

Part 3 of the Eight Critical Elements of Asset Management Survey.

Critical Element 5.

Reliability, Process and Practices Audits.

“You can’t manage what you don’t measure”. If you don’t know the reliability level of your equipment how can you possibly improve it? How do you know that the practices you have in place are being followed and are they correct to begin with? Auditing your processes and practices is a must so you can acknowledge your reality. The problem with Auditing is that very few people enjoy or feel comfortable doing audits and the people being audited generally feel threatened so act defensively. How do you encourage people to be involved in auditing and make people being audited more comfortable?

The key to both sides of this question is to provide context as to why the audit is required? For example, why do you need to review PM work instructions? These need to be reviewed as there may be unnecessary steps detailed in the process, the time or resources allocated for task doesn’t allow it to be completed effectively, the time allocated to the task is far too much, the tasks are being done too often or not often enough, the output requirements of the equipment has changed. There are many reasons, but the facts are that equipment evolves both physically and operationally, so this means the tasks related to asset management need to evolve also. If you want to know what elements you should audit refer back to the Introduction of this report.

Management support of process and practice audits.

Question 42 is aimed at understanding the level of management support for auditing of processes and practices. Without support and understanding, auditing is not likely to occur.

42. Management support the view that Auditing processes and practices is a critical part of any continuous improvement process.

5. Indicates management do support and understand the importance of Auditing processes and practices. Scheduling of Audit processes are driven from this level.

3. Indicates management support and understand the importance of auditing processes and practices.

1. Management to not support Auditing.

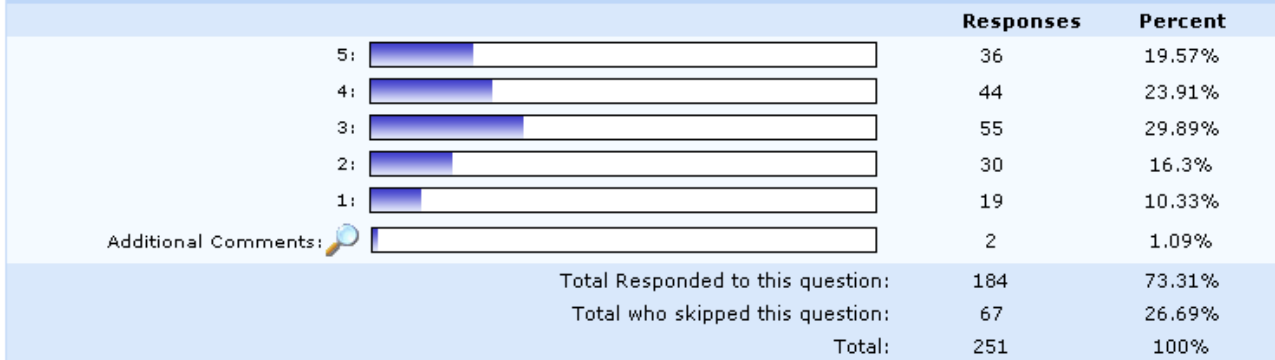


Figure 61. Question 42.

With over 43% scoring a 4 or a 5 the responses show management support at the highest level as they not only support and understand the importance of auditing, they also set schedules for the auditing to occur. If compliance is measured and actions put in place from these audits the continuous improvement loop it closed and this would indicate best practice. A further 30% of responses scored a 3, which still shows significant levels of management support.

In the context of this survey “audits” refer to maintenance and reliability audits, so if these are not occurring within your business how can you build management support? In many businesses you often find auditing processes for quality, environmental and safety practices. If these types of audits are already occurring within your workplace it should not be difficult to bring your management on board with maintenance and reliability audits. The quickest way to gain support is to complete some trial audits and progress with some “Quick Win” improvements, which can be used to support improvement initiatives.

Auditing work sites.

A key component of Reliability, Process and Practice Audits is getting out to the worksites and reviewing the effectiveness of work instructions. Poor instructions can lead to the instructions not being valued, over or under servicing, and in the worst cases rework and infant mortality. **Question 43** is aimed at determining how often maintenance work sites are audited to confirm compliance to work instructions.

43. Maintenance Work sites are audited on a regular basis to confirm compliance to work instructions.

- 5. Indicates Auditing occurs on a daily basis.
- 4. Indicates Auditing occurs on a weekly basis.
- 3. Indicates Auditing occurs on a two weekly basis
- 2. Indicates Auditing occurs on a monthly basis
- 1. Auditing does not occur.

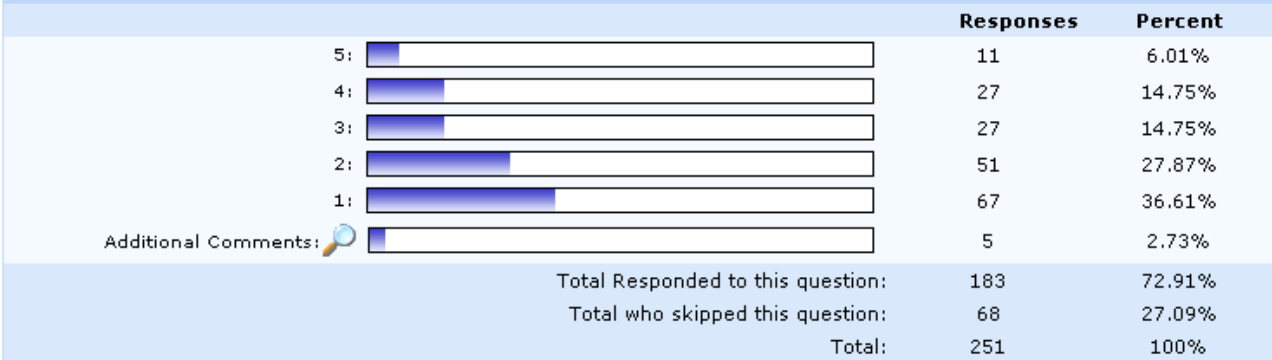


Figure 62. Question 43.

Of all questions in this survey the responses to Question 43 show the greatest overall opportunity for improvements to be made. Nearly 37% of respondents do not audit their work sites at all, and a further 28% audit on a monthly basis. Regular auditing of work sites conducted in a positive manner that engages the maintainers will lead to rapid improvements to work instructions. Questions that may be included in an audit:

- Is the task on this week’s schedule?
- Was this task discussed in the morning meeting?
- Was the machine ready for work to commence?
- Were all materials and tools required to complete the task ready on the day?
- Does your team leader visit the work site? How often?
- Have you got the work instruction with you?
- Do you read it? If not why not as the job may have changed since you last did it?
- Is the work instruction able to be used as a training guide? If you hadn’t done the job before could you do the task from this instruction?
- What actions in this current task don’t add value?
- Does the task address a failure mode?
- Are there any parameters that could be measured that that could prevent or help predict potential failure.
- Is the time allocated on the task adequate?
- Is this task done too often or not enough?
- Is the task list complete? Should there be more actions included?
- Are the tools and equipment listed on the task list adequate?

- Do you provide feedback at the end of a task? (Quality of task, further work required)
- If not why don't you do it?
- Do you see results from your feedback on tasks?
- Do you generate requests for follow-up work? If not who does it?

Operations audits of unplanned downtime.

Question 44 is aimed at understanding how well the operations groups understand the causes of their unplanned downtime. Generally these losses can be split into a few areas such as: Breakdowns, quality issues, rate losses, lack of labor, lack of feed. Ideally a system will be in place that captures these delays and if audited regularly will point to areas where improvement is required.

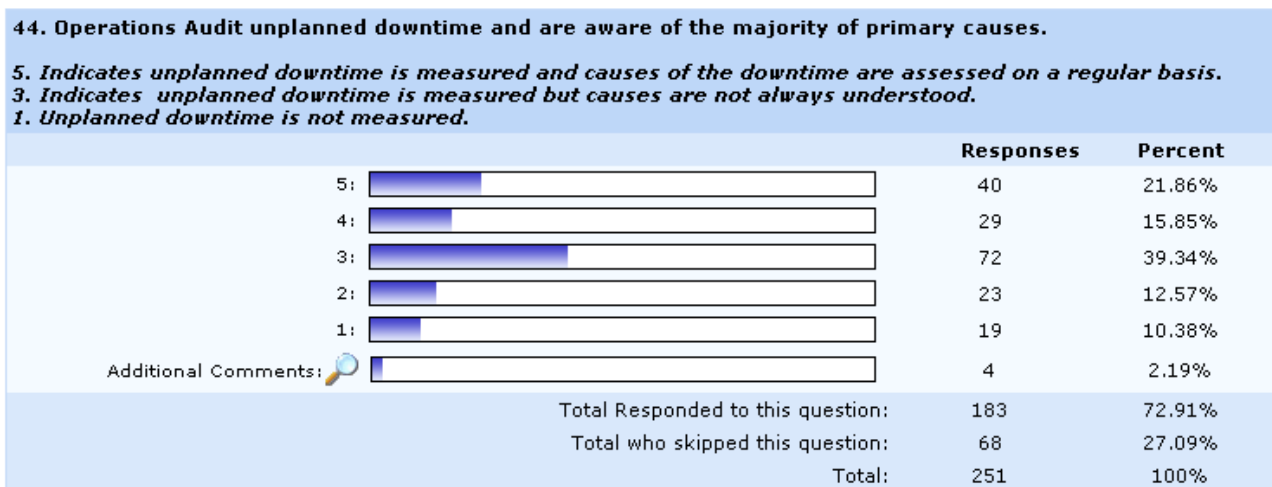


Figure 63. Question 44.

The positive side of these results is that 75% of respondents measure unplanned downtime, but only 37% actually review the data on a regular basis. If you are measuring any data but not doing anything with it then the effort collecting the data is wasted. Pareto your losses and determine the problems that are the most significant contributor. Address the issues with minimal cost implication first and build business cases for others. If you have the data use it!!

Segmentation Analysis of Reliability, Process and Practices Audits data.

The results of the three Reliability, Process and Practices Audits questions have had scores allocated from 1 to 5 in line with the scoring criteria. The total scores have then been averaged by Industry type, the position of the respondents and total no. of employees to give the results below.

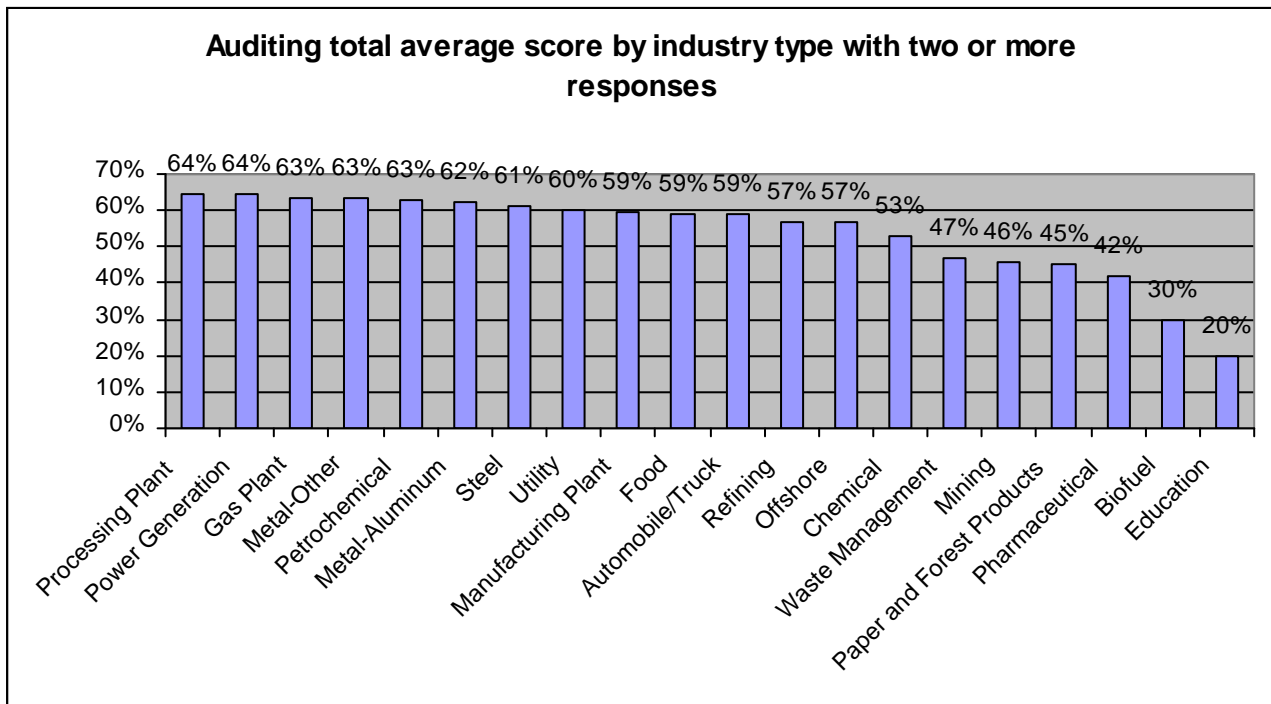


Figure 64. Process and practice Audits by industry type.

The total average scores for this element was the lowest of all elements at 57%. Processing Plants and Power generation had the highest average score of 64%. Again we find heavy industries such as offshore, chemical and mining rating themselves at the low end of the scale.

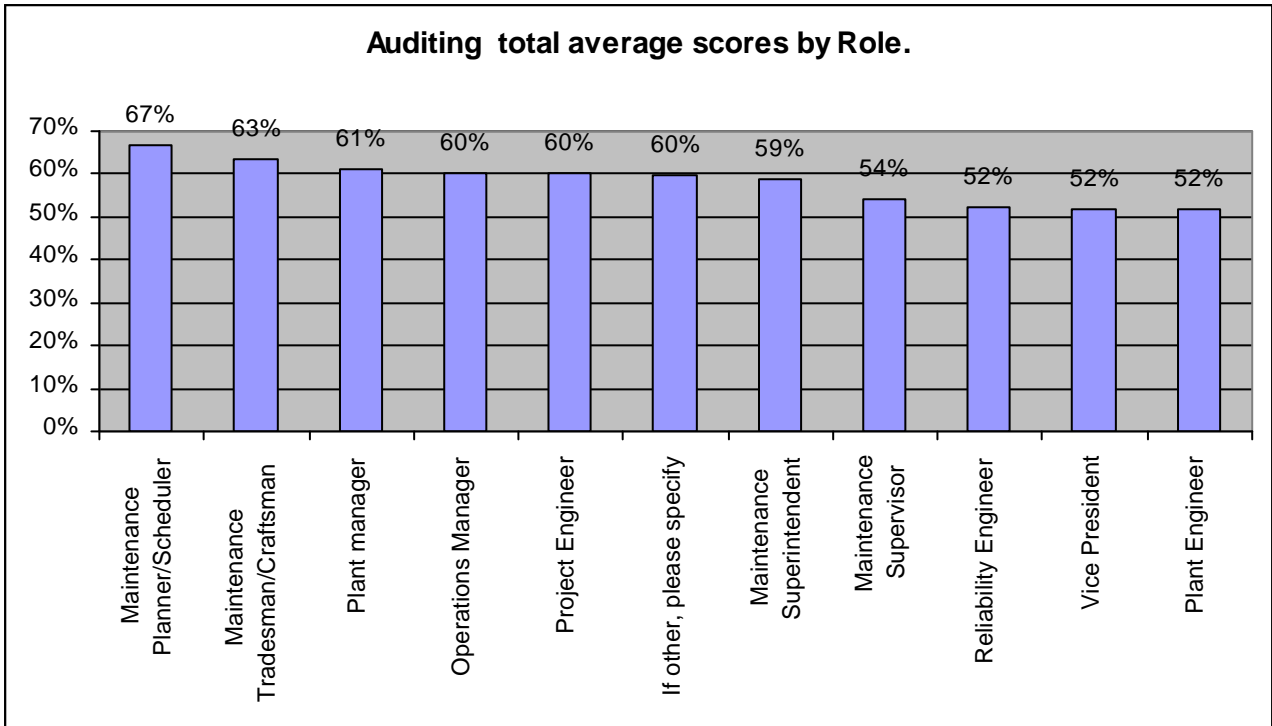


Figure 65. Process and practice Audits by Role.

The maintenance planners and schedulers have provided the highest average rating in this element with a score of 67%, with the tradesmen being 4% behind. . It makes sense that Planners and schedulers rate higher here as much of their time will be spent on working with work instructions and in many cases modifying these instructions will be a part of there role. The Low ratings from the Maintenance Supervisor and Reliability Engineers indicate acknowledgement that they do not Audit their systems regularly.

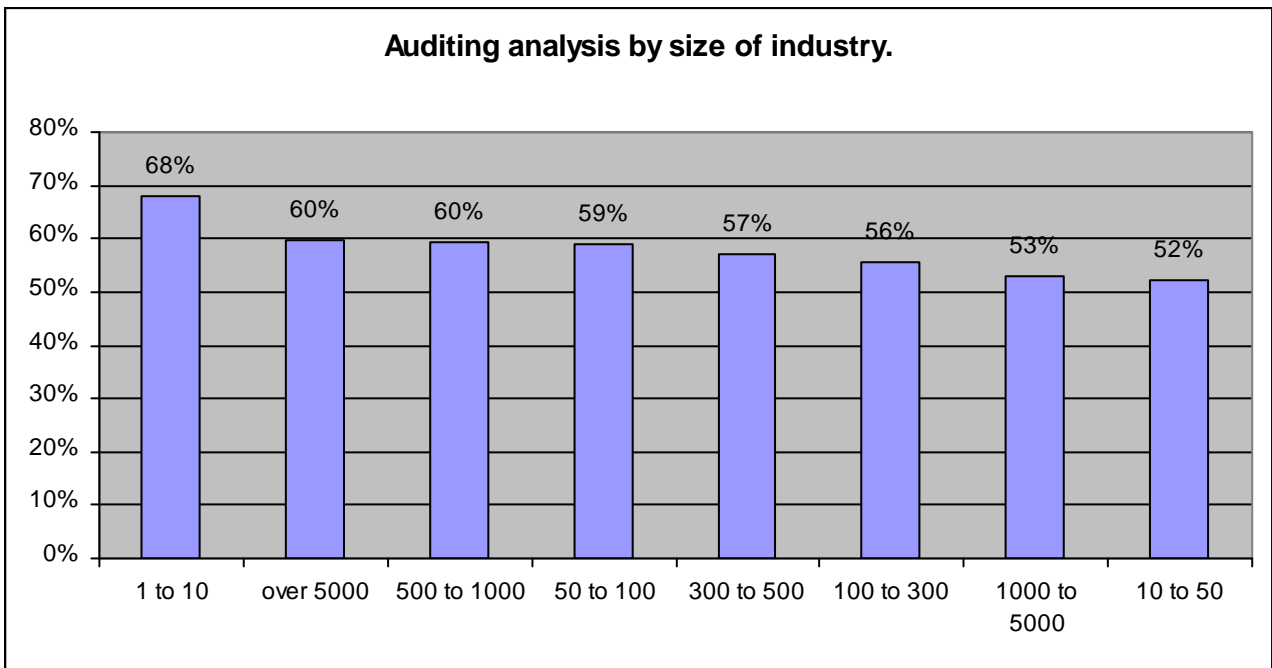


Figure 66. Process and practice Audits by Industry size.

In keeping with the trend to date the smallest of businesses have rated themselves the highest. The other emerging trend is that the business only slightly larger (10 to 50) are almost always rated the lowest. It could be assumed that the very small businesses are often run by owners or the crews rely heavily on one another, which breeds a strong culture of ownership.

Conclusions on Reliability, Process and Practice Audits.

Management support exists for Auditing processes, but the maintenance and reliability fraternity do not do audit processes often or effectively. There is also clear evidence that operation departments don't do this well either.

If you want to enter the realm of continuous improvement, your principles and practices must be audited, shortfalls identified and actions put in place to mitigate losses. For further reading do some research on Deming's Plan, Do, Check, Act cycle.

Critical Element 6.

Computer Maintenance Management System. (CMMS)

Your CMMS is your maintenance management database, and like any database, if the input is bad the output will also be bad. A well utilised and managed CMMS is an invaluable tool that should be in close alignment with Work Management system. What does a good CMMS look like?

What good is a CMMS? (a fictional example)

In a great step forward from management an experienced Reliability Engineer was hired to help improve plant reliability. The first task for this Engineer was to determine the equipment that causing the biggest losses for the business. Having had a CMMS in use for a number of years this was the obvious place to start. The first place to look was the breakdown data and this was easy to locate as all breakdown work requests had been tagged in the CMMS. The breakdown crew had been trained well in the use of the CMMS and each breakdown had been coded appropriately, which made it easy work to pareto chronic losses. The next place to look was high cost areas, so a work order cost report was run which spilt the costs against the equipment hierarchy. Because the equipment hierarchy had been structure well and all relevant hours and materials had been booked against the correct area most of the time, a picture of high cost items was developed quickly. Matching the chronic losses and costly repairs over the last 12 months it was easy to find where the effort needed to be applied, so task briefs were raised so maintenance planners could begin planning some critical repairs and Engineering could prepare some capital submissions.

The planners developed a plan in the CMMS for the repairs by estimating hours and purchasing materials, which were easy to find as they had all be catalogued and put in bills of materials. In a few instances the planning had already been done as the work had been done before, and the job had been saved as a task list in the CMMS. When all materials were available for the task the scheduler reviewed his list of work orders from within the CMMS, checked his labor availability through the automated connection to the HR module, and then matched the labor to the task that would be completed in the following week. In the following week, all task were completed as they had been planned so well, the planner closed off all the tasks in the CMMS and this data was now captured for reporting. At the end of the week a

PM compliance measure of 100% was reported, and planning accuracy was spot on. The capital work was still in the approval stage, but at least all the maintenance work was completed on time and to budget.

Is this how it works at your workplace?

Management and the CMMS.

Does your management value the CMMS and the data captured in it or do they not have a good understanding of it? Often managers have little understanding of the system because to put it simply, they don't need to use it. If costs are low and equipment gets fixed quickly with only a few major breakdowns then we must be doing well, right? If management value the CMMS then they will be driving the improvements to the system, and this is what question 45 is aimed at understanding.

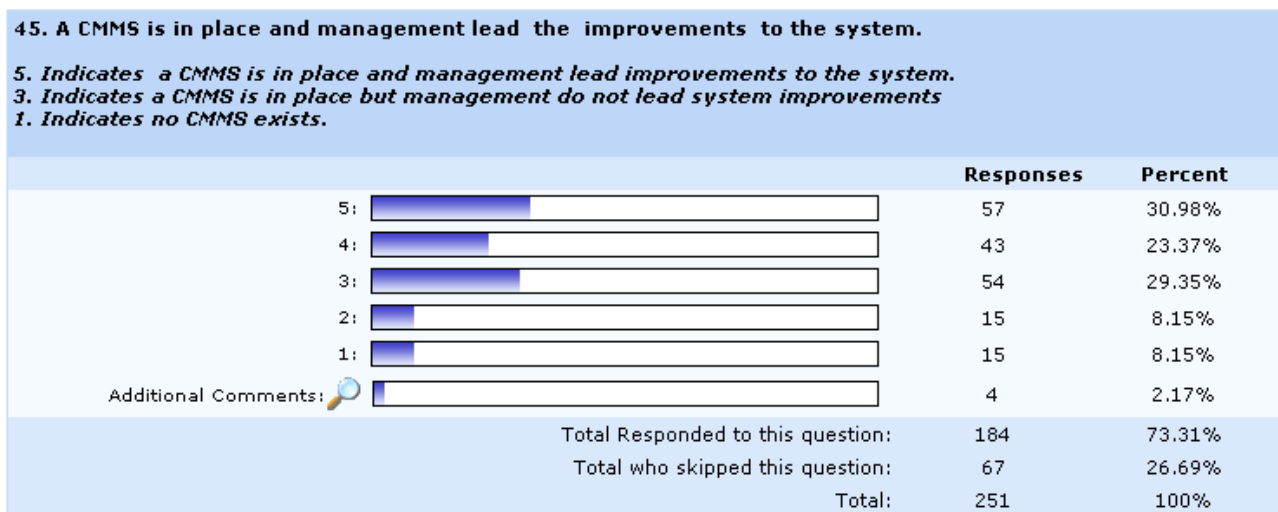


Figure 67. Question 45.

The really good outcome here is that 85% of respondents reported that they had a CMMS in place. With 54% rating this a 4 or a 5 it also shows a clear trend towards management driving the improvement to the system. Of the responses from the 15 respondents that said no CMMS exists, 6 had more than 300 permanent employees. Of the 57 responses that rated themselves a 5, 21 had less than 300 employees with 3 of those having 1 to 10 employees. How is it that some business's of significant size do not have a CMMS in place, where very small businesses do? How do the businesses without a CMMS manage their workload?

Are all maintenance tasks captured in the CMMS?

If you want to drive improvement you must have measures to compare your performance. You also need data to help diagnose significant issues. Drawing from experience it has been found that many plants have limitations on what data is entered into their CMMS and this presents itself as a lost opportunity. For example, a reactive plant only puts significant breakdowns into SAP and doesn't bother with the quick fixes. The clear loss here is that chronic short time losses will not be assessed. Does the problem that occurs every shift cost you more than a catastrophic breakdown that happens once every 10 years? Clearly this call can't be made, as these chronic issues are not being measured. Question 46 is aimed at understanding the extent of the use of the CMMS for capturing all maintenance tasks.

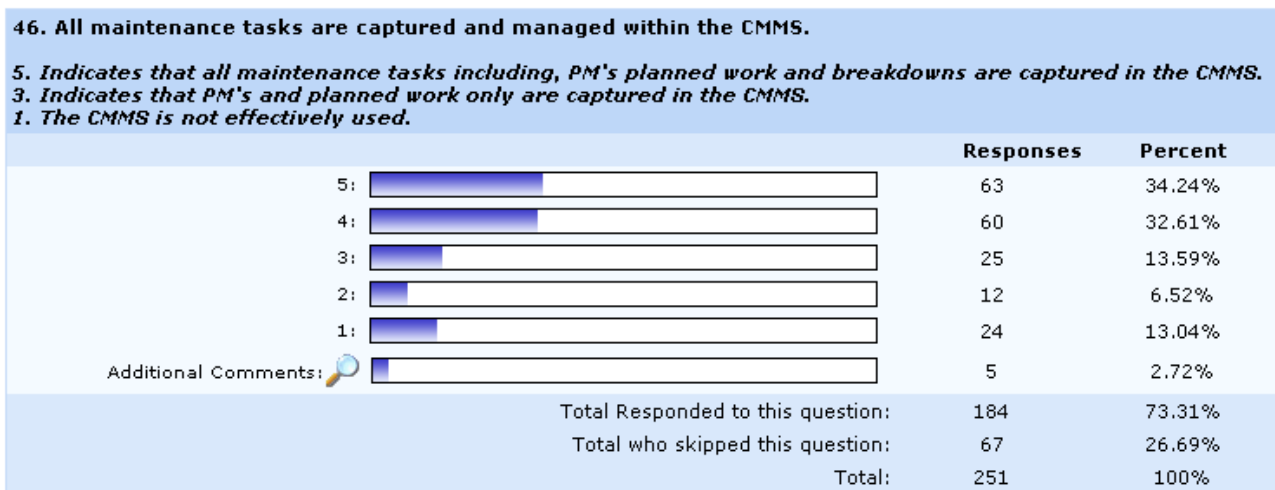


Figure 68. Question 46.

The results to the question were very pleasing with over 66% of respondents scoring a 4 or a 5. This indicates a high level of acceptance that all work should be captured and managed within the CMMS. Equally pleasing was that only 19% of respondents scored a 1 or 2. It was expected that this number might have been higher, as it is common to here complaints about the usability of the CMMS.

Training maintenance in the use of the CMMS

If you have a good work management process it will most definitely be closely linked to the use of the CMMS, so training needs to occur for both areas. The work management system is the business process whereas the CMMS is the transactional side of the same process. If your maintenance employees do not know how or why they need to use the CMMS, the data available will be of little value and efficiencies of using the system will not be realised.

Question 47 is aimed at determining the level of formal training has occurred in the use of the CMMS.

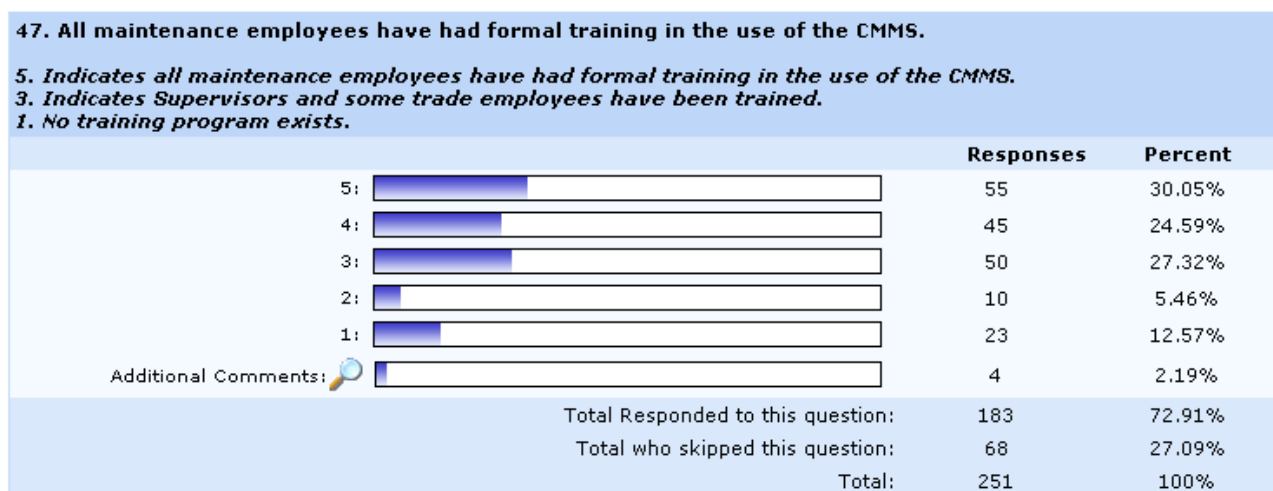


Figure 69. Question 47.

With 55% of respondents scoring a 4 or 5 it shows a very high level of commitment to effectively training maintenance employees in the use of the CMMS. Of the 27% that scored themselves a 3, in many cases this level of training may be appropriate for that type of business. Overall this is again an excellent result.

Training Operations in the use of the CMMS.

The CMMS is the interface for the maintenance and reliability groups customer to enter their requirements for work. In most cases the customer is operational and technical production groups. If they do not know the right way to enter requests in the system and then track the progress of this work it will lead to frustration and a perception that the system is inefficient. For example a production based technical expert enters a work request into the CMMS but doesn't have a clear understanding of the priority definitions and that he should fill out the "required by" field. The expectation of the expert is that his task is important so it should be done as soon as possible. The planner gets the task, which has an open required by date and says to himself, "this couldn't be important because the priority is low and he doesn't care

when it should be finished”. This scenario explains why operations personnel need to understand the work management process and be competent in the use of the CMMS.

Question 48 is aimed at understand the level of formal training for relevant operational personnel.

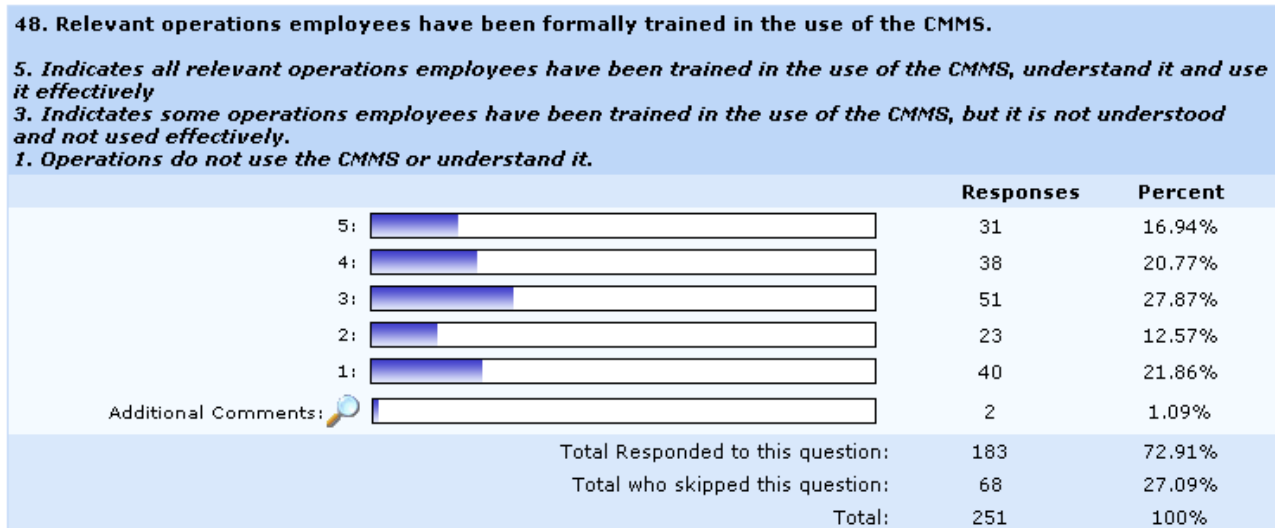


Figure 70. Question 48.

A very even spread of responses here with a significantly negative connotation of 62% scoring a 3 or less. This is a clear indication that operations employees do not value the use of the CMMS or don't see it as their job to use it.

Cataloguing and BOMing of spares.

The CMMS being a structured database of sorts is the best place to store information about spares. The CMMS will have the ability to store spares details in the relevant area of the equipment hierarchy which make the right spares very easy to locate if it has been set up well to begin with. Other information may include how many are kept in the store, how long delivery will be, whether the equipment is repairable or not and how much it costs. **Question 49** is aimed at determining what proportion of equipment has been catalogued and entered into a Bill of materials.

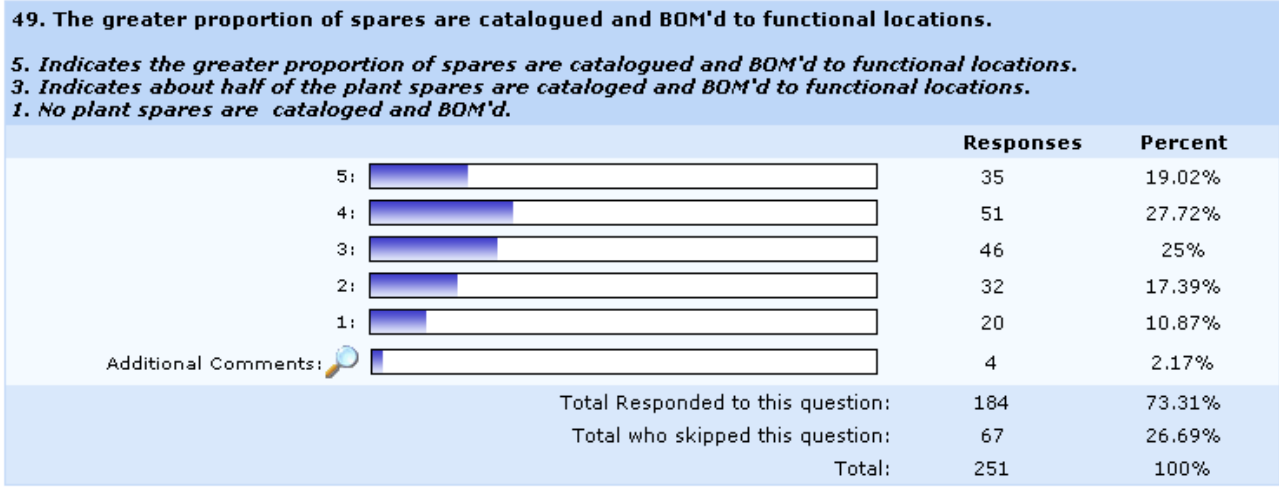


Figure 71. Question 49.

The results from this question were not unexpected, as when you discuss this with people in industry they generally say, “We are doing something about this”. The reality is that most see this as important but rarely is this work a priority, as there are many other aspects of Asset management that need to be working well before having great bills of materials is of significant help. Organisations that are mature in their asset management systems are usually heading down the path of improving their cataloguing and BOM’s

Support of the CMMS.

Contrary to the belief or understanding of many a CMMS does not support or manage itself. Users and their authorities have to be managed, new users have to be trained, existing users require technical support, the equipment hierarchy must be managed, bill of materials need to be built and reports will need to be generated. Without a dedicated support function the CMMS will not be maintained correctly and will become less effective over time. **Question 50** is aimed at determining whether an effective support function exists for the CMMS.

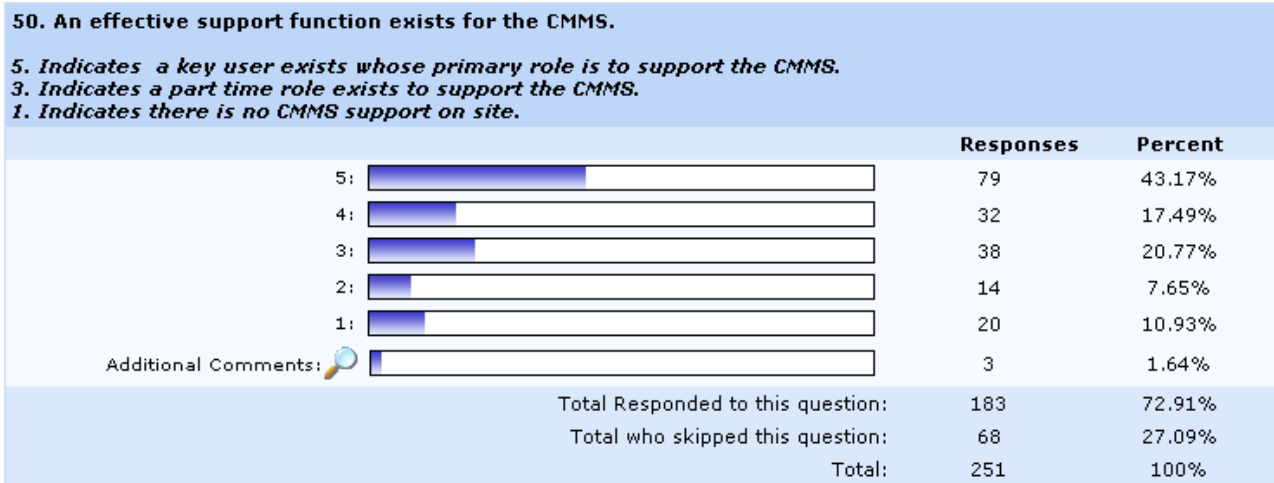


Figure 72. Question 50.

This proportion of respondents that scored a 5 in the question was the highest response for any question. With over 80% of respondents having either a full time or part time resource whose role is the support of the CMMS it is clear that businesses understand that there is a requirement for this resource.

Segmentation Analysis of CMMS data.

The results of the six Computer Maintenance Management System Reliability questions have had scores allocated from 1 to 5 in line with the scoring criteria. The total scores have then been averaged by Industry type, the position of the respondents and total no. of employees to give the results below.

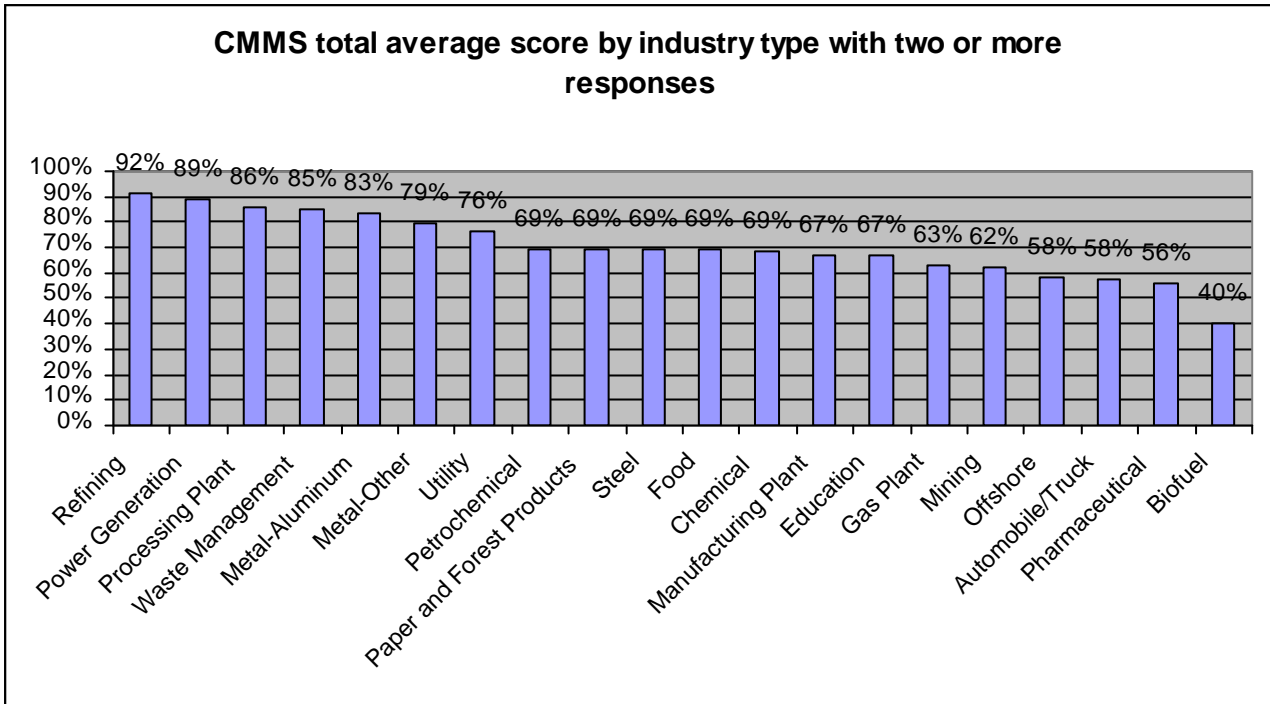


Figure 73. CMMS score by industry type.

The refining and Power generation industries were the highest scoring in the area of CMMS with 92% and 89% respectively. This element had a large extremes in scores from 40% to 92%. Mining and offshore again appear at the low end of scores. There is plenty of room for improvement here with 13 out of 20 industry types scoring below 70%

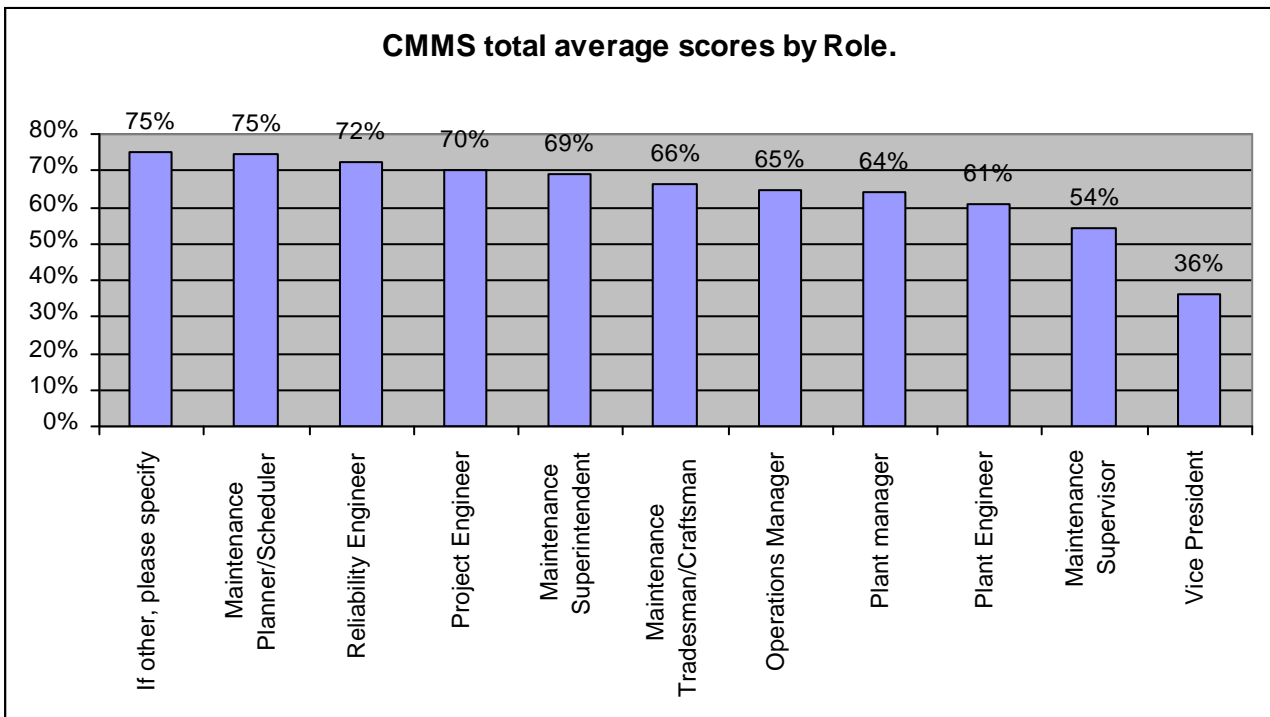


Figure 74. CMMS score by role.

It is of no surprise that planners and schedulers have score the CMMS questions the highest of all role types as they are the ones that use the system the most regularly and in effect this

element is a lot about how well the planning and scheduling function works. All of the operations roles have rated this element at the lower end of the scale and this also makes sense, as often they do not have a clear understanding of how the system works. This presents an opportunity in that operations personnel should have a better understanding of the CMMS and how it links into work management.

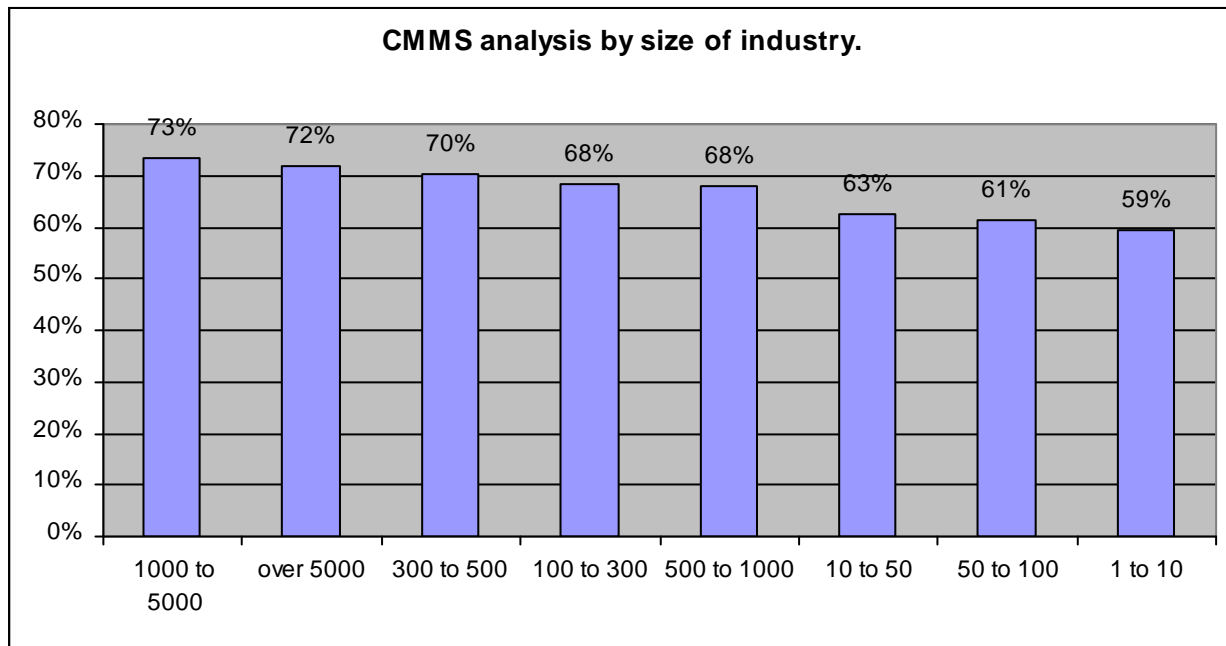


Figure 74. CMMS by industry size.

This is the first element where the larger businesses have score well and the smaller businesses scored at the low end of the scale. It would be expected that larger organisations would have a fully integrated business system and have a large support network where the smaller organisations are likely to have a stand-alone system with less support.

Conclusions on the CMMS element.

The scores for the CMMS were high with a total average score of 68%, with larger industries using their system more effectively than smaller ones. There were many excellent results to these questions including:

- Indication of significant management support with management driving system improvement.
- By far the greater majority companies indicated they capture most of their maintenance work in the CMMS, and manage the work with the system.
- There is a high level of training occurring for maintenance personnel.
- The support function for the CMMS is in place in most industries.

Areas for opportunity include:

An improvement in the level of training, understanding and use of the CMMS by the operations personnel would be of benefit. More effort could be spent building Bills of materials; this in turn will help to improve the planned and reactive maintenance effort.

Critical Element 7.

Shutdowns.

Shutdowns are undesirable events as they are often costly and reduce plant availability. To minimise the effect on output, organisations need to manage shutdowns so all work is completed safely, to a defined standard, and within the shortest possible time frame. This requires detailed planning and scheduling utilising many task lists and procedures.

A Shutdown is defined as an “an engineering event during which new plant is installed, existing plant overhauled and redundant plant removed” (Lenahan 2006, p.5)

At different industries this definition could be applied to any planned task from one shift machine down days, to 10 yearly three-month shutdown. Shutdowns by their nature require significant resources and are a major cost to any business at a time when production is stopped and there is no revenue being generated.

The seven elements in a shutdown model.

A shutdown can be broken down into a seven-element model of excellence in which there are many questions to be addressed:

1. Organisation.

- Is there a formal organisation in place to progress with the shutdown? How is this organisation formed?
- Does the team set shutdown objectives?

2. Planning.

- Is the plant shutdown schedule known well in advance?
- Are shutdown plans developed?
- When is shutdown start and finish dates fixed?
- Is a scope of work developed for all proposed work?
- Do all shutdown jobs have work orders raised for them?

- Are all tasks verified as being required before being included in the Shutdown? What criteria are used to determine whether the work will be included?
- Is a safety management plan developed for shutdowns?
- How is emergent work and handled in relation to the shutdown schedule?

3. Contractors.

- Is there a formal system in place for the control of contractors?
- How is contractor performance reviewed?

4. Costs.

- How is the budget set for the shutdown?
- How are budget costs tracked during a shutdown?
- What actions occur if the budget amount is expected to be exceeded?

5. Logistics.

- How do you ensure that all parts and equipment are on site and ready before the turnaround?
- Is a site plan put in place that details the plant layout, pickup and lay down areas, location of services, access roads, evacuation assembly areas etc?

6. Execution

- At what stage is the plant handed over to the shutdown crew? Is there a signoff to indicate this?
- Are daily meetings held to discuss the current status of the project and any safety issues? Are these discussions minuted?
- Is there a specific access point with sign on/off book at the work area?
- How do you ensure that the shutdown stays on schedule? What process is followed if the schedule can't be met?
- Is there a process used to assess emergent work? How is this normally handled?
- Is there a process to hand the plant back to production.

7. Termination

- Is a commissioning period allocated on the shutdown plan?
- Are debriefing meeting organised at the end of the shutdown?
- Are learning's from each turnaround recorded and improvement actions put in place?

Management and Shutdowns.

Question 51 is aimed at determining whether the management of the business has a clear understanding of the need to have shutdowns, and value the benefits that come from running them well; or do they see them as a cost with little benefit.

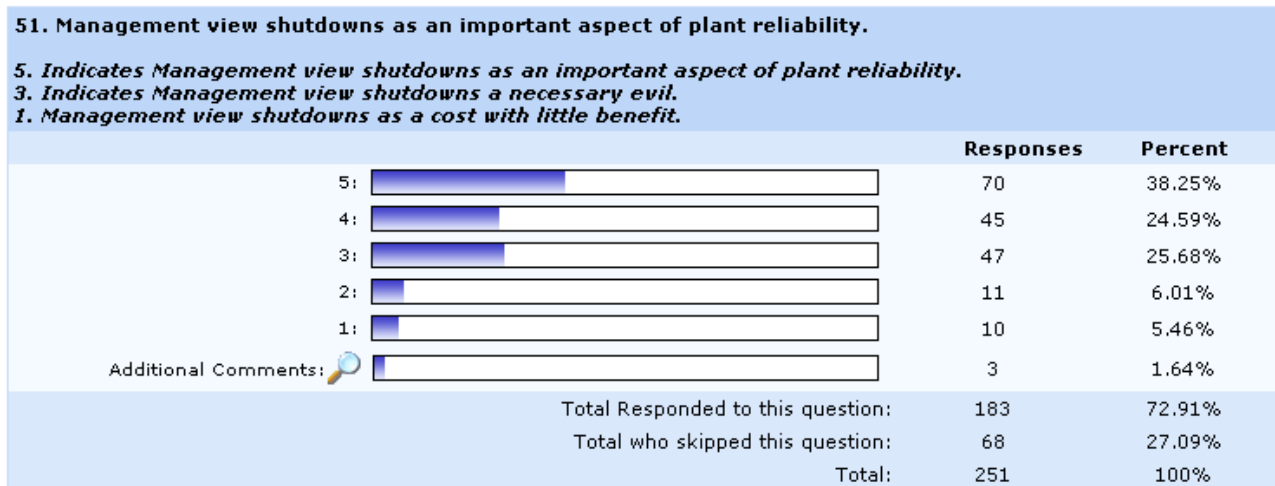


Figure 75. Question 51.

With 62% of respondents rating this question a 4 or 5 it is clear there is support and understanding of shutdowns by management. It is expected that this would be the case as generally shutdowns are budgeted and signed off at a management level due to the potential high costs associated with them. Acceptance of these costs will indicate a certain level of support. Of significant interest is the 38% that score a 5. This indicates that the management of these companies has a very deep understanding related to the importance of shutdowns and how they effect reliability and hence output.

Shutdown schedules.

A well-managed shutdown must have a detailed schedule highlighting all work required, available labor, a timeframe for each task and the dependencies between tasks. When the schedule is agreed upon, it must be locked in place and then monitored on a daily basis to ensure all tasks are being completed to schedule. **Question 52** determines how many businesses have shutdown schedules and segregates the number of detailed vs simple schedules.

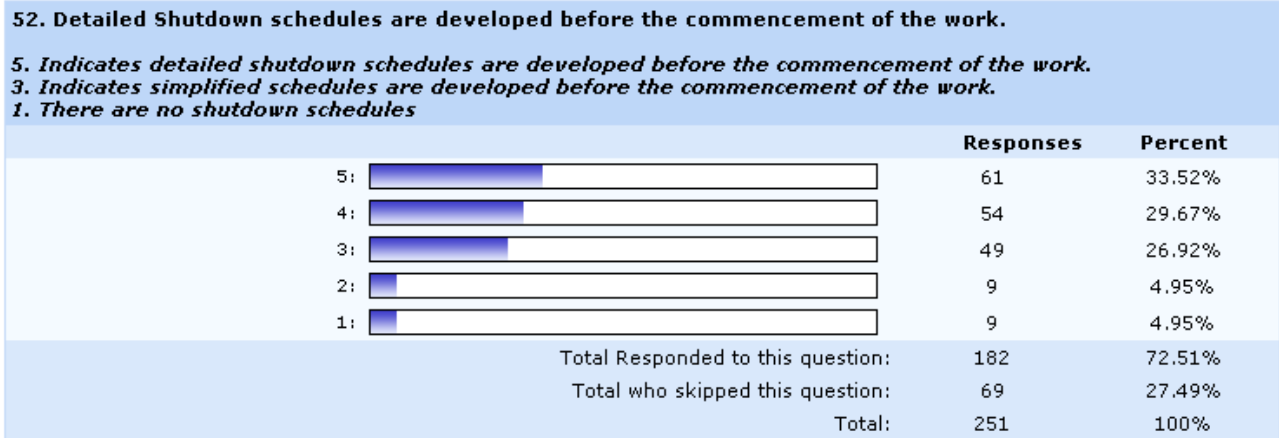


Figure 76. Question 52.

Over 60% of respondents scored a 4 or 5 which indicates most industries are mature in this element as shutdown schedules are well developed and have significant detail in them, with a further 27% having a more simplified schedule in place. With detailed schedules in place in most cases it would be of interest to understand how often the shutdown is completed to plan. The success of the shutdown schedule should be reviewed during the Termination part of the process and learning documented so they can be incorporated in future plans.

Shutdown documentation.

A Shutdown management document should include the following types of information: The Shutdown organisational structure, safety information, safety induction and audit records, emergency evacuation points, a detailed shutdown schedule, a map of the areas covered by the shutdown detailing entry points, materials lay down areas and areas of caution. **Question 53** will determine if shutdown management documents are in place and to what extent they are followed.

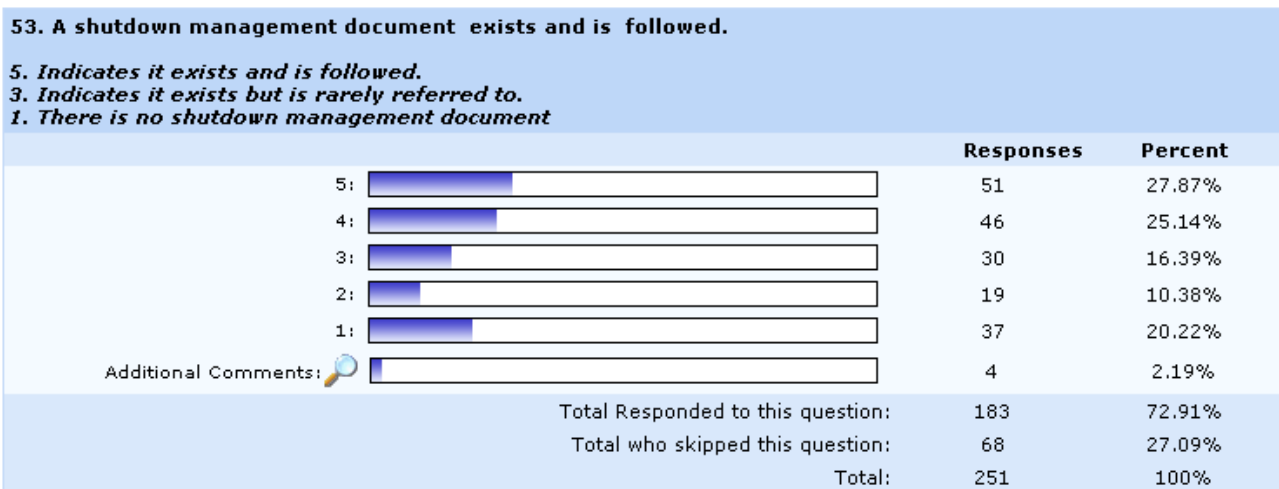


Figure 76. Question 53.

Again there was a very high number of responses with a rating of 4 and 5 which shows considerable support for the use of shutdown management documents. Of more interest is that 20% of respondents don't have a shutdown management document at all and a further 26% have one that is rarely referred to. Its difficult to make an overall comment here as shutdowns will vary significantly in size from a number of hours to months, so shutdown plans need to be sized to suit the specific circumstances. Without a plan in place shutdowns will not be effective as they could be. Follow the plan and keep to the schedule.

Shutdown Managers.

To keep to the plan there will need to be a single point of responsibility. For significant shutdowns a manger must be in place for the Planning, Execution and Termination stages of the shutdown. The manager must have a total overview of how the shutdown is running at any time, they will run daily update meetings, ensure work instruction and safety audits are completed and ensure the shutdown remains on schedule. **Question 54** is aimed at understanding whether shutdown managers are used for outages of 3 days or longer.

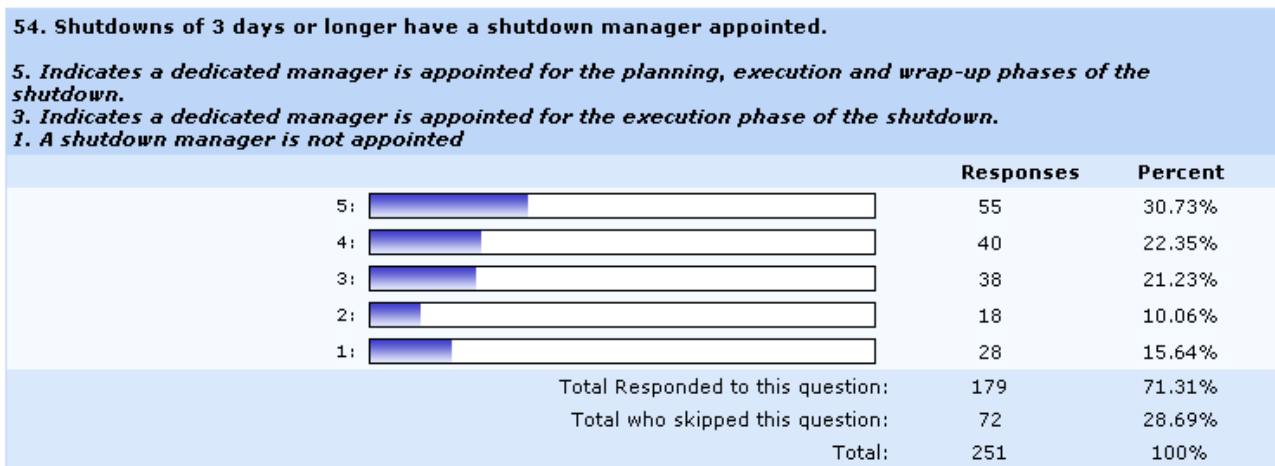


Figure 77. Question 54.

As has been the case with all shutdown questions so far there is over 50% of responses scored as 4 or 5. This is an excellent result however as was the case with question 53 there was a very significant amount of responses where no shutdown manager is appointed at all. This question was specifically pointed at shutdowns of 3 or more days, however all shutdowns no matter the size must have a manager. In the case of a 4 hour shutdown this could be the tradesman or leading hand, whereas a 1 week shutdown may require a senior maintenance supervisor or project Engineer.

Task lists for shutdown work.

If your business is mature and has been using the CMMS well, the majority of shutdown tasks should have already been generated and stored for use as required. Having standard task lists shortens planning time and ensures that tasks are completed the most efficiently. If a standard task list does not exist for a shutdown task, then a task list should be generated and stored on the CMMS for later. **Question 55** is determining the level of use of tasks lists for shutdown tasks.

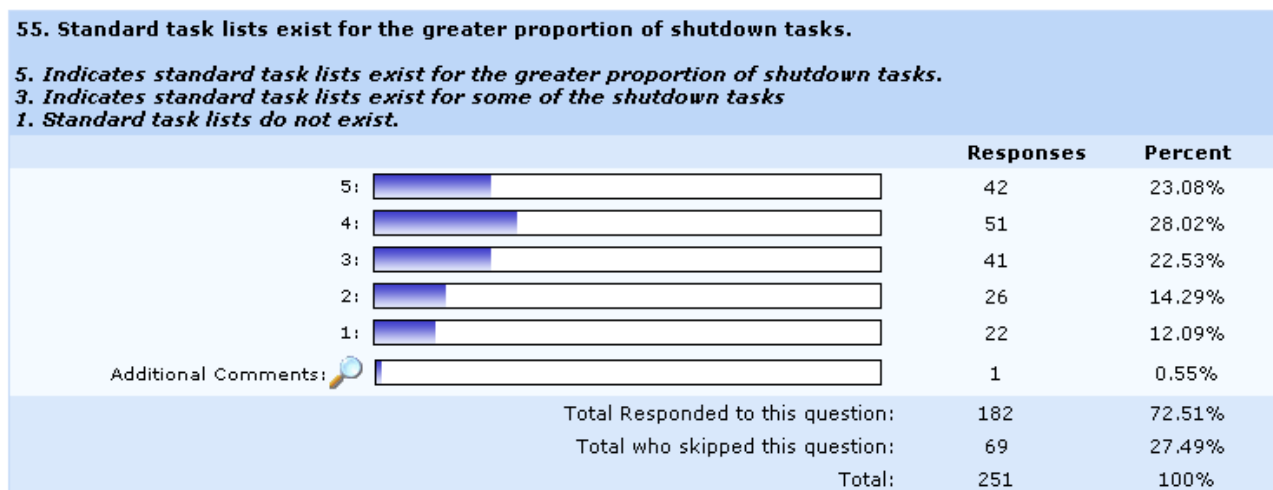


Figure 78. Question 55.

Responses to this question were again good with 73% of respondents having some or a large proportion of their shutdown tasks in task lists which can be stored for reuse in future shutdowns. This is considered to be best practice and should be the aim for businesses that do not currently do this.

Shutdown work and the CMMS.

Question 56 determines what amount of shutdown work is managed through the CMMS. Although a shutdown schedule is in place it does not mean that the CMMS should not be used to manage the shutdown work. The CMMS coupled with a Excellent Work management process will always be the most appropriate place to manage the planning and execution of work. All tasks on the schedule must have a work request entered in the CMMS and should be managed like all other planned tasks.

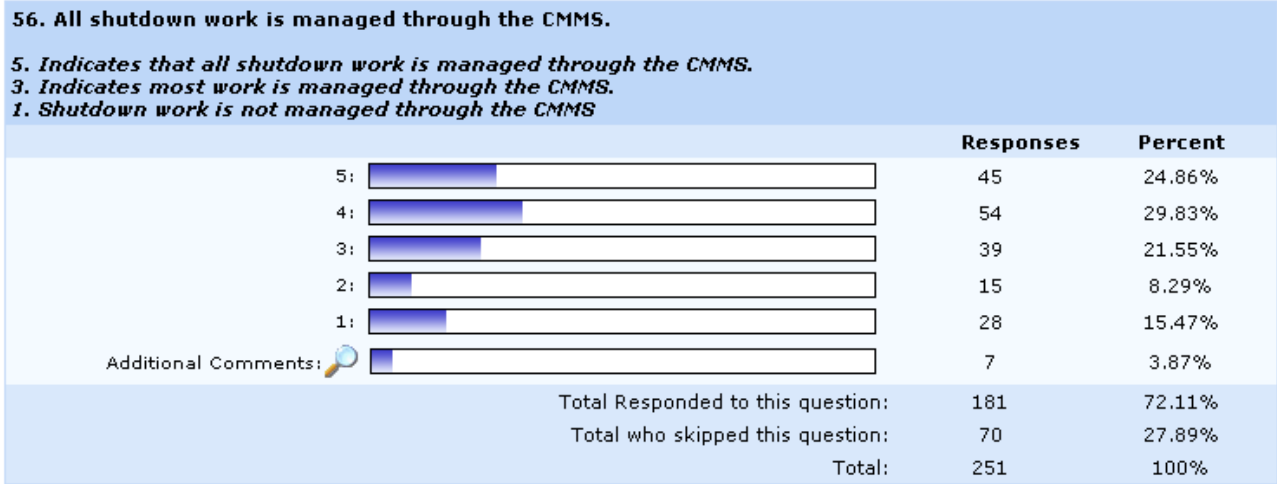


Figure 79. Question 56.

With 75% of responses having all or most of the work managed through the CMMS it is clear most industries understand the advantage of working this way.

Segmentation Analysis of Shutdown data.

The results of the six shutdown questions have had scores allocated from 1 to 5 in line with the scoring criteria. The total scores have then been averaged by Industry type, the position of the respondents and total no. of employees to give the results below.

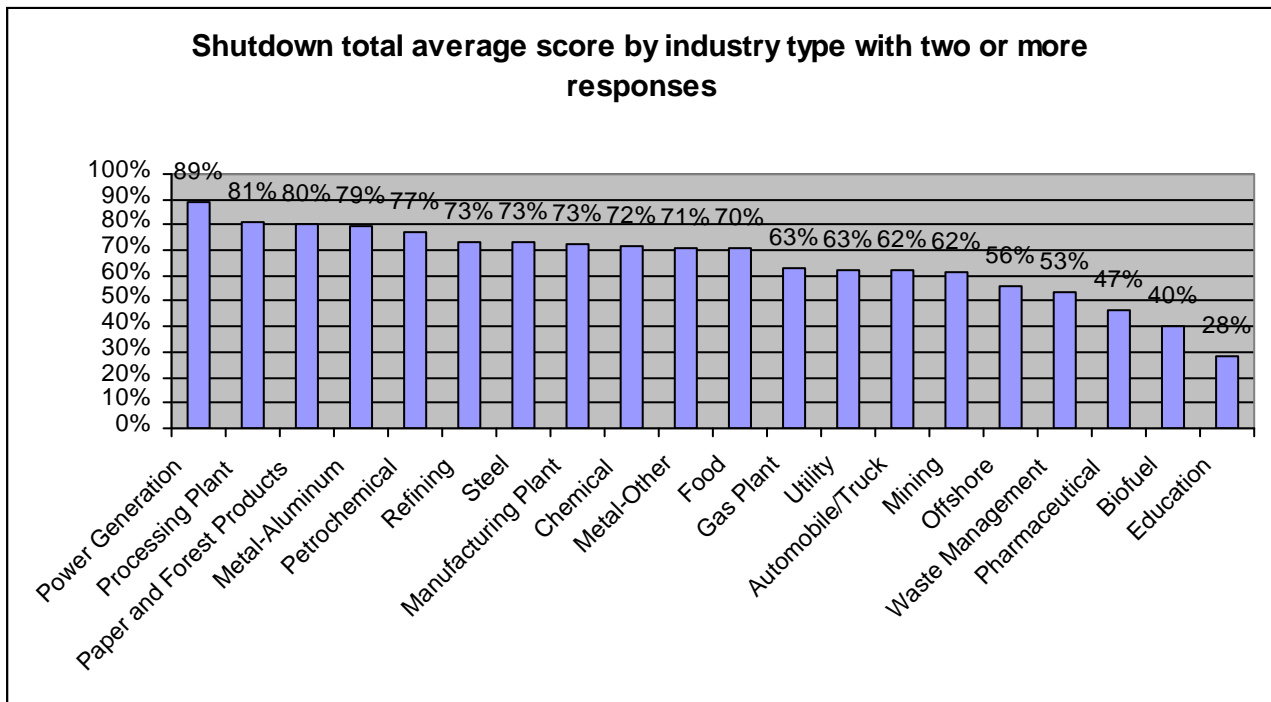


Figure 80. Shutdown scores by industry type.

The power generation sector rated themselves by far the highest here with average result of 89% being based on 5 responses. Considering the size and implication of an unsuccessful shutdown on equipment such as large generators and turbines, it is not surprising that shutdowns are managed well. There is a significant gap to the next best being processing plants at 81%. This result is also on an average of 5 responses. At the low end of the scale we find education, and this is not unexpected as the need for shutdowns would be minimal, however large capital-intensive industries such as mining and offshore have again scored poorly, with 62% and 56% respectively.

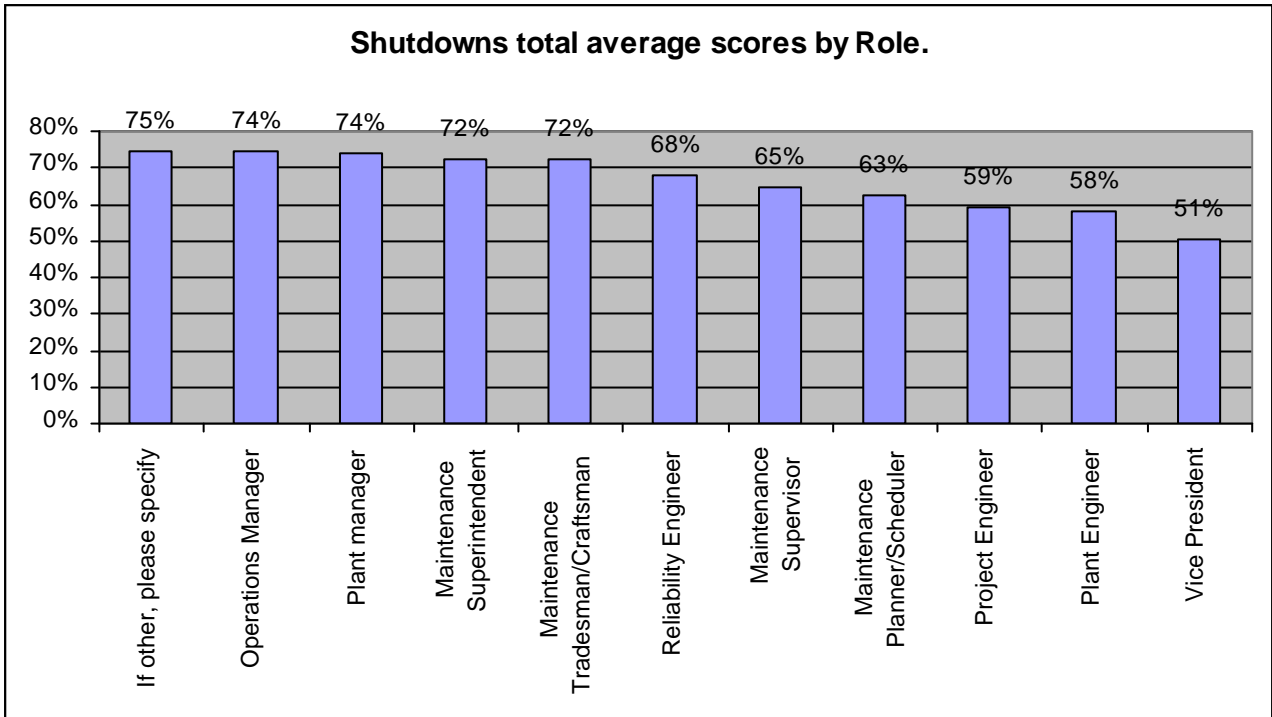


Figure 81. Shutdown scores by role.

Of the scores by role there is a tendency for Operations and Maintenance Managers to rate higher in this element. Does this mean they believe shutdowns are executed better than they actually are? Of interest also is the overall scores from the planners and schedulers which is on the low end of scoring. Considering that they will be the most involved in shutdown planning they are in the best position to rate the overall success of the process.

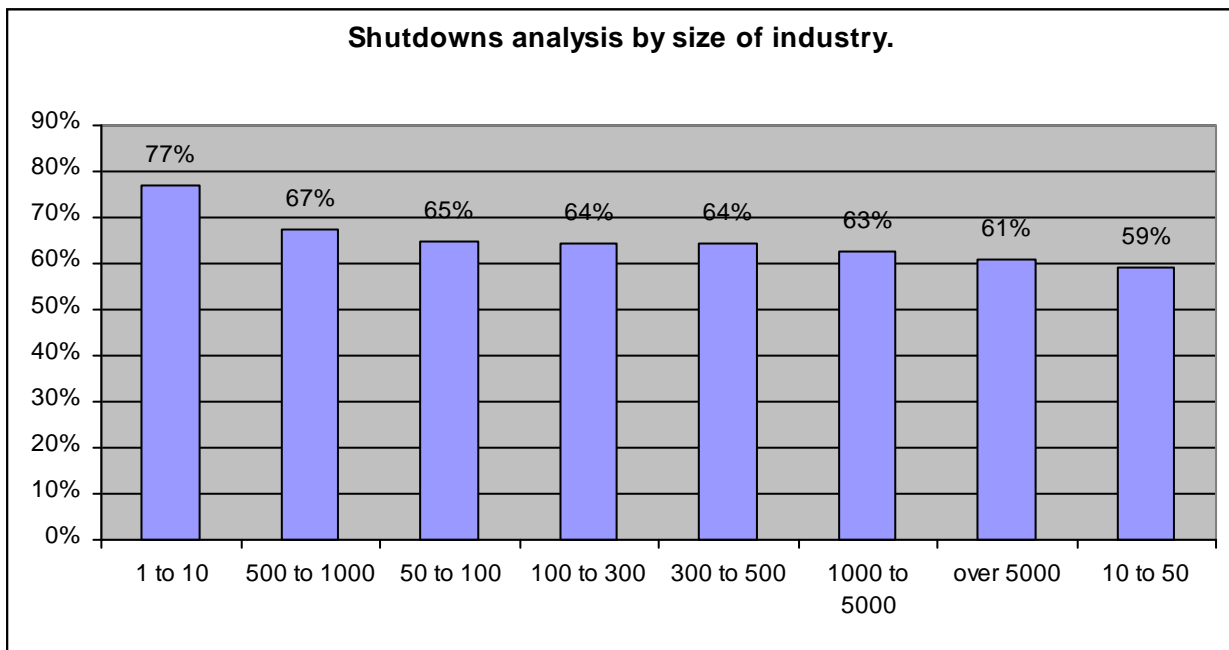


Figure 82. Shutdown scores by industry size.

In this element we are back to the trend where the smaller businesses rate themselves the highest. There is so little difference between the other average score the results are of no significant consequence.

Conclusions on the Shutdown Element.

The general results for the shutdown element were excellent and they highlight that the majority of industries value shutdowns and execute them adequately, utilising the business tools provided.

Results were particularly good in the use of shutdown schedules, the existence of shutdown plans and the use of standard task lists, which are stored in the CMMS. Areas of opportunity include significant amount of businesses that don't have shutdown plans, use shutdown managers or manage their work through the CMMS. This was up to 20% of respondents in some cases. There was some significantly low scores in this element for some industry types which should provide some significant scope for improvement.

The survey is still open for those who would like to assess themselves against the results presented in this report. Use the following link to participate.

<http://tinyurl.com/onesteelsurvey>

Bibliography.

Asset Maintenance Council Website. "Definition of asset management"

http://www.amcouncil.com.au/wiki/index.php/Asset_Management

Viewed 1/08/09

PAS 55-1:2004. "Asset Management. Part 1: Specification for the optimized management of physical infrastructure assets. British Standards Institution

Van Dullemen, R, Comment on, "Preview survey results from the eight critical elements of asset management". Reliabilityweb. Viewed 9-8-2009.

http://reliabilityweb.com/index.php/articles/preview_survey_results_from_the_eight_critical_elements_of_asset_management/

Onesteel Wire Maintenance Business plan on a page. 2007-09.

<http://www.alltestpro.com/products.html>, All-Test Pro Website. Viewed 19-09-2009

Rules of Thumb for Maintenance and Reliability Engineers. Smith and Mobley 2008. Butterworth-Heinemann Burlington MA USA.

Advanced Condition Monitoring Study Guide. Module ENMM 20017. Central Queensland University. 2006.

Lenahan, Tom. "Turnaround shutdown and outage Management" Butterworth-Heinemann, 2006. (p5)

Central Queensland University (CQU) ENMM 20018, Turnaround management study guide.