

3.1. The Escravos gas plant

Chevron's Escravos gas plant or the gas plant as it is often called in Escravos is a gas processing plant that gathers and processes the majority of the gas that is produced along with crude oil from the crude oil wells that chevron operates in the Niger Delta area of Nigeria. These gases are called associated gas and are first separated at oil producing platforms close to the oil well and then transported by compression through pipeline to the gas plant. The plant also collects gases from purely gas wells called non associated gas by similar means (Escravos gas plant intranet. Website assessed on August 22, 2007).

The gas plant was commissioned in 1997 and is able to process two hundred and ten million standard cubic feet of gas per day by the following processes:

1. Separation and filtration. Gas condensate and water that flow through the pipelines from the wells are removed.
2. Dehydration. The moisture content of the gas is reduced to less than one part per million by passing the gas through molecular sieve beds where the moisture is adsorbed by the molecular sieves particles contained in the reactor beds.
3. Liquefaction. The dehydrated gas is cooled to -80degC temperature by passing it through a cold box heat exchanger and a turbo-expander.
4. Fractionation. The gas is separated into fractions in distillation columns. The fractions are liquefied petroleum gas (LPG), gas condensate and lean natural gas.
5. Compression. The lean natural gas is compressed by turbine drive gas compressors and transported through a pipeline to the Nigerian gas company (NGC). NGC sells the gas to users like the electricity power company in Nigeria which uses the gas to drive turbine generators to produce electricity.
6. LPG Shipping. The LPG is pumped to an off-shore vessel for export to Europe and South America.

3.2. The Escravos gas plant turnaround maintenance

The turnaround maintenance is done over a three weeks period once every two years. The major tasks done during the turnaround maintenance are the change-out of the two molecular sieve beds, the servicing of the two compressor turbines, the servicing of the expander turbo-machinery, the clean-out of the fired gas heater tubes and burners and tie-ins for major upgrades.

The molecular sieves are one of the major equipment of the plant. There are three similar molecular sieve beds A, B and C and three similar turbines A, B and C. The work done on these sets of equipment are exactly the same during all turnarounds. The molecular sieves particles in the molecular sieve beds are offloaded and replaced with fresh ones and the turbine engines are overhauled. The life span of the molecular sieve particles in the molecular sieve beds is about thirty months(based on the feed rate and composition of the gas plant). This life span is the basis for the timing of the EGP turnaround maintenance.

Prior to the EGP management does not involve the contractor personnel that carry out the tasks in the management of the turnaround maintenance. The contractor's personnel simply follow the work plans and instructions developed by the EGP management.

The EGP management includes the EGP coordinator who is the head of the turnaround maintenance team, the EGP shift supervisors, the maintenance supervisors (rotating equipments maintenance supervisor, instrumentation and electrical maintenance supervisor, and static equipment maintenance supervisors), the safety supervisor, the maintenance planner, the process engineer and the construction supervisor.

All these listed personnel in the preceding paragraph and the supervisors of the contractor teams participate in the pre-turnaround meetings which happen once in a month for the first 10 months out of the 12 months leading to the turnaround. The meeting frequency increases to once every two weeks during the last two months leading to the turnaround maintenance. The meeting is held daily during the turnaround maintenance and once every two weeks for the first month after the turnaround maintenance.

During the preceding months to the turnaround maintenance, the work scope is defined, the job sequence is outlined and plans and schedules developed to complete all work. Resources needed are also detailed and procured by the EGP coordinator. During the turnaround maintenance the focus of the turnaround meeting is to discuss potential deviations, observed at-risk behaviors and likely challenges. Plans are then made to address these deviations, challenges and at-risk behaviors. After the turnaround maintenance, “lesson learnt” are captured and the turnaround maintenance is closed out.

The turnaround contractor, Techint Nigeria Limited divides the work group into teams. Each team is responsible for certain tasks. Six teams (team A, team B, team C, team D, team E and team F) were studied. The EGP management will not allow the researcher to study more that this six teams for fear of the research disrupting the turnaround maintenance and increasing its cost. The tasks managed by these teams are amongst those not on the project’s critical path. EGP manages the turnaround as a project and its operations coordinator (see interview in appendix A) is the project manager.

Team A, team B and team C are mechanical maintenance teams of 8 personnel each and were responsible for changing the EGP molecular sieves A, Band C in the 2007 and 2009 turnaround. The tasks are very similar because all the molecular sieve beds are identical.

Team D, team E and team F are also mechanical maintenance teams of 6 personnel each and were responsible for servicing the EGP Turbine Engine A,B and C during the 2007 and 2009 turnaround maintenance. Their tasks are also very similar because all the turbine engines are identical.

According to the gas plant coordinator (see interview in appendix A), the plant management uses incentives to motivate early and safe completion of the turnaround maintenance. However there has not been a considerable improvement in safety performance since the 2003 and 2005 turnaround. For example the total recordable incident rate for the 2001, 2003 and 2005 turnaround maintenance was 0.31, 0.30 and 0.30 respectively

Question 39 to 46 of the interview with the gas plant coordinator provides the answers required for the Vroom and Yetton’s model in section 2.5.2. The model suggests a consultative II type of management strategies be applied to the EGP turnaround maintenance as against the autocratic I style the gas plant currently applies. The researcher's investigates if a change in management style from autocratic I style to the consultative II style can improve the completion times and safety performance of the 2009 turnaround by comparing it with the data from the 2007 turnaround maintenance.

3.3. Research hypothesis

The research hypothesis is as follows:

3.3.1. The effect of change in management style on time

The effect of change in management style from Autocratic I to consultative II on time is tested by analyzing the time steam A and team D used to complete their tasks in the 2007 turnaround with the times they spent doing the same tasks in the 2009 turnaround. Team A's tasks was to change out of molecular sieve bed A. Team D serviced the turbine A engine.

An autocratic I style was used by the gas plant coordinator to manage the 2007as well as previous turnaround maintenances. A consultative II style was tested on the team A and team Din the 2009 turnaround maintenances based on the recommendation from Vroom and Yago's model. Consultative II management style was conducted by involving both teams in the development of the job safety analysis and the procedures for their tasks. They also attended the daily turnaround maintenance meetings.

The researcher was not sure whether task repetition, increased knowledge or improved team cohesion would account for improved completion times of team A team D in the 2009 turnarounds maintenance. To research these possibilities, the 2007 and 2009 turnaround maintenance times for Team B, team C, team E and team F is also analyzed against each other. Team B and team C changed out mole sieve bed B and bed C respectively. Team E and team F serviced turbine engine B and C respectively.

Null hypothesis, $1H_0$: There is no significant difference in the time spent by team A and team Din 2007 when they did not participate in the development of the procedures and processes with the time in 2009 when they did($\mu_1 - \mu_2 = 0$).

Alternate hypothesis, $1H_1$: There is a significant difference in the time spent by the team A and Din 2007 when they did not participate in the development of the procedures and processes with the time in 2009 when they did ($\mu_1 - \mu_2 \neq 0$).

3.3.2. The effect of a change in management style in the number of at-risk behaviors

The effect of change is management style on the number of at-risk behaviors exhibited by the teams is tested by analyzing the number of at-risk behaviors observed to have been exhibited by team A and team D in the 2007 turnaround with the number of at-risk behavior they exhibited in the 2009 turnaround.

The researcher was not sure whether task repetition, increased knowledge or improved team cohesion would lead to a reduced numbers of at-risk behaviors exhibited by team A and team Din 2009 so the number of at-risk behavior exhibited by team B, team C, team E and team F in 2007 and 2009 turnarounds maintenances are also analyzed against each other.

Null hypothesis, $2H_0$: There is no significant difference in the number of at-risk behaviors observed to have been exhibited by the team A and team D in 2007 when they did not participate in the development of the procedures and processes with the number in 2009 when they participate in developing the procedures and processes ($\mu_1 - \mu_2 = 0$).

Alternate hypothesis, $2H_1$: There is a significant difference in the number of at-risk behaviors observed to have been exhibited by the team A and team D in 2007 when they did not participate in the development of the procedures and processes with the number in 2009 when they participated in developing the procedures and processes($\mu_1 - \mu_2 \neq 0$).

3.4. Research methodology.

Research is a systematic method of finding solutions to problems. It is essentially an investigation, a recording and an analysis of evidence for the purpose of gaining knowledge.

According to Aakard et al (2008) Clifford Woody said that, “research comprises of defining and redefining problem, formulating hypothesis or suggested solutions, collecting, organizing and evaluating data, reaching conclusions and testing conclusions to determine whether they fit the formulated hypothesis”.

The methods applied to this research are explained as follows:

3.4.1. Sampling design

A sample design is a finite plan for obtaining a sample from a given population. Hedayat A.S. (2003).

The sample selected for this research are the times and numbers of at-risk behaviors exhibited by team A that was responsible for the molecular sieve A change-out in 2007 and 2009 and team D that was responsible for the servicing of turbine A during the 2007 and 2009. The times and number of at-risk behaviors exhibited by team B, team C, team E and team F are the experimental controls to investigate the effect of task repetition, increased knowledge or improved team cohesion on the times and number of at-risk behaviors.

Limitations of cost and time are the major reason for selecting this sample instead of analyzing more turnaround teams. In addition restrictions were placed on the research by the gas plant management because of the possible negative impact of the research on the turnaround maintenance time, cost and quality. According to the gas plant coordinator (see interview in appendix) the turnaround maintenance costs 1.2 million dollars, takes about 3 weeks and has a total recordable incident rate of 0.30.

Also the nature of the research itself limits the researcher to tasks that are exactly similar and will be repeated in both turnarounds. Hence the decision to analyze the molecular sieves change out and the servicing of the engines. Finally the gas plant coordinator limited the researcher to those activities that are not on the critical path of the turnaround project plan (see interview in appendix A).

3.4.2. Universe

The universe chosen for the research is the EGP turnaround maintenance team for 2007 and 2009.

3.4.3. Sampling procedure

The procedure adopted in the research is convenience sampling sometimes known as "grab and opportunity" sampling.

Convenience sampling is a type of non-probability sampling which involves the sample being drawn from that part of the population close to hand. That is, a sample population selected because it is readily available and convenient. The researcher using such a sample cannot scientifically make generalizations about the total population from this sample because it would not be representative enough.

For example, if the interviewer was to conduct a survey at a shopping center early in the morning on a given day, the people that he/she could interview would be limited to those present there at that given time. This might not represent the views of other members of the society in such an area if the survey was to be conducted at different time of the day and several times per week. This type of sampling is most useful for pilot testing.

According to Kothari (2005) several important questions this researchers using convenience samples should consider are:

1. Are there controls within the research design or experiment which can serve to lessen the impact of a non-random convenience sample whereby ensuring that the results will be more representative of the population?
2. Is there any good reason to believe that a particular convenience sample would or should respond or behave differently than a random sample from the same population?

3. Is the question being asked by the research one that can adequately be answered using a convenience sample?

In the case of the EGP turnaround maintenance consideration 2 and 3 are true with respect to the EGP turnaround maintenance. This is why this method is selected especially within the constraints stated in 3.4.1above.

3.4.4. Methods of data collection

The data were collected through primary and secondary sources.

Two primary sources of data is the time used to complete tasks and the number of at-risk behavior observed to have been exhibited by team A, team B, team C, team D, team E and team F during the 2007 and 2009 turnaround. The EGP safety officers collected these data and they were recorded in their daily turnover reports.

Another primary source of data is the interview with the Escravos gas plant coordinator (Appendix A). The researcher's thinking is that the number of at-risk behaviors observed by the different safety officers will depend on their knowledge and experience. The interview focuses on establishing this. However the EGP coordinator affirms that there is no much difference in the experiences of the safety officers and in their ability to identify at-risk behavior. According to the gas plant operations coordinator they were employed at the same time, with the same area of expertise and qualification, they have all undergone the same training and have been doing the same job since employed. He further said that chevron has an extensive list of clearly defined at-risk behaviors that are explained in its manuals of safe operations, it plant instruction documents. In addition the safety officers are guided by chevron's tenet of operation.

Finally the interview provided the answers for the selection of the proffered managerial style based on Vroom and Yago's model outlined in section 2.6.2.

The secondary data are in the form of finished products as they have already been treated statistically in some form or another. The secondary data consists of information from records, company websites.

3.4.5. Variables of the research

The variables of a research are those elements of the research that are under study. They can change either as a result of time or as a result of some other element. Hence, they are classified as dependent and independent variables respectively.

The variable for the research are:

1. The time to complete task,
2. Number of at-risk behavior observed and
3. Change in management style from autocratic I style to consultative II style.

The change in management style from autocratic I style to consultative II style is the independent variable, while the others are the dependent variables.

For the purpose of the research, improvement is defined as a reduction in time used to complete tasks and a reduction in the number of at-risk behavior exhibited by the teams in completing their task. Although the gas plant measures safety performance based on the total recordable incident rate, the researcher used the more pro-active method of measuring safety of number of at-risk behavior based on the arguments and discussions in the section 2.2 to 2.5 of the literature survey.

3.4.6. Presentation of data

The data are presented through charts and tables in chapter four.

3.4.7. Tools and techniques for analysis

Analytical and comparative descriptive statistical methods are used to test the hypothesis and draw inferences. In specific the student t test for sample differences is used to test the research hypothesis. All hypotheses were tested at the 0.05 and 0.025 significance level. The collated data from the research is analyzed in the next chapter.

In the next chapter the result of the investigation will be presented in tables and charts. The statistical analysis will also be presented.

Chapter four

Results

The data from the research is presented and statistically analyzed to determine the effect that a change in management style has on the time spent in the turnaround and in the number of at-risk behaviors exhibited by the teams while completing the tasks

4.1. Determination of the proffered management style for the gas plant turnaround maintenance using Vroom and Yago's model

To determine the proffered management style for the Escravos gas plant turnaround, question 36 to 42 of the interview of Escravos gas plant coordinator (see Appendix A) provides the answers to the eight criteria required by Vroom et al and enumerated in section 2.6.2. The answers are provided in the table below.

Criteria Number	**Criteria Area**	**Question**	**EGP coordinators response**
1	Quality Requirement (QR)	How important is the technical **quality** of the decision you **require** with respect to the EGP turnaround maintenance?	**High**
2	Commitment Requirement (CR):	How important is subordinate **commitment** to the decision you make in respect to the EGP turnaround maintenance?	**High**
3	Leader's Information (LI):	Do you as the turnaround maintenance **leader** have sufficient **information** to make a high quality decision on your own?	**Yes**
4	Problem Structure (ST):	Is the **problem** well **structured** (e.g., defined, clear, organized, lend itself to solution, time limited, etc.)?	**Yes**
5	Commitment Probability (CP):	If you were to make the decision by yourself, is it **reasonably certain** that your subordinates would be **committed** to the decision?	**No**
6	Goal Congruence (GC):	Do subordinates share the organization **goals** to be attained in solving the problem?	**No**
7	Subordinate conflict (CO):	Is c**onflict** among **subordinates** over preferred solutions likely?	**No**
8	Subordinate information (SI):	Do s**ubordinates** have sufficient **information** to make a high quality decision?	**No**

Table one: Answers to the deterministic question (see Appendix A)

The criteria number column in table one above is the same as the number written in figure ten below. The criteria area is shown as squares in the figure. An acronym is used for each criterion. For example QR is the acronym for the criteria area of quality requirement. The criteria areas are denoted by boxes in figure ten. Each box (criteria areas acronym) must lie directly below its criteria number.

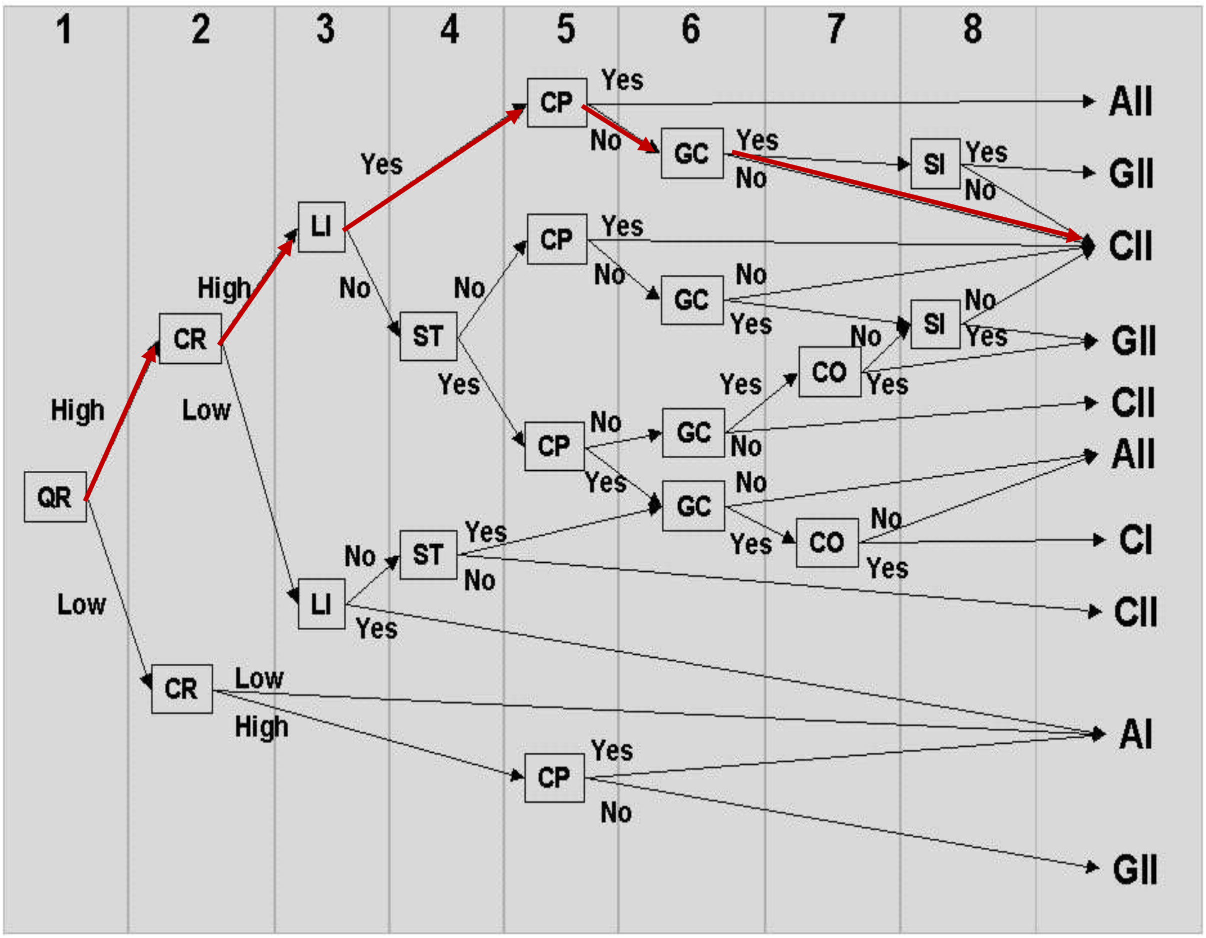

Figure ten: Vroom and Yago's for the EGP turnaround maintenance

Starting from the first criteria area (i.e. QR), the EGP coordinators response to the question for each criterion will determine the direction the decision will go. His response to criteria QR (which is "How important is the technical **quality** of the decision you **require** with respect to the EGP turnaround maintenance?") is High hence the red arrow on "High" from "QR" to "CR". CR is the acronym for the second criteria area which is commitment requirement and his response to the question in this area (which is "How important is subordinate **commitment** to the decision you make in respect to the EGP turnaround maintenance?") is "High", so the High route is followed with a red arrow to the next criteria. The same pattern is repeated for successive decisions till the last decision which leads to CII is reached. It is concluded thus that the management style Vroom and Yago's model proffer for the EGP turnaround maintenance is a consultative II management style.

4.2. Determining the effect of change in management style on the time

Table two and chart four shows the times team A used to complete the different activities in the molecular sieve A change outs during the 2007 and 2009 EGP turnarounds. The total time was observed to reduce from 80.4hrs to 65.3hrs. This is a reduction of 19%.

	Team A's time in hrs	
Activity	2007	2009
Depressurize	6.3	5.9
Drain	2.1	2.1
Purge	5.6	6.2
Offload catalyst	23.1	16.5
Inert	2.4	1.8
Steam wash	5.7	4.7
Screen inspection	2.3	1.1
Load Fresh catalyst	16.9	13.4
Pressurize	4	3.5
Regenerate	11.4	9.2
Bottle ready to be put in service	0.6	0.9
Total time	80.4	65.3

Table two: Team A's times for molecular sieve A change out

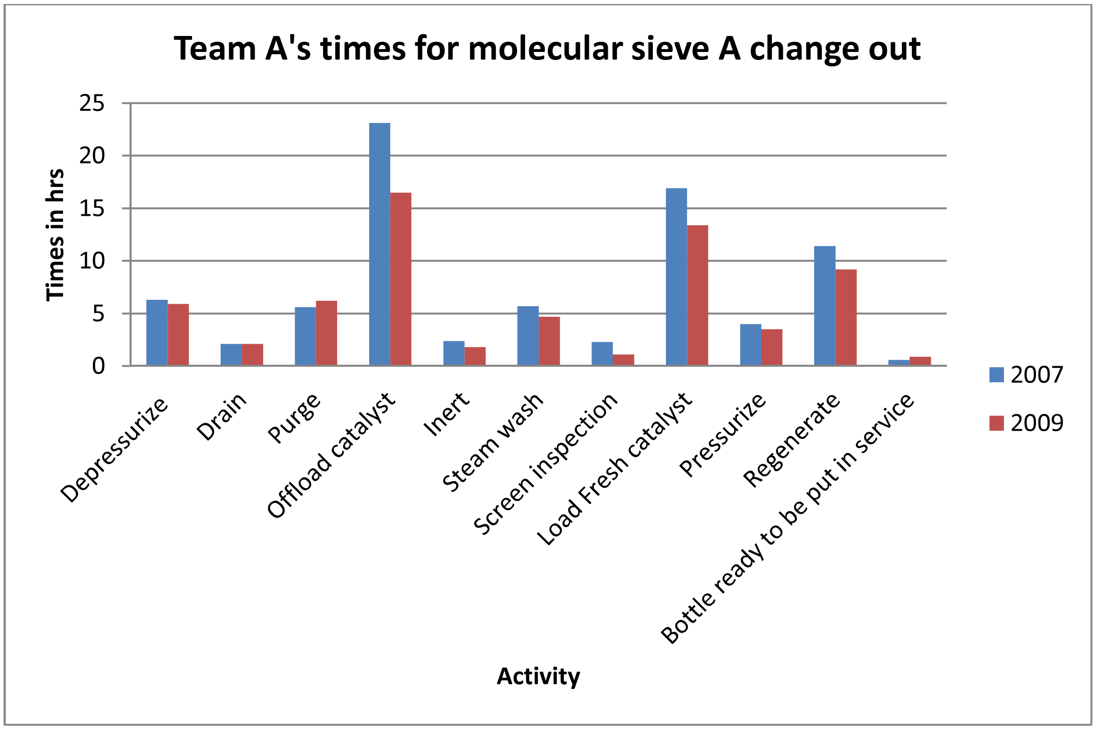

Chart four: Team A's times for molecular sieve A change out

Similarly table three and chart five shows the times used by team B to complete the change out of molecular sieve B during the 2007 and 2009 EGP turnarounds. The time reduced from 82.7hrs to 82.hrs. This is a change of just 0.4%.

Activity	Team B's times in hrs	
	2007	2009
Depressurize	6.7	6.5
Drain	1.8	1.9
Purge	5.4	5.7
Offload catalyst	23.5	22.6
Inert	4.5	4.4
Steam wash	4.2	4.2
Screen inspection	2	1.9
Load Fresh catalyst	18.9	19.2
Pressurize	3.5	3.3
Regenerate	11.9	12.2
Bottle ready to be put in service	0.3	0.5
Total time	82.7	82.4

Table three: Team B's times for molecular sieve B change out

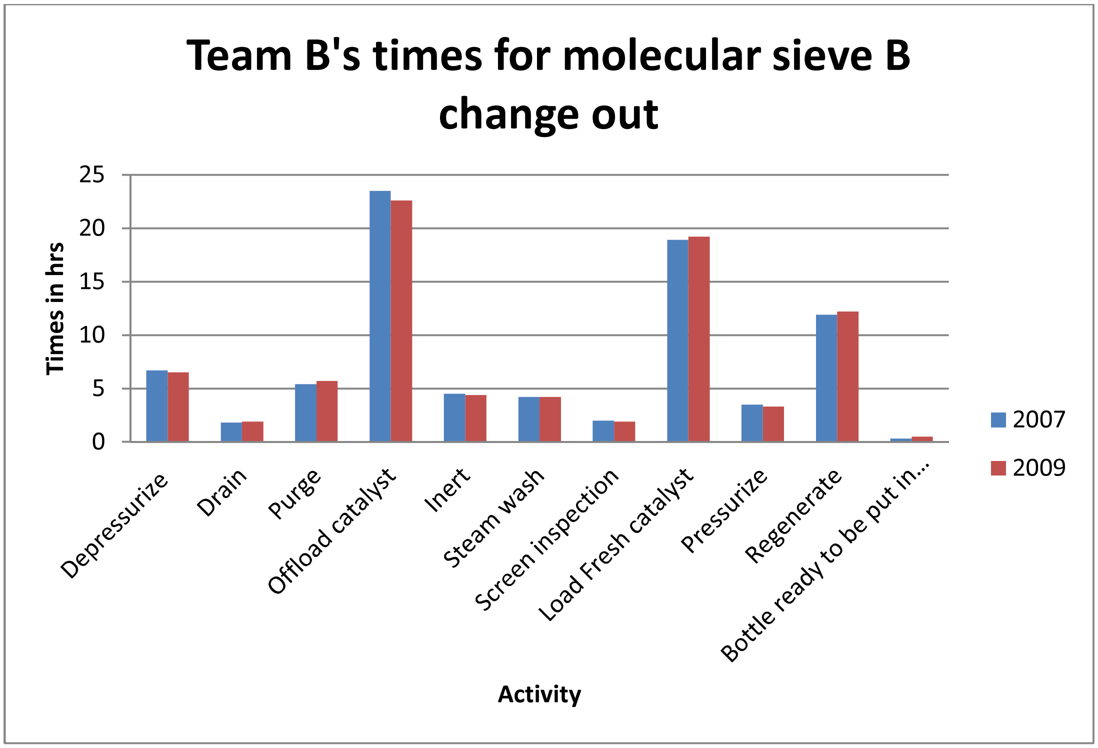

Chart five: Team B's times for molecular sieve B change out

Finally table four and chart six shows the time used by team C to change molecular sieve C during the 2007 and 2009 EGP turnarounds. The time reduced from 82.7hrs to 81.hrs. This is a change of just 1.2%.

Activity	Team C's times in hrs	
	2007	2009
Depressurize	6.0	6.4
Drain	1.9	1.7
Purge	5.3	5.3
Offload catalyst	23.0	25.6
Inert	5.0	4.2
Steam wash	4.2	4.6
Screen inspection	2	1.8
Load Fresh catalyst	19.9	17.3
Pressurize	4.2	3.7
Regenerate	10.9	10.6
Bottle ready to be put in service	0.3	0.5
Total time	82.7	81.7

Table four: Team C's times for molecular sieve C change out

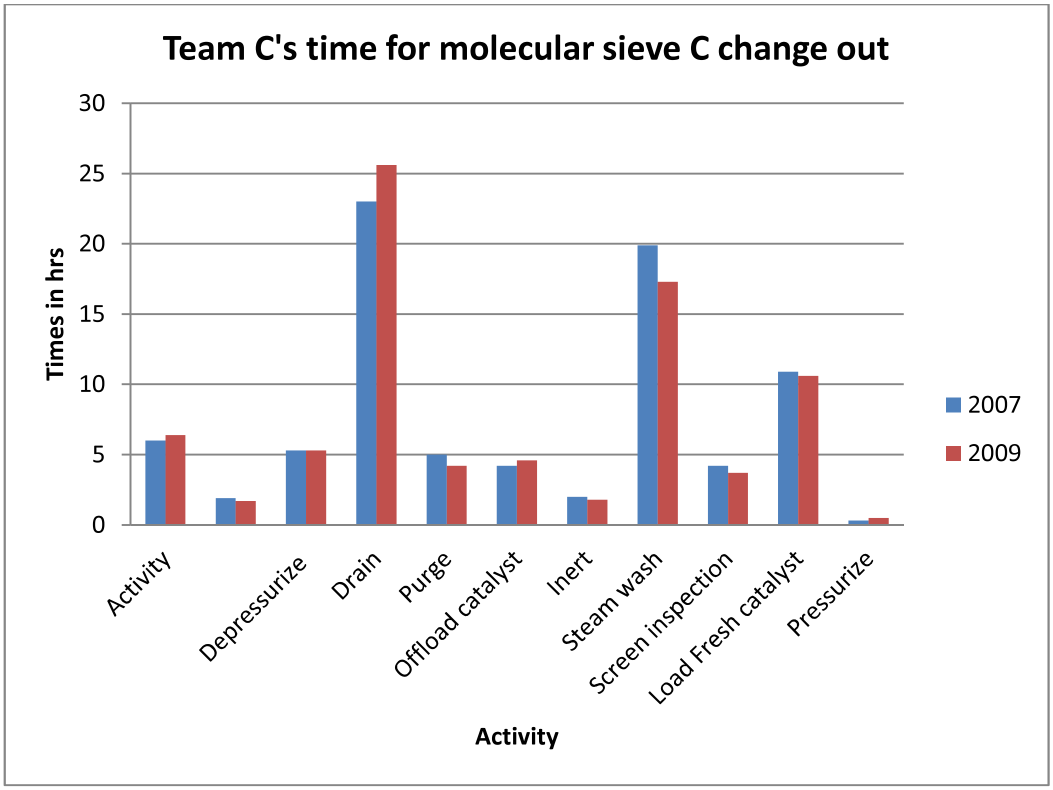

Chart six: Team C's times for molecular sieve C change out

Table five and chart seven shows the time team D used to complete the service of turbine A during the 2007 and 2009 EGP turnarounds. There was a reduction in times from 22.8hrs to 18.6hrs which is a 22.6% reduction in time.

Activity	Team D's times in hrs	
	2007	2009
Drain lube oil	3.4	2.7
Replace filter	0.5	0.5
Fill in fresh oil	5.6	4.2
Engine steam wash and dry out	7.2	5.6
Engine cooler steam out & dry out	2.4	2.3
Start-up	3.7	3.3
Total time	22.8	18.6

Table five: Team D's times for servicing turbine A

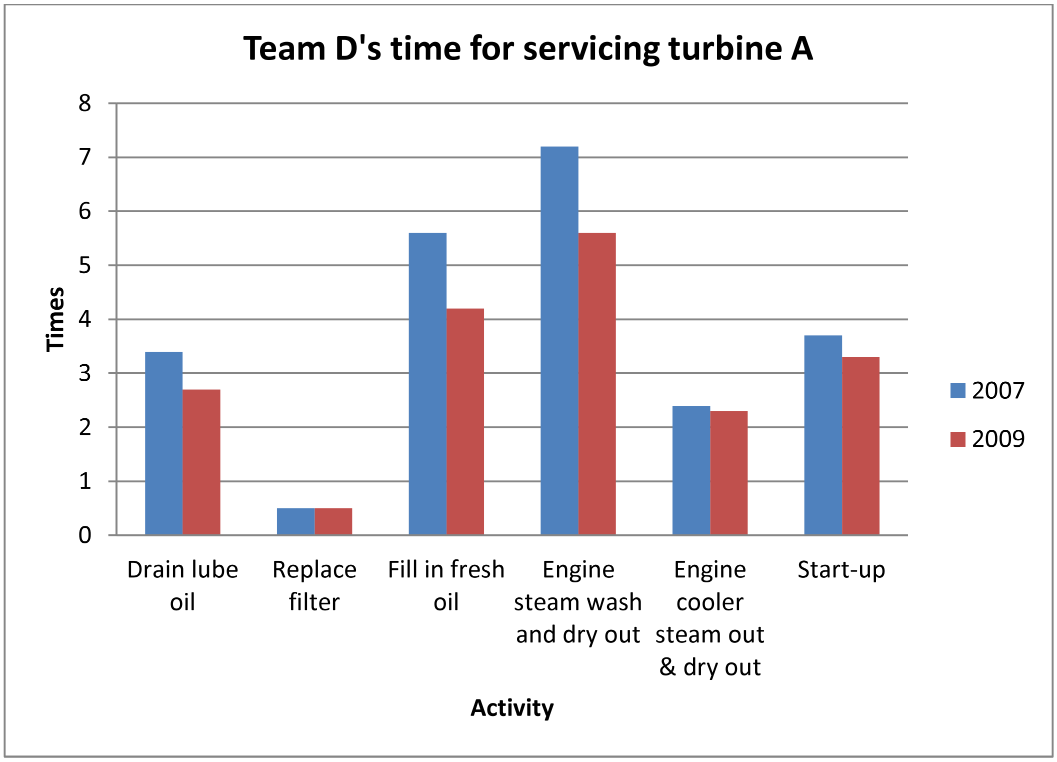

Chart seven: Team D's times for servicing turbine A

Similarly table six and chart eight shows the times used by team E which service turbine B during the 2007 and 2009 EGP turnarounds. There was a reduction from 22.2hrs to 21.7hrs. This is a reduction of just 2.2%.

Activity	Team E's times in hrs	
	2007	2009
Drain lube oil	3.7	3.5
Replace filter	1.1	0.8
Fill in fresh oil	5.4	5
Engine steam wash and dry out	6.5	6.7
Engine cooler steam out & dry out	2	2.4
Start-up	3.5	3.3
Total time	22.2	21.7

Table six: Team E's times for servicing turbine B

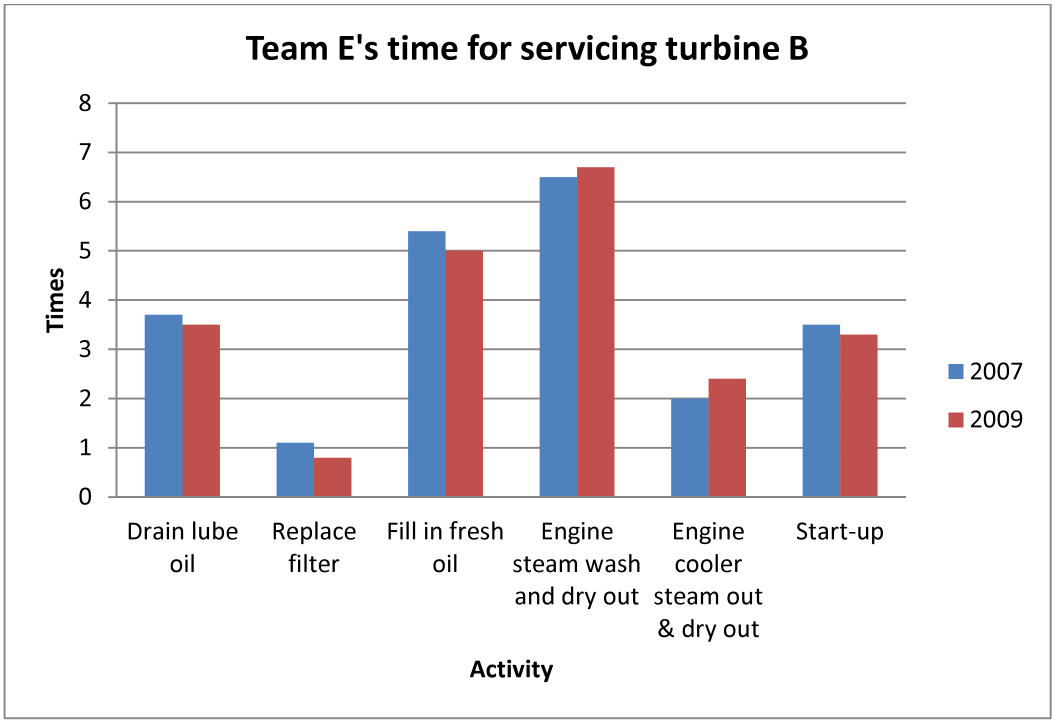

Chart eight: Team E's times for servicing turbine B

Finally table seven and chart nine shows the times used by team F which service turbine C during the 2007 and 2009 EGP turnarounds. There is a reduction in the time from 23.4hrs to 20.6hrs. This is a percentage reduction of 11.9%.

Activity	Team F's times in hrs	
	2007	2009
Drain lube oil	3.9	3.2
Replace filter	1.6	0.4
Fill in fresh oil	5.6	5.1
Engine steam wash and dry out	6.3	6.3
Engine cooler steam out & dry out	2.5	2.2
Start-up	3.5	3.4
Total time	23.4	20.6

Table seven: Team F's times for servicing turbine C

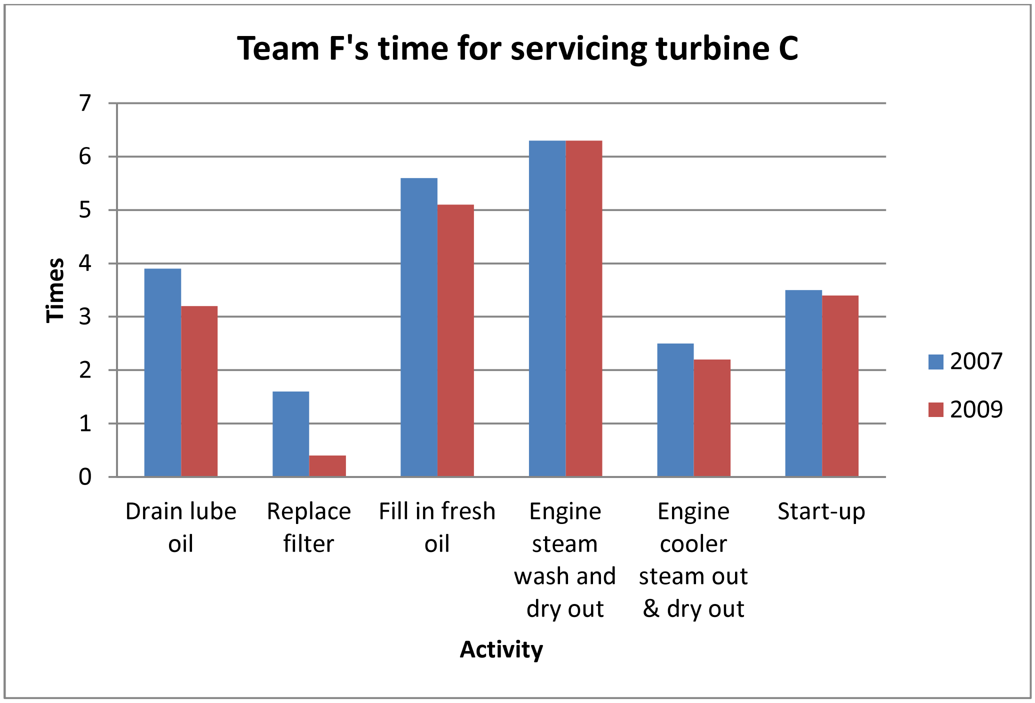

Chart nine: Team F's times for servicing turbine C

Considering:

Null hypothesis, 1H$_0$: There is no significant difference in the time spent by team A and team Din 2007 when they did not participate in the development of the procedures and processes with the time in 2009 when they did ($\mu_1 - \mu_2 = 0$).

Alternate hypothesis, 1H$_1$: There is a significant difference in the time spent by the team A and Din 2007 when they did not participate in the development of the procedures and processes with the time in 2009 when they did ($\mu_1 - \mu_2 \neq 0$).

Applying the usual formula for the t - test

$df = n_1 + n_2 - 2$ --(4.1)

$$S^2 = \frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2} \quad \text{---(4.2)}$$

$$S_{\bar{X}_1 - \bar{X}_2} = \sqrt{\{S^2(1/n_1 + 1/n_2)\}} \text{---}(4.3)$$

$$t^* = \frac{\bar{X}_1 - \bar{X}_2}{S_{\bar{X}_1 - \bar{X}_2}} \text{---}(4.4)$$

n_1 = number of samples before (2007)

n_2 = number of samples after (2009)

df = degree of freedom and

S = the standard deviation of the common sample

S_1 = standard deviation of the before (2007)

S_2 = standard deviation of the data after (2009)

$\bar{X}_1$ = mean of data before (2007)

$\bar{X}_2$ n of data after (2009)

$S_{\bar{X}_1 - \bar{X}_2}$ = standard error of the difference in sample means

t^* = computed t - test statistic.

α = is the significance level (0.025and 0.05 are used for the whole research).

Cases	Team A times	Team B times	Team C times	Team D times	Team E times	Team F times
n_1	11	11	11	6	6	6
n_2	11	11	11	6	6	6
Df	20	20	20	10	10	10
SEM	2.63	3.24	3.23	0.883	0.867	0.876
t*	0.552	0	0.03	0.79	0.095	0.3
t at 0.025 level of significance	2.086	2.086	2.086	2.228	2.228	2.228
t at 0.05 level of significance	1.725	1.725	1.725	1.812	1.812	1.812
% reduction in times	19%	0.4%	1.2%	22.6%	2.2%	11.9%
Conclusions	Reject alternate hypothesis at both significance level	Reject alternate hypothesis at both significance level	Reject alternate hypothesis at both significance level	Reject alternate hypothesis at both significance level	Reject alternate hypothesis at both significance level	Reject alternate hypothesis at both significance level

Table eight: Statistical analysis for the times the teams spent to complete their tasks

The statistical analysis says that we should reject the alternate hypothesis for all the teams. This means change in the management style from authoritative I to autocratic II will not lead to a change in the times the teams use to complete their task.

What is interesting however is the relatively higher percentage reduction in the times the teams who experienced consultative II style in the 2009 turnaround used to complete their tasks. Team A and C respectively spent 19% and 22.6% less time unlike the team B, team C, team E and team F who showed a percentage reduction were 0.4%, 1.2%, 2.2% and 11.9% respectively.

4.3. Determining the effect of change in management style on the number of at-risk behavior

Table nine and chart ten shows the number of at-risk behaviors team A was observed to have been exhibited while changing out the molecular sieve A during the 2007 and 2009 EGP turnaround. There was a 60% lesser number of observed at-risk behavior from the initial value of 87in 2007 to 35 in 2009.

Activity	Number of at-risk behavior for team A	
	2007	2009
Depressurize	3	1
Drain	5	2
Purge	0	1
Offload catalyst	16	9
Inert	13	4
Steam wash	19	6
Screen inspection	11	3
Load Fresh catalyst	9	4
Pressurize	4	1
Regenerate	2	2
Bottle ready to be put in service	5	2
Total	87	35

Table nine: Number of at-risk behavior by team A

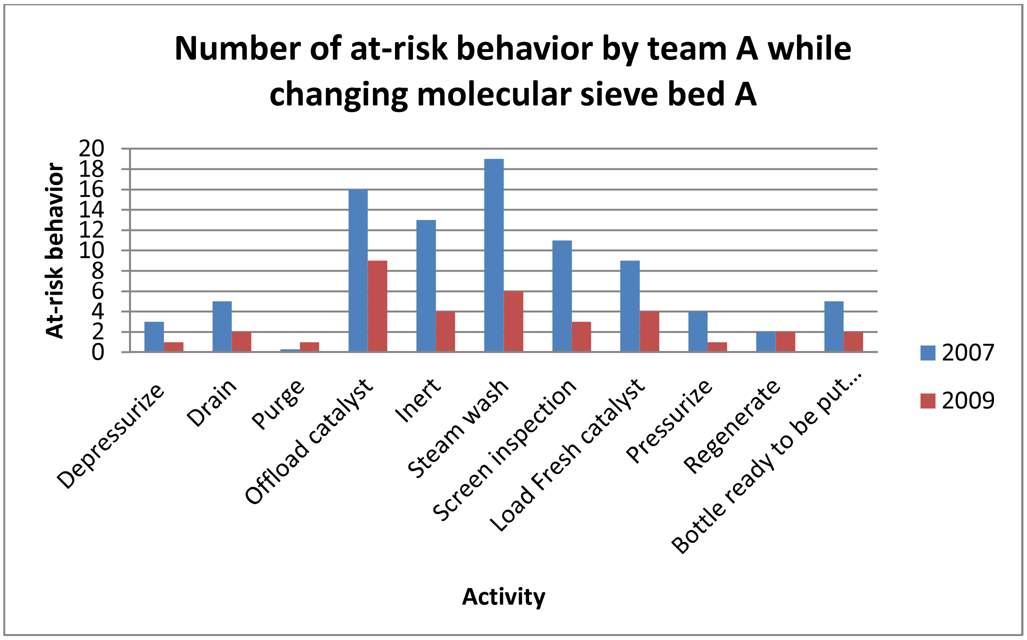

Chart ten: Number of at-risk behavior by team A

Table ten and chart eleven shows the number at-risk behavior team B was observed to have exhibited while they changed the molecular sieve B. The number reduced from 92 to 76, which is a 17.4% reduction.

Activity	Number of at-risk behavior for team B	
	2007	2009
Depressurize	4	4
Drain	4	2
Purge	1	1
Offload catalyst	18	15
Inert	12	15
Steam wash	16	14
Screen inspection	16	11
Load Fresh catalyst	9	5
Pressurize	4	2
Regenerate	3	5
Bottle ready to be put in service	5	2
Total	92	76

Table ten: Number of at-risk behavior by team B

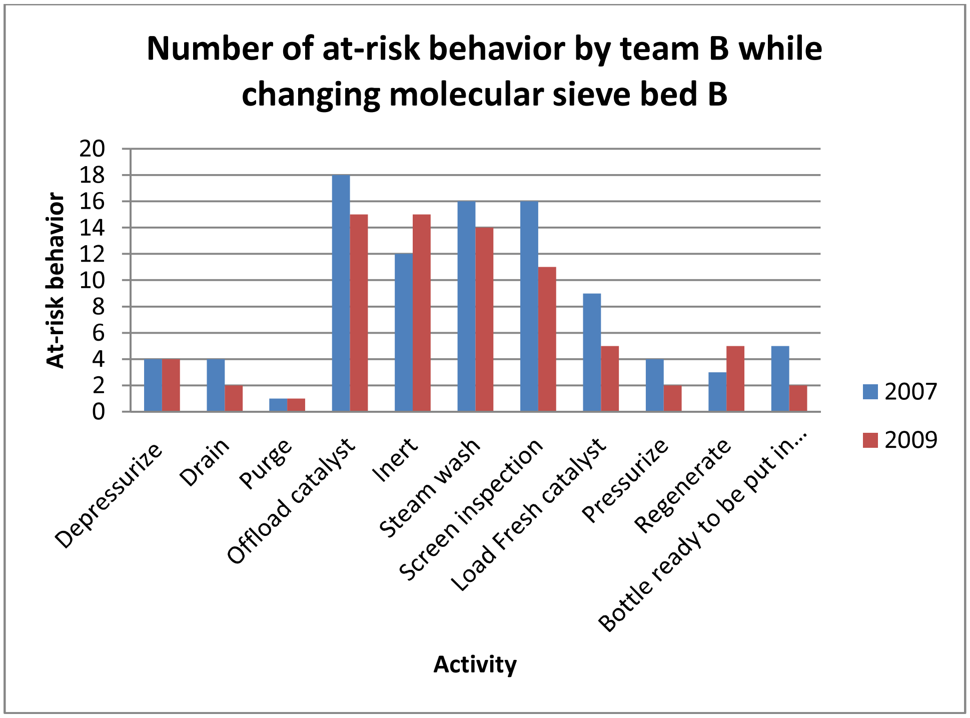

Chart eleven: Number of at-risk behavior by team B

Table eleven chart twelve shows the number of at-risk behavior team C exhibited while changing out molecular sieve C. There was a reduction from 90 to 71. This represents a reduction of 21%

Activity	Number of at-risk behavior for team C	
	2007	2009
Depressurize	5	3
Drain	3	2
Purge	1	0
Offload catalyst	18	16
Inert	11	11
Steam wash	14	14
Screen inspection	16	11
Load Fresh catalyst	10	5
Pressurize	4	2
Regenerate	2	3
Bottle ready to be put in service	6	4
Total	90	71

Table eleven: Number of at-risk behavior by team C

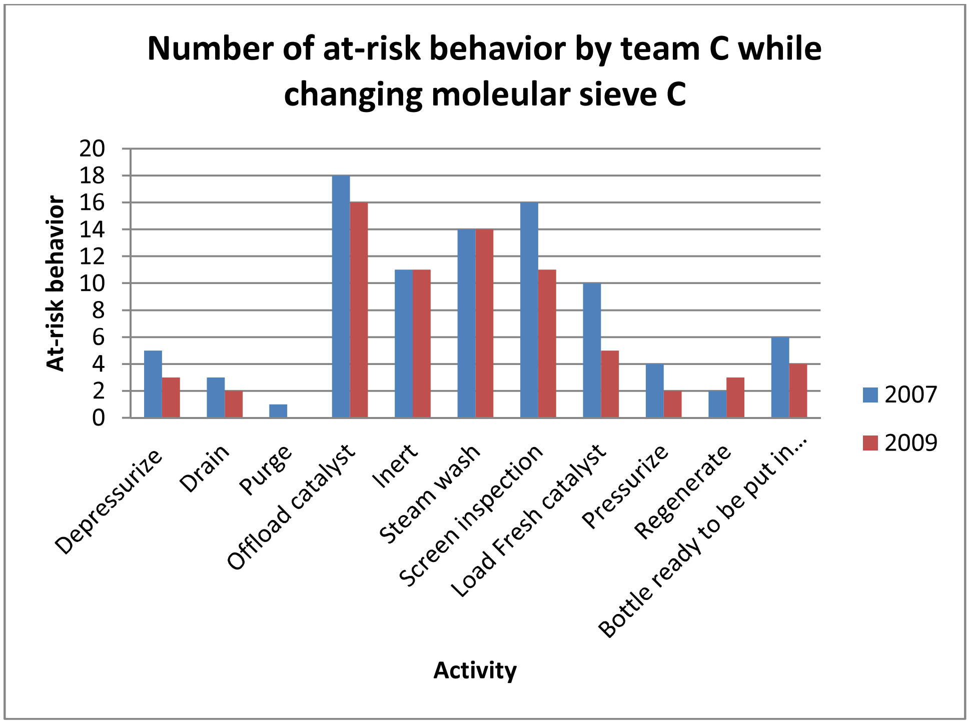

Chart twelve: Number of at-risk behavior by team B

Table twelve and chart thirteen shows the number of at-risk behaviors observed to have been exhibited by team D while servicing turbine engine A during the 2007 and 2009 EGP turnaround maintenance. There was a reduction from 44 to 15 which is a 66% reduction

Activity	Number of at-risk behavior for team D	
	2007	2009
Drain lube oil	2	4
Replace filter	4	0
Fill in fresh oil	7	1
Engine steam wash and dry out	14	5
Engine cooler steam out & dry out	12	4
Start-up	5	1
Total time	44	15

Table twelve: Number of at-risk behavior by team D

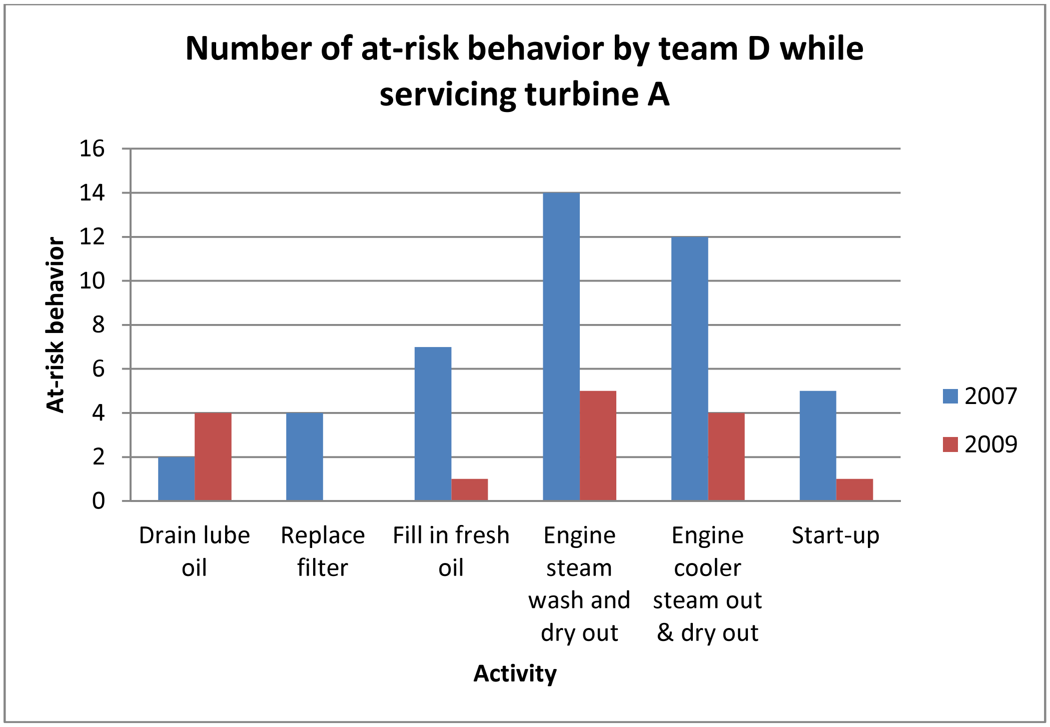

Chart thirteen: Number of at-risk behavior by team D

Table thirteen and chart fourteen shows the number for at-risk behavior team E who serviced turbine B was observed to exhibit. There was only a reduction of 13.5% from 37 to 32

Activity	Number of at-risk behavior for team E	
	2007	2009
Drain lube oil	2	1
Replace filter	4	2
Fill in fresh oil	5	3
Engine steam wash and dry out	13	15
Engine cooler steam out & dry out	9	8
Start-up	4	3
Total time	37	32

Table thirteen: Number of at-risk behavior by team E

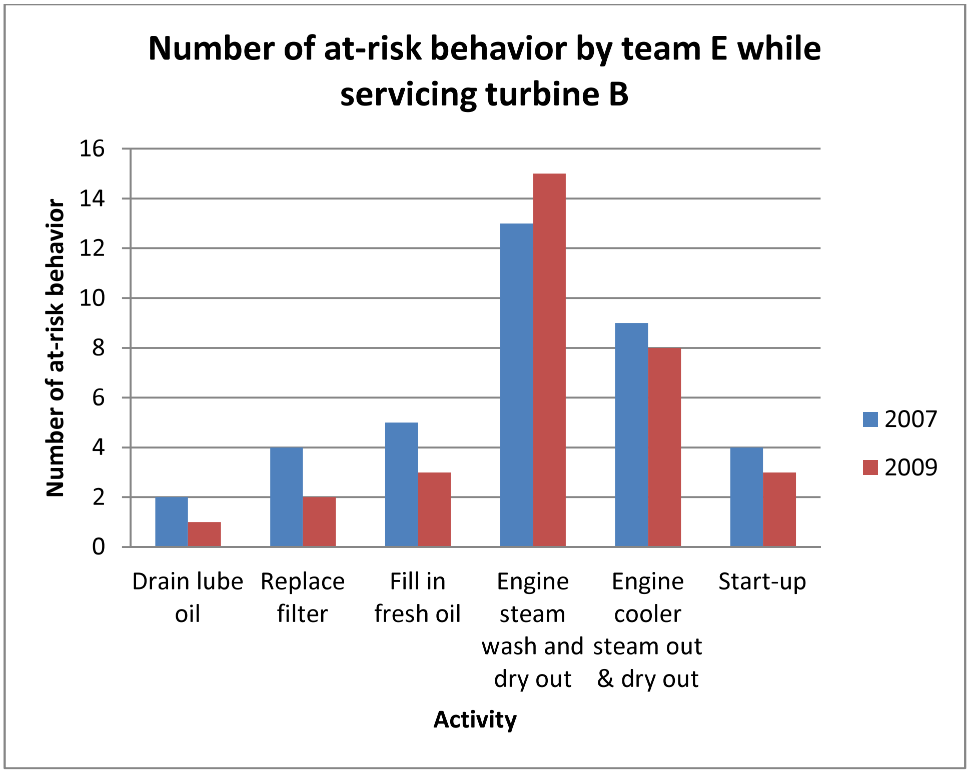

Chart fourteen: Number of at-risk behavior by team E

Finally table fourteen chart fifteen shows the number of at-risk behavior team F was observed to exhibit while changing out molecular sieve C. There was a reduction of 15% from 40 to 34.

Activity	Number of at-risk behavior for team F	
	2007	2009
Drain lube oil	3	2
Replace filter	4	3
Fill in fresh oil	4	3
Engine steam wash and dry out	16	15
Engine cooler steam out & dry out	7	8
Start-up	6	3
Total time	40	34

Table fourteen: Number of at-risk behavior by team F

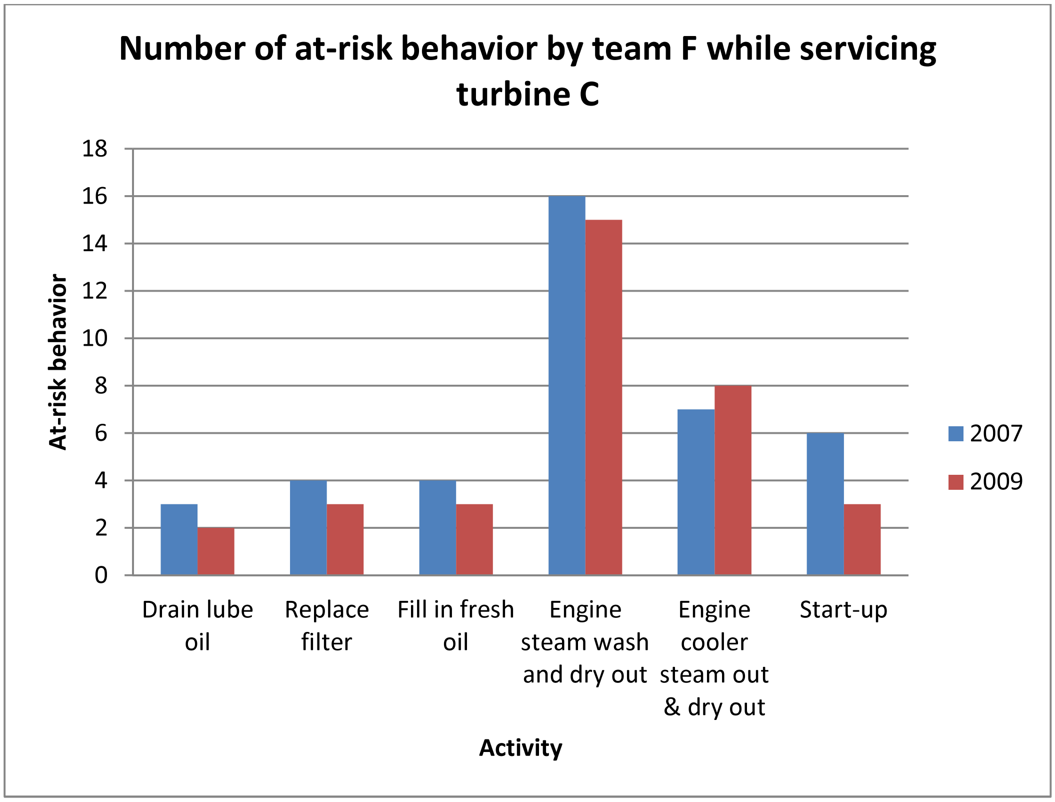

Chart fifteen: Number of at-risk behavior by team F

Considering:

Null hypothesis, $2H_0$: There is no significant difference in the number of at-risk behaviors observed to have been exhibited by team A and team D in 2007 when they did not participate in the development of the procedures and processes with the number in 2009 when they did ($\mu_1 - \mu_2 = 0$).

Alternate hypothesis, $2H_1$: There is a significant difference in the number of at-risk behaviors observed to have been exhibited by the team A and team D in 2007 when they did not participate in the development of the procedures and processes with the number in 2009 when they did ($\mu_1 - \mu_2 \neq 0$).

Applying the usual formula 4.1, 4.2, 4.3 and 4.4 for the t – test:

Cases	Team A at-risk behaviors	Team B at-risk behaviors	Team C at-risk behaviors	Team D at-risk behaviors	Team E at-risk behaviors	Team F at-risk behaviors
n_1	11	11	11	6	6	6
n_2	11	11	11	6	6	6
Df	20	20	20	10	10	10
SEM	2	2.5	2.4	2.104	2.73	2.8
t*	2.36	0.056	0.71	2.4	0.24	0.35
t from table at 0.025 level of significance	2.086	2.086	2.086	2.228	2.228	2.228
t from table at 0.05 level of significance	1.725	1.725	1.725	1.812	1.812	1.812
% reduction	60%	17.4%	21%	66%	13.5%	15%
Conclusions	Reject null hypothesis at all significance level	Reject alternate hypothesis at all significance level	Reject alternate hypothesis at all significance level	Reject null hypothesis at all significance level	Reject alternate hypothesis at all significance level	Reject alternate hypothesis at all significance level

Table fifteen: Statistical analysis for the number of at-risk behaviors.

The statistical analysis shows that a change in management style from autocratic I to consultative II style led to a significant reduction in the number of at-risk behaviors team A and D was observed to have exhibited. It also shows that the experimental control teams (team B, team C, team E and team F) did not show a significant reduction in the number of their at-risk behavior. This is proof that task repetition, increased knowledge or improved team cohesion was not responsible for the reduction in the number of at-risk behavior team A and team D were observed to have exhibited.

Still interesting is also the high percentage reduction in the number of at-risk behaviors the teams who experienced consultative II style in the 2009 turnaround exhibited. Team A and D displayed 60% and 66% less at-risk behaviors respectively unlike the team B, team C, team E and team F whose percentage reduction were 17.4%, 21%, 13.5% and 15%respectively.

In the next chapter the results enumerated in this chapter will be discussed and interpreted to clarify them. The results will be explained to eliminate misinterpretations

Chapter five

Discussion and interpretations

The results and outcomes of the research are discussed

Prior to the 2009Escravos gas plant turnaround maintenance, all the contractor task teams who actually do the work in the Escravos gas plant turnaround maintenance were not consulted in the development of the job safety analysis and the development of the procedures for the work. They also did not participate in the turnaround meetings were these procedures and potential deviations in the turnaround maintenance plans are discussed. They only had to follow well documented and well defined procedures and instructions to complete their assigned tasks. These procedures and instructions were developed by the EGP operations team, the process engineer, the EGP maintenance team, and the contractor supervisors. This type of management where others develop work instruction for other to follow religiously is defined by Vroom and Yetton (1988) as Autocratic I type of management style.

The safety officers and the operations team were to ensure the contractor task teams follow the instructions at all times. The safety officers were to note all at-risk behaviors exhibited by the task teams to complete their tasks and the times used to complete the tasks are recorded. These at-risk behaviors were discussed in the daily safety meeting and the safety officers and contractor supervisors were to communicate decisions to the contractor task teams.

However based on Vroom and Yago's model, the consultative II management style was prescribed for the type of work done during the turnaround maintenance based on the complexity of the work, the amount of information available to the leader and worker, and the likelihood that they would follow instruction amongst other criteria.

Consultative II management style is a management style where employees are consulted in decisions that impact their work. There are many ways this can be applied however for the purpose of this research study it was applied to only team A and team D in the 2009 turnaround as the involvement of these teams in the development of the procedures, processes and job safety analysis for the tasks they completed during the turnaround. In addition team A and team D also participated in the turnaround maintenance meeting where the turnaround plans are discussed. Like all other teams in the turnaround maintenance, team A and team D only completed their tasks during the 2007 turnaround.

Four other teams B, team C, team E and team F were studied as experimental controls for team A and team D respectively. The researcher was not sure whether task repetition, increased knowledge or improved team cohesion would lead to a reduced time or a reduced numbers of at-risk behaviors exhibited by the team hence the need for the experimental control. The control teams only completed their tasks during the two EGP turnaround maintenances.

Four hypotheses $1H_{0,}1H_1$, $2H_0$, $2H_1$, are tested using the student t test at the 0.025 and 0.05 level of significance. The first two hypotheses was for the test of the effect of change in management style from Autocratic I management style to consultative II type on the time used by the team to complete their tasks and the last two on the number of at-risk behaviors exhibited by the teams while completing their task.

The data from the times team A, team B, team C, team D, team E and team F used to complete their tasks in the 2007 turnaround where measured against the times in the 2009 turnaround. The student t value is 0.552, 0.0, 0.03, 0.79, 0.0095 and 0.3respectivelyas against the standard value from the table of 2.086, 2.086, 2.086, 2.228, 2.228 and 2.228respectively at 0.025 level of significance and 1.725, 1.725, 1.725, 1.812, 1.812 and 1.812respectively at the 0.05 level of significance (see table seven). This finding supports the null hypothesis 1Ho for all the teams that there is no significant difference in the time spent by team A and team Din 2007 and in 2009 (see table eight).

When the data from the number of at-risk behaviors observed to have been exhibited by team A, team B, team C, team D, team E and team F while completing their tasks in the 2007 turnaround where measured against the number of such observation in the 2009 turnaround maintenance. The student t values are 2.36, 0.056, 0.71, 2.4, 0.24 and 0.35respectively as against the standard values of 2.086, 2.086, 2.086, 2.228, 2.228, and 2.228 respectively at 0.025 level of significance and1.725, 1.725, 1.725, 1.812, 1.812 and 1.812 respectively at the 0.05 level of significance(see table fifteen).

This finding is against the null hypothesis 2Ho for team A and team D. It however supports the null hypothesis for team B, team C, team E and team F.

The statistical outputs from the test indicate that the number of at-risk behaviors observed reduced when consultative style II management is applied for team A and team D and it does not when consultative style II management is not applied as indicated by the results from the experimental control for the research (team B, team C, team E and team F). It also means that the team B, team C, team E and team F did not exhibit a lower number of at-risk behaviors in the 2009 turnaround maintenance. It follows that task repetition, increased knowledge or improved team cohesion was not responsible for the reduction of the number of at-risk behaviors by team A and team D. All teams (team A, team B, team C, team D, team E and team F) did the same work in 2007 and 2009.

The reduced number of at-risk behaviors observed in the 2009 turnaround for team A and D however can also be attributed to many reasons other than management styles. The researcher would have loved to test these if not for the limitations mentioned in section 3.3.1.

It could have been due to better supervision on the part of the EGP management team; although the researcher was lucky that the same supervision was provided for both turnarounds. However the researcher supposes that there is a possibility for people to behave safer as people gather more experience, repeat tasks and share more lessons from other incidents as done in the chevron organization on a regular basis. They may also become more aware of their surroundings. They may better understand what is safe or unsafe. This applies to both the teams and the supervisors. While the researcher tested this possibility for the task teams, he could not do same for the supervisors.

Another possible explanation for the reduced number of observed at-risk behavior is the provision of better work tools and better planning. The researcher observed better models of tools such as A-frame ladders and quick pipe connect were used in the 2009 turnaround as against the standing ladders used in 2007. Another example is the lift carriage for moving tools from one level to another used in 2009 as against the rope and bucket method used to lift tools in 2007.Yet another example is the use of barrier netting to restrict movement to work area in 2009 as against the use of caution tapes which could be easily breached in 2007.

Finally the number of at-risk behavior observed by the safety teams and operations personnel is also based on their knowledge and understanding of the turnaround processes and what is considered as at-risk behavior. What is safe to one person may be unsafe to another. The safety officer and operations team used the Chevron's tenets of operation listed in 2.5.1, Chevron plant instructions mentioned in section 2.4 and its safe work practices as a basis for determining what is considered as at-risk behavior. The EGP safety personnel captured this data as they normally do in all turnaround maintenance by constantly observing what work was being done.

There were four different observers selected from the EGP team; one for each of the four different task teams. The EGP operations coordinator (see interview in appendix A) in Jan 2007 confirmed the observers were employed the same year fresh from school, have worked the same number of years in the plant in the same roles. They had also received the same number of training. In addition they were also trained by Chevron to use Chevron's tenets of operation listed in 2.5.1, Chevron plant instructions mentioned in section 2.4 and its safe work practices as a basis for determining what is considered as at-risk behavior. Based on this, it was assumed that they had the same level of skill when it comes to observing safety and has the same definition of safe and at-risk behaviors.

However no two people have exactly the same skill level or maintain the same level of concentration on the job at all times. People are usually distracted by personal issues and different things that happen in their environment. So the researcher agrees that the assumption made in the last paragraph is arguable.

Also no two sets of activities can be exactly the same, weather changes, economic changes, changes in people personal lives, just to mention a few will effect performance and behavior. No two turnaround maintenance is the same either. It is however not practical for the researcher to analyze all the factors largely because they would be too many and many factors cannot produce mutually exclusive results.

Finally careful examination of the data mathematical averages, show a reduction in the mathematical mean times and mathematical mean number of observed at-risk behavior despite the results of the t test. This may mean that as the sample number increases the likelihood that the null hypothesis for the times $1H_0$may fall into the acceptable region. This does show that there may be benefits to change in management style in this turnaround maintenance.

In chapter 6 conclusions are made about the research and recommendations made for any possible future study of this nature.

Chapter six

Conclusions and Recommendations

Conclusions about the research are made and recommendations for further study and users of the research are discussed.

6.1.Conclusions

The first objective of this research is to understand the Escravos gas plant turnaround maintenance through the stages of planning, pre-shutdown, shutdown, execution to start up. This was achieved through several visits to the Escravos gas plant.

The researcher was given a general overview of the Escravos gas plant operations on two occasions. The researcher sat in on the turnaround monthly planning meetings for the 2007 turnaround maintenance from May to September 2007. The meeting is attended by the shift supervisors, the production planner, the maintenance planner, the maintenance supervisors, the lead safety officer, the contractor lead representatives and the Escravos gas plant operations coordinators. The scope of work was decided in this meeting and plans were developed. The schedule was developed by the planner and agreed to by all. The scope of work was frozen in June. During the months of October, the meeting was held weekly.

A formal interview was conducted with the coordinator on the 15thof September (see Appendix A). The researcher read previous of the gas plant turnaround maintenance reports. The organization did not permit that the documents be published. The researcher also read Chevron's safety reports, manuals and instructions and he had to receive permission from the EGP management to quote some parts of these documents in this research work.

He discovered that the gas plant used incentives to drive performance but over the years there had not been any improvement. For example the total recordable incident rate did not change from 0.3 over the last two turnaround maintenance and had only moved marginally from 0.35 since the first turnaround in 1999. In addition the cost of the turnaround was presently 1.2million US dollars which represents about 35% of the plants annual operating expense. The turnaround is done every other year and it is normally planned for the October to November period. This is after the rains have stopped and before the windy, dry and the dusty harmattan season begins in Nigeria.

The second objective of the research is to conduct a literature survey on measuring the success of turnaround maintenances and the different management styles that can be applied to turnaround maintenance work like that of the Escravos gas plant.

Existing literature also reveals that it is not easy to compare any two turnaround maintenances because no two plants are exactly the same because of differences internal and external to them. In addition no two turnaround maintenances are exactly the same because of difference in the task that will be completed.

However according to Rod Oliver (2002), Tom Lenahan (2006), and the EGP coordinator, the most common indices of measuring the performance of turnaround maintenances are cost, safety, time and quality.

Existing literature argues the benefits of measuring leading safety indicators instead of lagging safety indicators. Leading indicators are indicators that can be measured before accidents occur. According to Heinrich iceberg theory, leading indicators are a sure sign that accident would occur. They include at-risk behaviors, near misses, unreported incidents, uncompleted audits etc. Lagging indicators measure actual accidents. They include Total recordable incident rate (TRIR), motor vehicle accidents, lost time injuries and the number of days employees were away from work because of accident. The benefits of both types of indicators are enumerated in section 2.3.1.

The researcher chose to measure the safety of the turnaround maintenance by the number of at-risk behavior the safety officer observed the workers commit while completing their tasks. This is because of the benefits of leading indicators enumerated in section 2.3.1. In addition Fleming et al (2001) noted that many organization claimed success in efforts to reduce accidents by focusing on eliminating lagging indicators like at-risk behaviors. Also the gas plant captures this indicator but do not really report it for the turnaround maintenance. Finally leading indicators are statistically more convenient to analyze because of the large quantities of at-risk behaviors that occur in a turnaround environment when compared to the number of accident (Bird 1980).

Existing literature reveals that many theories on management style existed. The theories are grouped into trait theories, situational theory and behavioral theories. The trait theories tries to explain management styles by traits of the managers like initiative, wisdom, compassion and ambitious. On the other hand situational theory suggests that there are no best management styles and managers will need to determine which management style best suits the situation and behavioral theories explain management success by what successful managers do. Behavioral theorists identify autocratic, benevolent, consultative and participatory management styles. Vroom and Yetton (1973) identified variables that will determine the best management style based on eight variables namely:

1. Nature of the problem- Is it simple, hard, complex or clear?
2. Requirements for accuracy- What is the consequence of mistakes?
3. Acceptance of an initiative- Do you want people to use their initiative to develop a solution or not?
4. Time-constraints- How much time do we have to finish the task?
5. Cost constraints- Do we have enough or excess to achieve the objective?.

A decision model was developed by Vroom and Yago (1988) to help managers determine the best management style for situations based on these variables. They defined five management styles that could be applied namely the:

1. Autocratic I leader who solves the problem alone using information that is readily available to him/her,
2. Autocratic II leader who obtains additional information from group members, then makes decision alone. Group members may or may not be informed,
3. Consultative I leader who shares problem with group members individually. He also asks for information and evaluation. Group members do not meet collectively, and leader makes decision alone,
4. Consultative II leader who shares problem with group members collectively, but makes decision alone,

5. Group II leader who meets with group to discuss situation. Leader focuses and directs discussion, but does not impose will. Group makes final decision.

The third objective is to identify the management styles the EGP uses for its turnarounds. This objective was achieved through the interview with the gas plant coordinator and by observing how the tasks and information needed to perform them was developed.

The shift supervisors developed the procedures and Job safety planning tools such as the Job safety analysis. The contractor supervisor and the lead safety officer had to endorse the job safety analysis. The coordinator had to endorse the procedures. The contractor only communicated the procedures and plans to the workers once it has been agreed.

The conclusion was that the autocratic I management style was applied by the Escravos gas plant management in all turnarounds prior to 2009.

The fourth objective of the research is to determine the best management style the Escravos gas plant should adopt based on the literature survey conducted.

There was no real agreement in the literatures enumerated in chapter two on management styles about which management style was the best. Many seem to agree that the situation will determine the best management style to use.

Many models for management style exist but the Vroom and Yago deterministic model stands out most. By answering a set of questions (see section 4.1.) enumerated by Vroom and Yago and plotting the results on the model it can be seen that Vroom and Yago recommends the Consultative management style II for the management of the Escravos gas plant turnaround.

According to Coye et al (1995), participatory management and consultative style II creates a sense of ownership in organization. Coye et al believe these management styles instill a sense of pride and motivate employees to increase productivity. In addition to these they stated that employees who participate in the decisions of the organization feel like they are a part of a team with a common goal, and find their sense of self-esteem and creative fulfillment heightened. However writers like Patchen (1962) disagree with these postulations and found nothing to support these conclusions.

In addition according to Wall et al (1977) the concept of employee involvement in organizational decision-making is not a new global concept. Brannen (1983) confirmed that particularly since the early 1960s, interest in, and support for, employee participation has been rapidly increasing globally. According to Wright (1944) this participation had been called many different names such as participatory management, democratic management or Consultative management. Based on these arguments, the researcher decided to test the effect of a change in the management style on the performance of the turnaround maintenance.

The fifth objective of the research is to reach agreement with the EGP management on how to test the change in management style selected to improve the turnaround maintenance. The gas plant coordinator said they were willing to allow tests to be conducted only on tasks that did not fall on the critical path of the turnaround maintenance project plan. The tasks also had to be one that would be repeated in subsequent turnaround and one in which a ready research control could be established. The change out of mole sieve bed A and the servicing of turbine A was chosen.

The EGP management also agreed to allow the all members of team A and team D to attend the daily turnaround meetings from May to 2009 and in the development of the procedures and safety plans provided the cost implication will not exceed 500 thousand naira. The contractor Techint Nigeria limited agreed not to charge the EGP for the times their personnel would spend doing this because it provided a training opportunity for their employees and would be beneficial to them too. EGP only had to provide Lunch and transportation for them.

The specific objective of the research was:

1. Determine if a change in management style could reduce the duration of activities in the project.
2. Determine if a change in management style could reduce the safety performance of the project.

This is achieved by analyzing the data from the research. The hypothesis for the study is as follows:

Null hypothesis, $1H_0$: There is no significant difference in the time spent by team A and team Din 2007 when they did not participate in the development of the procedures and processes with the time in 2009 when they did ($\mu_1 - \mu_2 = 0$).

Alternate hypothesis, $1H_1$: There is a significant difference in the time spent by the team A and Din 2007 when they did not participate in the development of the procedures and processes with the time in 2009 when they did ($\mu_1 - \mu_2 \neq 0$).

Null hypothesis, $2H_0$: There is no significant difference in the number of at-risk behaviors observed to have been exhibited by the team A and team D in 2007 when they did not participate in the development of the procedures and processes with the number in 2009 when they did ($\mu_1 - \mu_2 = 0$).

Alternate hypothesis, $2H_1$: There is a significant difference in the number of at-risk behaviors observed to have been exhibited by the team A and team D in 2007 when they did not participate in the development of the procedures and processes with the number in 2009 when they did ($\mu_1 - \mu_2 \neq 0$).

Statistical analysis of the research data using the student t test for standardized difference of means shows that the time used by both team A and team D to complete their 2009 tasks was no lesser than the time they used to complete the same tasks in 2007. This was measured at the 0.025 and 0.05 significance levels. There was however a reduction in the average times.

Using the same statistical approach, the number of at-risk behaviors exhibited by both team A and team D in 2009 tasks was lesser than the 2007 values. There were no changes in number of at-risk behaviors by the experimental control teams. This confirms that task repetition, improved team cohesion and knowledge had nothing to do with the reduced number of at-risk behaviors team A and team D was observed to exhibit.

The main conclusion is that while a change in management styles from authoritative I style to consultative II style did not lead to reduction in the time used by the teams to complete their tasks; it lead to an improvement of the safety performance of the turnaround maintenance teams by reducing the number of at-risk behaviors they exhibit.

A summary of the main conclusions are:

1. A change in management style from autocratic I to consultative II styles did not reduce the times workers used to complete their tasks.
2. A change in management style from autocratic I to consultative II management styles lead to a reduction in the number of at-risk behavior exhibited by task teams while completing their tasks.

6.2. Recommendations

'Empowerment' is now widely used in business and management as well as in development. 'Participative management', such as that proposed by Likert's 'System 4', is an increasingly popular approach to management. Beardwell et al (1994) wrote that lot of organizations have successfully applied employee participation. These include Nissan, Daewoo, Hyundai, Honda, Mitsubishi and Toyota.

Measuring the effect of change in management style from autocratic I style to a consultative management style II in turnaround maintenance is not an easy task. Turnaround maintenances are very intensive and well focused activities. They have a direct effect on the profitability of many companies that operate process plants like that of the Chevron Nigeria's Escravos gas plant. The costs implication and the fact that no two turnaround strategies are exactly the same do not help the researchers cause either.

The degree to which an organization involves employee in making organization decisions and plans is limited and largely dependent on other features internal and external to the organization. Ultimately, consultative management is at best an ‘ideal type’, providing the inspiration for many models, all manifesting to various degrees, and in different forms, a commitment to improving organizational impact through the greater involvement of staff in decision-making.

Applying Consultative management style II has its own cost implication and this must be measured against the benefits there off. For example involving workers who are paid hourly to develop procedures and job safety analysis may mean they spend more time at work. They will need to be compensated for these extra work hours.

In some other cases the contributions of these new individuals in these exercises may extend the time to complete these exercises. For example the discussion during the development of procedures may take longer because of the larger number of participants. This will take other participants away from their usual work for that period.

However these times may be gained from the time required to explain the procedures and requirements to the group.

The benefits with regards to safety are visible. This is particularly important as from the researcher’s experience many process plant management like the Escravos gas plant claim that safety is their number one priority and not production. If this is true, they will definitely test this management style in their turnaround maintenance projects.

Finally, the fact that there is no one model of consultative management is not necessarily a constraint. Indeed, one of the strengths of consultative management is that there is no one way of doing it, and therefore no ‘right’ way of facilitating greater staff involvement. Consultative management, therefore, presents real choices for organization, and real opportunities to improve effectiveness. At the same time, it is appropriate to note that participation in management has been, and continues to be, important in many organizations even though they may not be explicitly committed to consultative management. However, as organizations respond to the challenges now before them, the degree to which they are willing to develop existing, informal patterns of consultative may be a crucial factor in determining whether or not organizations, in the words of Edwards and Hulme (1992), can really ‘make a difference’.

Change in itself can impact an organizations negatively initially before the benefits of that change begins to show. This is why every organization must decide what will work best for it. What is certain is that in a turnaround environment change must be gradual because too sudden a change could have negative implications. The reason for change and the methodology to be used must be well communicated to all necessary parties. The cost implication of the change must be estimated and managed so as not to lead to a negative impact.

Recommendations for the managers of turnaround maintenances because of this research could be summarized as follows:

1. Involve the contractor workers who would perform the in the development of the procedures, processes and in the turnaround maintenance meeting. This will improve them a sense of ownership and relevance and in turn reduce the number of at-risk behaviors they exhibit.
2. There are many other ways that participatory management can be implemented other than involving workers in the development of procedures and in attending the turnaround maintenance meetings. Manager will have to investigate and determine what works best for them and then systematically implement it.

The following recommendations are made with regards to future research of the same nature:

1. Researchers will need to get the full support from the management of any process plants they want to analyze. Because the variable that impact turnaround maintenance are so many and because of the intensive nature of turnaround maintenances.
2. The more number of turnarounds the researcher analyzes the more accurate the result of the research will be. This researcher was limited to only two turnaround because of time and cost limitations,
3. Further research should include the financial cost analysis of applying Consultative II management style and the benefit and

4. Researcher should fully understand the environment they are studying as this will determine how change in management style will be implemented.

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Appendix A

Interview with Escravos gas plant coordinator

Date-September 15, 2007 **Location-**EGP coordinators office

Interviewer- Isaac Ishekwene **Interviewee**- Adeola Johnson

S/N	Question	Answer
1	Who manages the EGP turnaround?	The EGP operations coordinator.
2	What does the turnaround entail	The major tasks are the change-out of the two molecular sieve beads, the servicing of the two compressor turbines, the servicing of the expander turbo-machinery blades and the clean out of the fired gas heater tubes and burners and tie-in for major upgrades.
3	Which teams support the operations coordinator to complete the turnaround maintenance?	The construction group, maintenance, safety group, logistics and the contractors who do the change out of the molecular sieves and servicing of the compressor engines.
4	How do you ensure the tasks are completed safely?	The Safety group appoints one safety officer who supervises all task teams. Chevron uses a contractor health safety program to ensure the contractors understand and comply with all safety regulations.
5	By what parameters do you measure the performance of the turnaround maintenance?	Cost, completion type and the safety parameters such as total recordable injuries rate (TRIR), lost time index, days away from work and motor vehicle accident.
6	How much does the turnaround maintenance cost?	The 2005 turnaround maintenance costs 1.2 million U.S. dollars. The total tasks will depend on what tasks is performed.
7	What percentage of the overall annual operating expenditure is this?	This is 35%percent of the overall annual operating expenditure.
8	What are the typical safety indices for the turnarounds?	The total recordable injury rate was 0.35, 0.33, 0.31, 0.30, and 0.30 for the 1997, 1999, 2001, 2003 and 2005

		turnaround maintenance.
9	Do you involve the contractor teams in managing the turnarounds?	Only the contractor supervisors.
10	Do you think there can be benefits derived from involving the task team members in the management of the turnaround maintenance?	I am not very sure. Some people in the EGP management think so and others don't.
11	What will the constraint be in involving them in the turnaround maintenance?	The cost of involving them and the increased complexity of managing them.
12	Will you be interested in a project like mine to see if there are benefits to involving the contractor team members in the management of the turnaround maintenance?	Yes.
13	What measures do you take to ensure the costs are kept under control?	The TAM is treated as a project. Project plans are determined early, I ensure everyone understand their roles. Contracts are developed. The contracts specifies a 5% bonus for jobs completed in 90% of the time or and a penalty of 5% for any task completed in 110% of the time provided the delays is the fault of the contractor. The EGP coordinator monitors progress against plan.
14	What measures do you take to control the cost?	Costs are planned. Everyone understands the plans. The duration and the number of incidents do affect cost greatly so we try to minimize these.
15	How effective are these measures?	They yielded some results at first but there have not been significant changes in the performance indices over the last two turnarounds.
16	How do you appoint your safety officers?	Twenty safety officers were employed in 1995 when the construction of the plant started. They are responsible for the turnarounds.

17	What is the qualification of the safety officer?	Higher National Diploma.
18	In what field?	Engineering.
19	Is there much difference in the safety officer's ability to identify at-risk behavior?	No, because of their similar career. They are trained the same way, have the same experience and number of years in service.
20	How is the safety officers trained?	A standardized training plan is drawn for all of them. They have to complete all elements of the training which include chevrons emergency response, process safety management.
21	When is the next turnaround scheduled for?	December 2009.
22	How long does it take to plan for it?	We essentially start planning for the next turnarounds immediately the current one ends. So it takes a year and a half.
23	Is it possible that some at-risk behaviors will go un-noticed?	Yes because you cannot be there all the time.
24	How do you ensure that safety is adhered to all the time even when you are not there?	We offer safety incentives. 5% if the contractors can achieve 95% of our targets and a fine of 5% if they go above 110%. We use our contractor safety program to ensure contractor workers are trained to know at-risk behavior and for them to follow all applicable rules.
25	Has this been working?	Yes up till 2003. The safety performance has not changed since 2003.
26	Do you have pro-active measures of safety?	Yes we record the amount of at-risk behaviors using the company's icare process, and the number of identified incidents reported from audit processes.
27	What is icare?	It is the company's behavioral safety program where employees are observed for unsafe behaviors in eight categories namely body position, tools and equipment, work area, procedures, PPE, ergonomics and body use, transportation and other. Employees are required to observe each other at least once a month and complete a

		reporting card without including the names of the persons or team being observed. The data is captured and forms the basis of decisions on directing company safety strategies. It’s a proactive safety tool.
28	Have you heard of management styles?	Yes.
29	Do you think workers will work safer if they are involved in developing the safety plans for their tasks?	Most likely, yes.
30	Do you think workers will complete their task earlier if they are involved in developing the work plans?	Yes as long as they understand the work plans. This is also good training tool.
31	Would you support this research to see if a change in management style would improve the performance of your turnaround maintenance?	Yes provided the research does not affect the turnaround negatively.
32	What type of training do you give your safety officers?	Training in safe work practices, confined space, handling hazardous chemicals, hot work, Isolation of hazardous equipment, fire and safety watch and radiation safety, plant instructions and manuals of safe operation.
33	What are the chevron tenets of operation?	The tenets are a list of over bearing statements that determines how chevron operates to drive operations performance. There are ten namely: i. Always operate within design and environmental limits. ii. Always operate in a safe and controlled condition. iii. Always ensure safety devices are in place and functioning. iv. Always follow safe work practices and procedures.

		v. Always meet or exceed customers' requirements. vi. Always maintain integrity of dedicated systems. vii. Always comply with all applicable rules and regulations. viii. Always address abnormal conditions. ix. Always follow written procedures for high-risk or unusual situations. x. Always involve the right people in decisions that affect procedures and equipment.
34	How many turnarounds have you undertaken since inception?	A- Four.
35	How frequently do you conduct the turnarounds?	Every two years.
36	Is there any particular reason you do turnarounds every two years?	Yes. The molecular sieve beds contain beads that can only adsorb impurities for 30 months at most. This number is based on the plant feed rate and feed characteristics.
37	What is the duration of the turnarounds?	The first one was 21 days. It dropped to 19 days in 2001. There was no change in 2003 and 2005.
38	If you agree to involve the task teams in managing the TAM, in what areas will suit you?	We can try using them in the development of the procedures, the Job safety analysis, in self and cross audits and allow them participate in the daily turnaround meetings.
39	How is the cost of running the plant and the safety record when the plant is in normal operation compared with during turnarounds?	The cost of running the plant during normal operation and the number of incidents are much lower when compared with the periods of turnarounds because of the intense nature of the work done during turnarounds.
40	Rate the important of the technical quality of the decision. High or Low?	High.
41	Rate them commitment requirement	High.

	for the turnaround High or Low?	
42	Do you (the leader) have sufficient information to make a high quality decision on your own?	Yes.
43	Is the turnaround well structured (is it well defined, clear, organized, lend itself to solution, time limited, etc.)?	Yes.
44	If you were to make decisions regarding the turnaround tasks by yourself, is it reasonably certain that your subordinates would be committed to the decision?	No.
45	Do subordinates share the organization goals to be attained in solving the problem?	No.
46	Is conflict among subordinates over preferred solutions likely?	No.
47	Do subordinates have sufficient information to make a high quality decision?	No.