# Effectiveness of the Risk Based Inspection Process in the Sasol Business in South Africa

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*Abstract*--**In an era where companies need to be cost-effective in their operations without compromising safety or performance, a significant amount of effort is being directed towards the process of Risk Based Inspection (RBI). RBI addresses technical risks by means of establishing appropriate inspection strategies for equipment and is currently being utilised by Sasol petro-chemical businesses in South Africa. Although several organisations, especially petro-chemical, are incorporating RBI into their business strategies, little is known on the challenges involved in the successful implementation of RBI within an organisation. This paper researches the effectiveness of the RBI process currently followed in Sasol (Sasolburg) with emphasis on the adoption of the approach by personnel as well as business and personnel factors such as competency and training. The extent of management support and how it influences the company's RBI process are also investigated. The research was undertaken by means of a questionnaire completed by different role players who participate actively in the RBI process, influencing the outcomes or who are directly affected by the results of the process. The results obtained suggest that the expertise and preparation of the process personnel involved with the RBI process is lacking and that there is a definite shortage of RBI facilitators and training in the organisation.**

## I. INTRODUCTION

The issue with using traditional approaches to do inspection planning for a manufacturing plant is that there exists the tendency to only consider risk implicitly without truly assessing it in an auditable manner. Thus, there is a real concern that high-risk and low-risk areas may not be clearly identified. It is very probable that low-risk areas are inspected to an excessively high level which in turn results in unnecessary high inspection costs, while at the same time it could be that high-risk areas are not. Selva [5] defines Risk Based Inspection as being a technology process which, when correctly implemented, is used to formally optimize the inspection efforts for each equipment item of plant. Vacha [7] suggests that the reasons for an organization to implement the RBI methodology are largely based on long-term economics. Plant reliability and profitability are important performance indicators for oil refineries, and the overall performance of a plant is directly related to the amount of inspection and maintenance resources that are devoted to process equipment within the plant. The problem with dedicating the same level of resources to inspecting and maintaining each piece of equipment is that it is not cost effective, and there is a very good possibility that it can lead to oversight of high risk equipment. Thus, RBI helps organisations to prudently apply or assign the scarce and valuable resources in such a manner so as to effectively assess and maintain equipment integrity based on their risk levels.

The use of RBI as a Risk Based Decision Making (RBDM) method is growing in industries. The increase in interest for implementing such a system is due to the potential real benefits that can be realised in terms of cost saving by optimising inspection resources and without compromising the safety of high risk equipment.

Although it is known that several organisations are incorporating the process of RBI into their business strategies, little is known as to how effectively the RBI process is actually implemented and what the challenges involved in successful implementation of RBI within an organisation are.

This research therefore serves to investigate some of these challenges, particularly those involved with management support and other business factors such as lack of commitment, training and competency of personnel. The research further aims to identify areas where the organisation can focus more attention so as to improve the way RBI is implemented and ultimately attain the maximum benefits of the process.

### *A. RBI within Sasol Business in Sasolburg*

The Sasol business in Sasolburg forms part of the Chemical Cluster of the group, which comprises of the following plants: Sasol Polymers, Sasol Solvents, Sasol Olefins and Surfactants, Sasol Wax, Sasol Nitro, Sasol Infrachem and Merisol. RBI studies are conducted on a regular basis within the Sasol business in Sasolburg and are a multi-disciplinary team effort. The team comprises of a plant inspector, process or production personnel, maintenance or mechanical personnel, facilitator, planner, metallurgist and plant managers (depending on availability). The plant inspector is responsible for obtaining the equipment inspection history and ensuring that the working files (comprising of equipment drawings and other operational information) are in order and up to date. The process engineer and production personnel that attend the session are responsible for coming prepared with regards to the design and operating conditions of the equipment of interest. Further, they must also have a good understanding of the system where the equipment is located, as well as what the implications of upset scenarios are. The maintenance/ mechanical personnel have the important role of providing information regarding the mechanical integrity of the equipment and for confirming what equipment repairs, replacements or modifications have occurred. The

metallurgists are consulted during the session to provide information regarding various damage mechanisms and their applicability, as well as for providing recommendations for reducing the probability of failure.

The facilitator is responsible for conducting the sessions by means of inputting the relevant data obtained from the various disciplines into a database and facilitating team discussions to define the risks involved and communicate the mitigation measures. The planners attending the session must schedule and plan for the inspection and other activities that are identified as outcomes of the RBI sessions. The plant manager is responsible for providing the resources to conduct the studies and also to implement the actions that are identified to reduce or remove the risks relating to equipment. RBI studies conducted in the organisation focus on pressure equipment and a report is generated which is considered to be a legal document, as it exempts some of the equipment from the mandatory statutory inspections. These reports are reviewed or revised from time to time, in order to ensure that the risk management by means of inspection activities for particular equipment is still valid and acceptable, or whether new inspection intervals need to be allocated due to changes such as increased corrosion rate or discovery of a new degradation mechanism.

*B. Research objectives*

There are challenges that exist with the RBI process. One area of concern is the problems caused by lack of management support and leadership, and another is that the effectiveness of the RBI process could be influenced by factors such as competency, lack of quality information, lack of preparation and training as well as shortage of key personnel. In order to address the research problem, evaluations and analyses of the following were proposed:

- the effectiveness of the RBI process or study sessions within the various plants in Sasol Sasolburg, with regards to business factors such as safety, cost, time and resources.
- the extent of management support and leadership as seen by the different disciplines involved in the RBI process
- which human and business factors can potentially hinder the effective implementation of the RBI process
- the extent the different role players involved in the RBI process find the current system to be working effectively
- whether the firm is obtaining the results of improved operational safety as well as reduced costs, with the progression of years since the first implementation of RBI in Sasol Sasolburg.

By means of these evaluations, the objective of this study is to reveal the effectiveness of the RBI methodology in the Sasol business in Sasolburg. This research will further highlight the findings relating to proper management support and leadership as well as explore various factors or aspects relating to the implementation process of RBI including personnel competencies, shortage of personnel and lack of quality information. The findings may also be helpful for the various other petro-chemical firms in the country to try and improve the way RBI's get performed so that the full potential of the intended benefits of doing RBI's gets exploited. However, as the study focuses on only one petrochemical company, the results cannot be directly generalized to other firms or the industry as a whole.

## II. CONCEPTUAL FRAMEWORK

The model of the RBI process as given in the American Society of Mechanical Engineers Post Construction Code-3 (ASME PCC-3) [2] is the preferred methodology that is used in this research since it is currently being implemented within Sasol business in Sasolburg and is easier to follow than the American Petroleum Institute (API) Recommended Practice 580 [1]. This methodology provides guidance as to the focus of effort in the RBI process in the organisation. It also helps to determine what sorts of changes or improvements have been made to the prescribed RBI methodology during the process of implementing it within the respective work environments.

It is proposed that the effect of the mind-sets or attitude of the different role players towards the process, the availability of facilitators and experts, the competency levels and understanding of the value of RBI studies, and the extent of management support and effective leadership be incorporated into the RBI process as external factors influencing the implementation of the process. The level of influence of these factors is investigated in this research. The standard model of the RBI process is therefore modified by means of the above mentioned external factors and shown in Figure 1.

RBI methodology is followed in many onshore process and/ or petro-chemical companies all over the world. Simpson [6] demonstrates the application of RBI to pressure vessels and above ground storage tanks by means of two examples related to a crude distillation column and a crude storage tank within Caltex refineries in New South Wales, Australia.

RBI is also utilised on offshore environments such as floating units, where when applied properly helps in ranking the hull structural items by order of criticality and in turn improving the inspection program [4].

## III. RESEARCH METHODOLOGY

A questionnaire based research method was selected to gather data for this research. In order to improve the readability of the questionnaire it was pre-tested with a number of individuals familiar with the RBI process. The pre-test served the purpose of providing feedback on any difficulties that the candidates or participants may have faced whilst completing the survey [3]. In this way, minor adjustments and improvements were made to the questionnaire prior to sending it out to the rest of the population of interest.

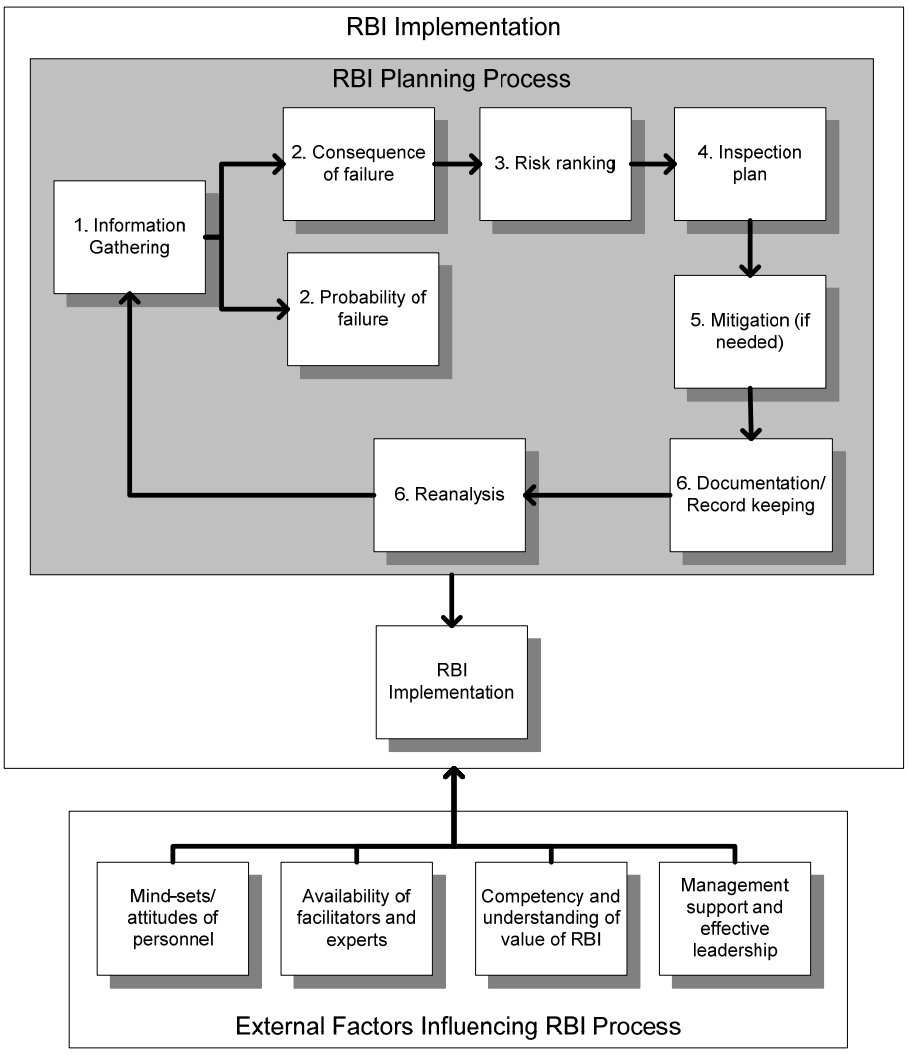


Figure 1: External factors influencing the standard RBI process model

The questionnaire was compiled by making use of attitude scales in the form of summated or Likert scales to determine the general attitude of, for example, RBI personnel and management personnel toward the RBI process. Nominal measurements were used for collating basic data such as occupation or role of individuals in the RBI process.

Ordinal scales were also used for parts of the questionnaire that require differences among individuals to be reflected in the variable being measured and also for questions seeking to rank order of importance as perceived by participants. A total of 100 questionnaires were distributed within the organization during RBI sessions amongst the various plants, sending via email and by performing site-visits on an individual basis. The voluntary questionnaire was distributed to personnel of different disciplines working in the different plants who participate actively in the RBI process, and who either influence the outcomes of the process or are directly affected by the results of the process. Thus, the sample included amongst others, personnel such as RBI facilitators, metallurgists, maintenance and operations personnel, safety personnel, planners, plant inspectors, mechanical and chemical or process engineers and plant managers. The questionnaires were distributed and collected primarily by means of arranging with the RBI facilitators to hand the questionnaires out at the end of each RBI session conducted at various sites, and to collect the completed ones before leaving the venue of the RBI study.

The questionnaire consists of a section with 27 statements, which the respondents had to score depending on to what extent they agree or disagree with the statement (Scale 0-10). This section is followed by an additional section comprising of 8 questions which require a selection to be made by means of marking the appropriate box. The questionnaire focused on the following main headings, which were derived from the research questions:

- Purpose or intent of RBI
- Cost and time associated with RBI process
- Effectiveness of implementation of the RBI process

- Personnel factors including mind-set toward RBI process
- Improvement of the RBI process
- Management support and leadership
- Actions arising from RBI studies
- RBI record keeping

Of the distributed questionnaires, 47 participants responded with completed questionnaires. Two out of the 47 completed questionnaires were spoilt due to careless completion and thus are not included into the analysis. A total of 45 usable responses were attained in this way for performing the data analysis. The fewer responses than anticipated reduces the confidence level of the results obtained. However, the completed questionnaires that were received back did not all come from one plant alone but rather from several different plants. This helps to obtain a broader view of the different personnel involved in the process.

Figure 2 is a pie chart which shows what percentage of participation each of the different role players had in the survey questionnaires.

The research survey questions were developed in such a manner that made it possible to analyse the results obtained from the different role players involved with the RBI process regarding the afore-mentioned headings, and to identify the factors that might be hindering or influencing the effective implementation of the RBI process. In addition, a brief interview was also conducted with one of the RBI facilitators within the organisation, who had a significant role in the development and implementation of the RBI system currently in place. This was done so as to attain some additional qualitative data other than that obtained from the surveys.

## IV. RESULTS

The results of the investigation are discussed based on the overview of the results of each the different role players, and major findings relating to the headings under which the questionnaire statements and questions were grouped. Pie charts and 100% stacked column graphs were plotted to help analyse the data that was captured by the different groups of headings as identified in the questionnaire.

In order to plot the 100% stacked column graph to determine the general overview of results it was decided that the scores 0 to 2 is "strongly disagreeing", scores 3 to 4 is "disagreeing", scores 6 to 7 is "agreeing" and scores 8 to 10 is "strongly agreeing" with a particular statement. A score of 5 is taken to be the case where the respondent is either neutral or unsure regarding a particular statement. Figure 3 shows the 100% stacked column graph for the overview of the survey results for all the participants.

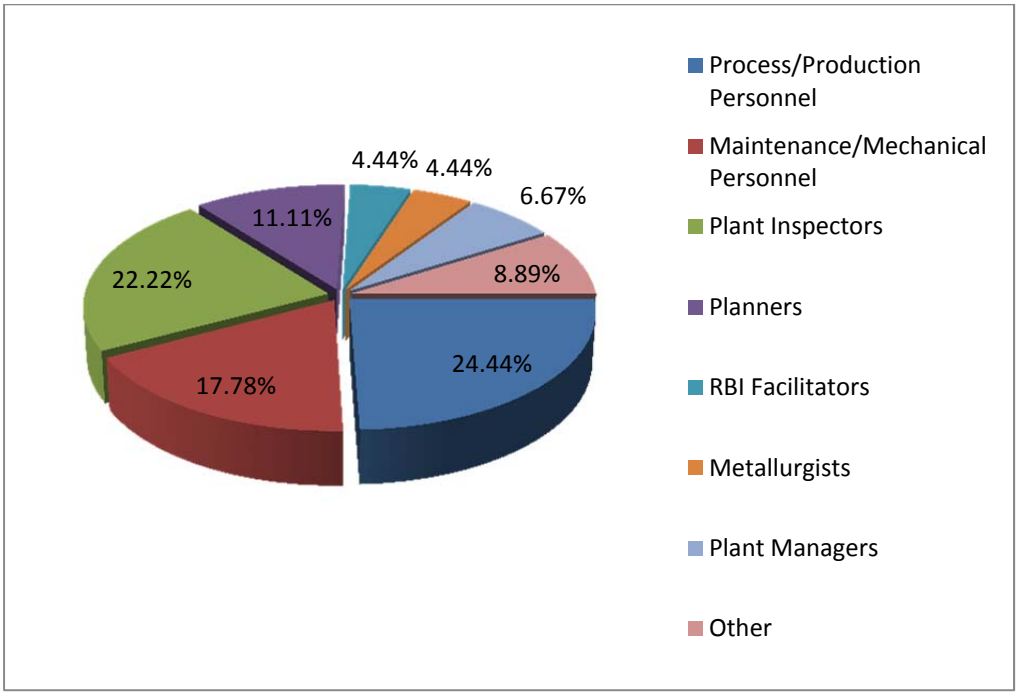


Figure 2: Breakdown of personnel that took part in the survey

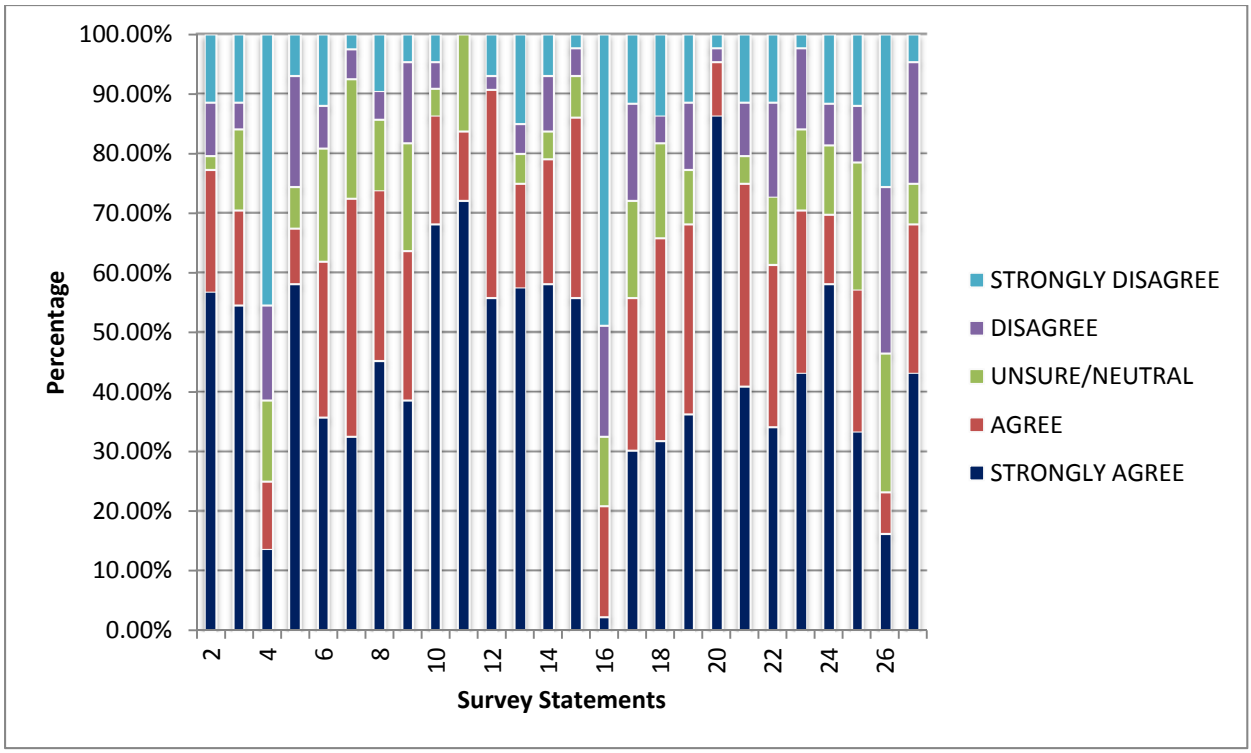


Figure 3: Overview of survey results for all the participants

This overview, which takes into account all the participants data, allows one to establish which statements the majority of the respondents tend to agree or disagree with the most. Looking at the graph, the majority of the respondents tend to agree with most of the statements given in the questionnaires with exceptions to statements 4, 16 and 26.

Statement 4 states that RBI sessions conducted focus only on high risk equipment which the majority believe is not true. Statement 16 states that RBI is a waste of time in that the effort required and the rewards reaped are not proportional, which the majority does not agree with. Statement 26 refers to the plant spending too much time and money trying to fulfil RBI outstanding actions. This statement is also not agreed with by the majority of the participants.

*A. General findings*

One of the first areas that was investigated was the degree of satisfaction the participants had with regards to the RBI process currently implemented. The results indicated that generally, the process and maintenance disciplines, the plant inspectors and the RBI facilitators are fairly satisfied with the outcomes of the RBI studies which takes into consideration the main headings as mentioned in section 3. Although the majority of the participants from each of the disciplines were fairly satisfied with the outcomes of the RBI process currently practiced, it was evident that there is a definite shortage of RBI facilitators within the organisation. This is an indication that upper management is not adequately involved to be aware of the amount of work an RBI facilitator's job profile entails and the difficulties experienced by plant inspectors and personnel to try schedule RBI sessions with this limited resource.

Another key finding was that it was the process or production personnel that presented the highest degree of difficulty with regards to the successful implementation of the RBI process. Lack of preparation, expertise and knowledge in the process systems in the respective plants were some of the factors that led to the survey participants to select the process or production personnel as being the most difficult role players. Figure 4 gives an indication of the most difficult role players as selected by the survey participants.

*B. General mind-set of personnel towards the current RBI process*

The investigation revealed that the majority (62.2 %) of the participants of the survey are not in favour of the idea of conducting RBI studies more frequently than is currently conducted. However, it was discovered that a good 75% of the mechanical or maintenance discipline participants wanted RBI studies to be conducted more frequently (Refer to Figure 5). The reason behind maintenance personnel wanting to see more RBI's being conducted could be so that they are able to get inspection plans in place for equipment, which when carried out properly will result in less maintenance work due to unexpected equipment failure and due to to them being legally accountable for equipment safety.

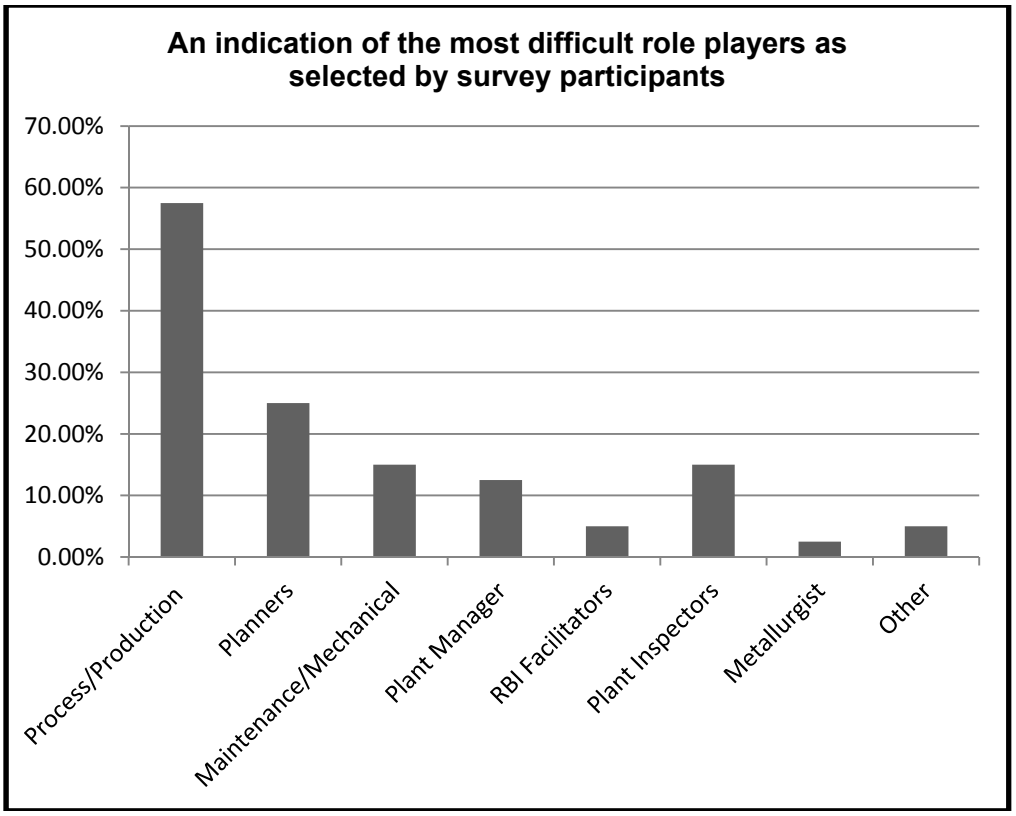


Figure 4: Bar chart showing the most difficult role players as selected by the survey participants

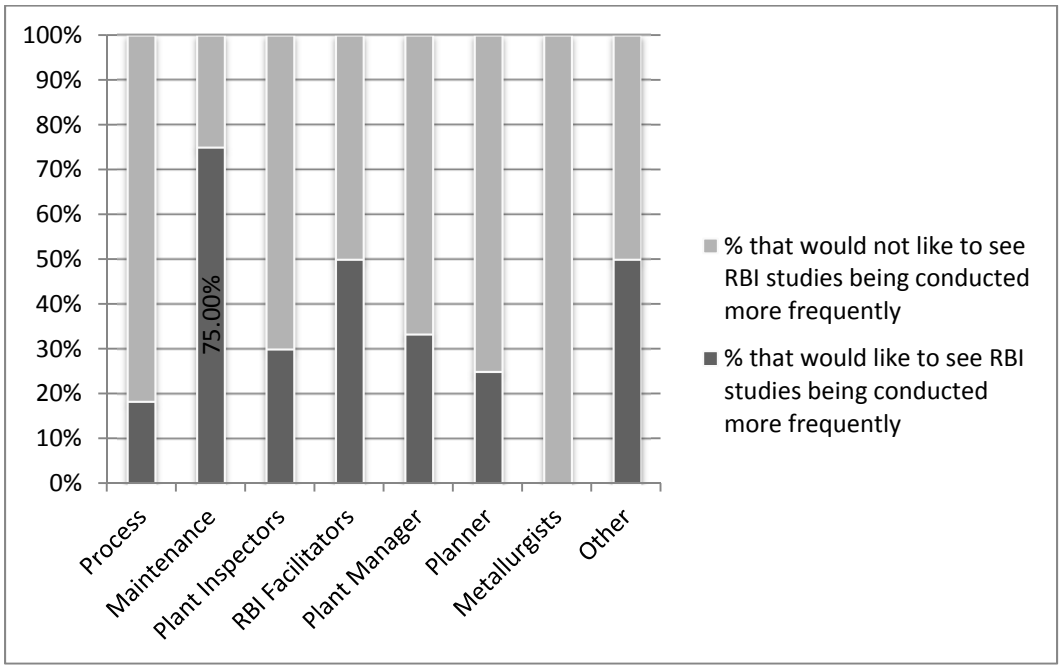


Figure 5: Response of different role players toward conducting RBI studies more frequently

With exception of the RBI facilitators, the maximum number of RBI sessions that the majority of each of the different role players or disciplines thought should take place in a week was one. RBI facilitators were willing to conduct up to three RBI sessions per week (Refer to Figure 6). An RBI facilitator drives or facilitates the RBI studies in various plants. The scope of work of an RBI facilitator is to conduct RBI studies and issue RBI reports to the different plants. One of the comments in the questionnaire given by an RBI facilitator said that the person believes plants should conduct a maximum of one session per week, whereas a facilitator a maximum of four sessions. This suggests that the RBI facilitator acknowledges the fact that the plant personnel will require adequate time to prepare for even one RBI session per week.

It was also found that most of the role players preferred for the RBI sessions not to exceed 3 hours.

*C. Correlation Findings*

Correlations are used to describe relationships between variables. Correlations estimate the extent to which the changes in one variable are associated with the changes in the other. The variables in this study are taken to be the statements as given in the survey and scatterplots were generated to determine the relationship. Only the scatter plot for the statements having the highest correlation coefficient is provided in this paper. The significant correlations which are of relevance to the study are discussed.

**1) Correlation between statement 21 and 22**

Statement 21: The competency of all personnel involved during an RBI study is satisfactory

Statement 22: Sufficient preparatory work is done prior to an RBI study session

The scatter plot indicates a positive correlation which in turn reflects a direct relationship – one in which an increase in the one variable corresponds to an increase in the other variable. The correlation coefficient (r) for the two statements is determined to be 0.78, which is a strong correlation. Thus, according to the responses given by the survey participants, those who feel that the competency of all personnel involved during a RBI study is satisfactory, also feel that sufficient preparatory work is done prior to an RBI study session and vice-versa. However, this need not necessarily be true, since there is a possibility that a person is competent but just not prepared. This could be due to other external factors such as time availability and lack of interest for instance.

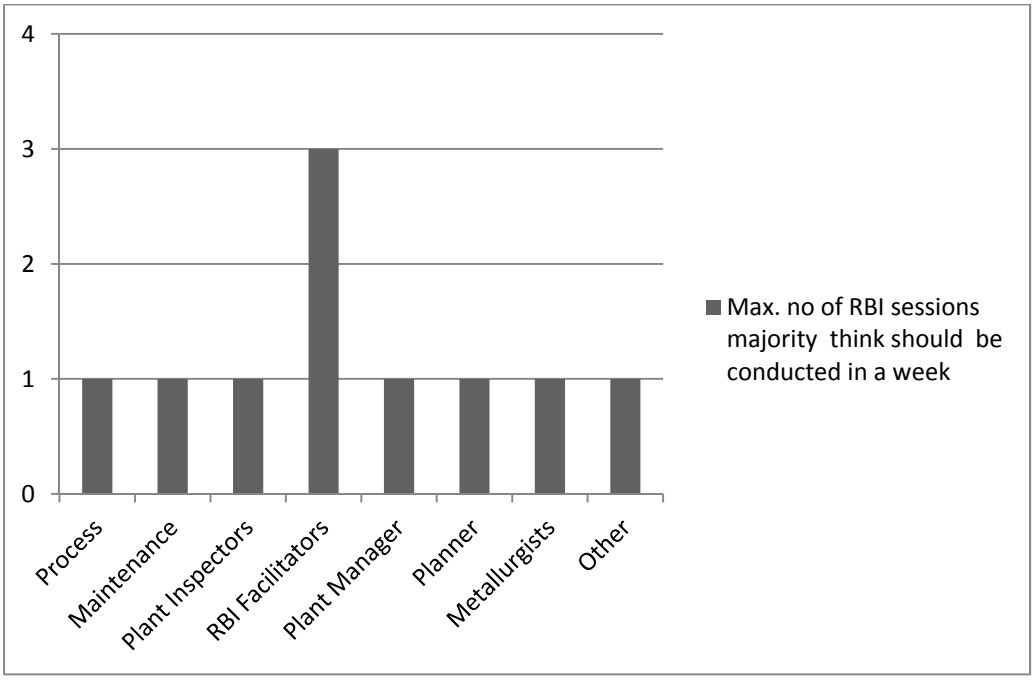


Figure 6: Maximum number of RBI sessions majority think should be conducted in a week

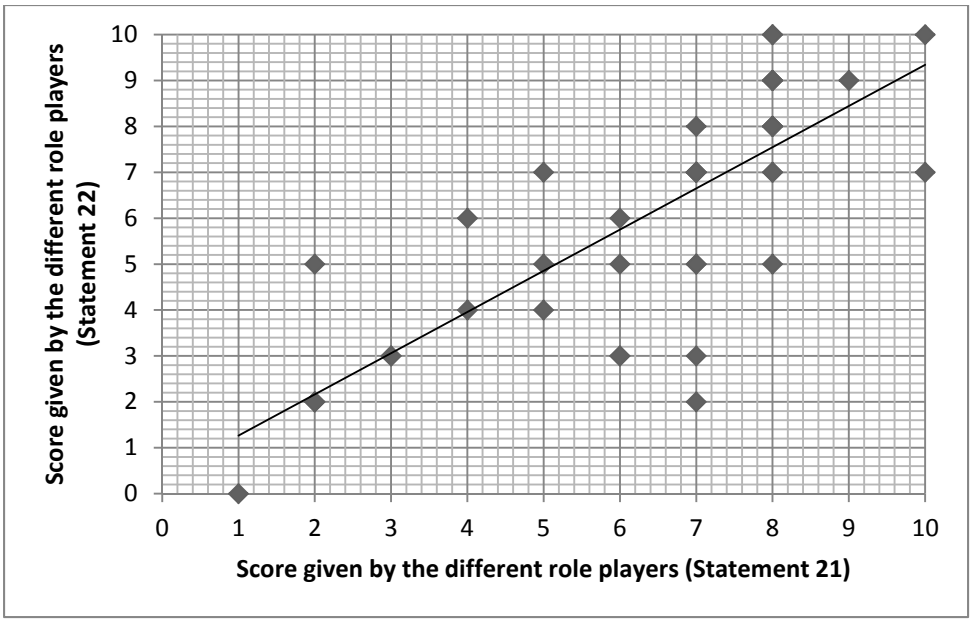


Figure 7: Correlation of statement 21 with statement 22

**2) Correlation between statement 14 and 15**

Statement 14: There is sufficient training on the RBI process implemented

Statement 15: The RBI process has improved significantly since implementation

The scatter plot for these two statements indicated a positive correlation which in turn reflects a direct relationship. The correlation coefficient (r) for the two statements is determined to be 0.64 which is a strong correlation. This suggests that the improvement of the RBI process implemented is related to the amount of training given on the RBI process. Those respondents that felt that there is sufficient training being given on the RBI process currently in place also felt that the RBI process has improved significantly since its implementation within the organisation.

**3) Correlation of statement 17 with 21**

Statement 17: There is sufficient support and effective leadership being provided by upper management towards the RBI process.

Statement 21: The competency of all personnel involved during an RBI study is satisfactory.

The scatter plot indicated a positive correlation which in turn reflects a direct relationship. The correlation coefficient (r) for the two statements is determined to be 0.71 which is also a strong correlation. Those respondents that felt that there is sufficient support and effective leadership being provided by upper management towards the RBI process also felt that the competency of all personnel involved during a RBI study is satisfactory. There are different plants in the organisation, each having its own plant manager. The amount of support and leadership offered differs from one plant manager to the other, and in turn seems to reflect a relationship with the competency of the personnel involved in RBI studies. The plants in which the respondents felt that there is poor support and leadership often also agreed that the competency of personnel is unsatisfactory. Competency would not be an area of concern if there is adequate support and leadership from upper management, since they would be aware of the negative impacts incompetency of personnel can have towards the effectiveness of RBI studies.

## V. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were reached:

- The majority of the role players or personnel involved in RBI studies in the organization are very satisfied with the outcomes of the studies. This is an indication that the RBI system or process currently practiced within the organization is working well. This does not mean to say that there is no room for improvement.
- The majority of the role players would not like to see RBI studies being conducted more frequently. The results also revealed that the majority of the personnel, excluding RBI facilitators and plant managers, would like to see only one such session per week not exceeding 2 to 3 hours.
- The results of the analysis indicated that according to the majority, the discipline or role players presenting the most difficulty in the RBI process (with regards to lack of preparation, interest, expertise etc.) is the process or production personnel.
- The research revealed that there is a definite shortage of RBI facilitators within the organization.
- A strong correlation exists between sufficient training on the RBI process implemented and the improvement of the RBI process since its implementation.

- A strong correlation exists between the competency of personnel involved in the RBI studies and the amount of preparatory work done prior to an RBI study session. The more competent the personnel involved in the RBI process and studies are, the more the likelihood that the preparations by the individuals prior to the sessions are satisfactory.
- A strong correlation exists between the support and effective leadership provided by upper management and the competency of personnel involved in the RBI study sessions. Plants that are managed by personnel showing adequate support and leadership towards the RBI process seemed to have more competent personnel taking part in the RBI studies.

A proper conclusion regarding whether the firm is seeing the results of improved operational safety as well as reduced costs, with the progression of years since RBI first started to get implemented in Sasol Sasolburg could not be reached from this research. This is because the savings in cost and time due to extending inspection intervals due as result of RBI studies will need to be compared with cost and time spent on the additional inspection activities that are, at times, specified by the study itself. Information on such a comparison is not readily available and might constitute another study on its own. In addition, although the majority of the personnel believe that RBI helps to reduce the safety incidents due to failure of equipment, there is no proof to back this statement.

As pointed out earlier in this paper, the findings and conclusions are the result of the study of RBI effectiveness in only one organization, and hence cannot be directly generalized to other firms or the industry as a whole. This could be a topic for further research.

Based on the conclusions that were drawn from the study, and the comments as given by some of the participants, the following recommendations are made to improve the effectiveness of the RBI studies conducted currently within the organisation:

- Provide improved training for all personnel, including management, so that the value arising from the RBI process can be realized and appreciated. The training should focus on helping the different role players to realize how their contribution impacts on the success of the process.
- Appoint additional RBI facilitators to help reduce the work load of the current facilitators and to increase the availability of facilitators.
- Include RBI study participation and preparation in the various role players' performance contracts so that personnel take the preparation for an RBI session seriously.
- Management should drive preparation work from all disciplines and not just the plant inspectors.
- The plant should put more emphasis on having dedicated and reliable process personnel to take part in the RBI study session.
- RBI studies should not be conducted on equipment that do not have a significant inspection cost and which can get inspected at any time without having an adverse effect on production.

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