Part 2 of the Eight Critical Elements of Asset Management Survey.

Critical Element 2

Condition Monitoring/Predictive Maintenance.

It has been widely documented about the cost of reactive maintenance. Some experts suggest that it can cost up to 5 times as much as work that is planned and scheduled. Coupled with research into the Potential Failure interval and advancements in predictive technologies, condition monitoring has given industry the potential to improve reliability of equipment like never before. Condition monitoring or predictive maintenance encompasses the following technologies and practices:

1. Thermography. Thermographic cameras detect radiation in the infrared range of the electromagnetic spectrum and produce images of that radiation. When these devices became commercially avaliable they were marketed very heavily as a specialist service to the electrical industry where they were aimed at locating hot joints. As the cost of the technology has decreased the applications have increased in industry to include monitoring of mechanical components and production processes. An effective condition monitoring process must include a thermography program.

2. Vibration analysis allows well-trained technicians to monitor and trend the very early stages of defects in rotating equipment. As is the case with thermography, the cost of tools and software required for vibration analysis has reduced significantly in the last few years, however, purchasing the equipment and learning how to use it doesn't mean you will be able to effectively assess the data gained. Effective analysis can take years to learn, and there are significant benefits if the analyst becomes very familiar with the equipment they are monitoring. Vibration analysis must be included as part of your predictive maintenance strategies, preferably with a dedicated analyst.

3. Oil analysis. Analysis of lubrication and transformer oils has been avaliable for decades in different forms. Analysis can be segregated into three areas including; Fluid property analysis, Contamination analysis and Wear debris analysis. Tests included in oil analysis begin with basic visual inspections detecting oil leaks and checking oil levels, through to spectrographic analysis, which can quantify the presence of up to 30 elements up to 8 microns in size during one test. Oil analysis along with thermography and Vibration Analysis

are the “Big Three” in the condition-monitoring world. If you are beginning your journey into condition monitoring these three technologies should be your highest priority.

4. Ultrasonic testing is able to monitor noises in the frequency range above 30000Hz, which makes it useful for locating leaks in air or gas systems that cannot be heard by the human ear. A recent study on a medium size industrial site located over 200 air leaks, which was causing air shortages and a large waste of power. The cost to repair these leaks was recovered within 6 months of fixing the leaks. The other common use of ultrasonics is to monitor the addition of grease into moving bearings. Trained technicians can now grease bearings with a new level of precision using grease guns with ultrasonic sensors fitted.

5. Electrical integrity testing. Not so long ago all AC and DC motors were tested relatively effectively by using an insulation tester. Insulation testers are used to apply between 250 and 1000 volts DC volts to a motors windings and between motor windings and system ground. The application of this voltage will determine the condition of the insulation in the motor. This has been a tried and true test methodology for many years, and then along comes a new technology that promises to detect all those odd faults that were never well understood. These further tests include winding, rotor and air gap faults in AC and DC machines. These devices usually are sold with software, which allows for test results to be recorded and trended over time. It is yet another tool that can be added to the condition monitoring toolbox.

6. Crack and thickness testing are other forms of non-destructive condition monitoring. There are many different tests avaliable that include technologies such as Eddy Current testing, Electrical Resistance testing, Magnetic partial testing, and die penetrant coupled with Ultraviolet light inspections.

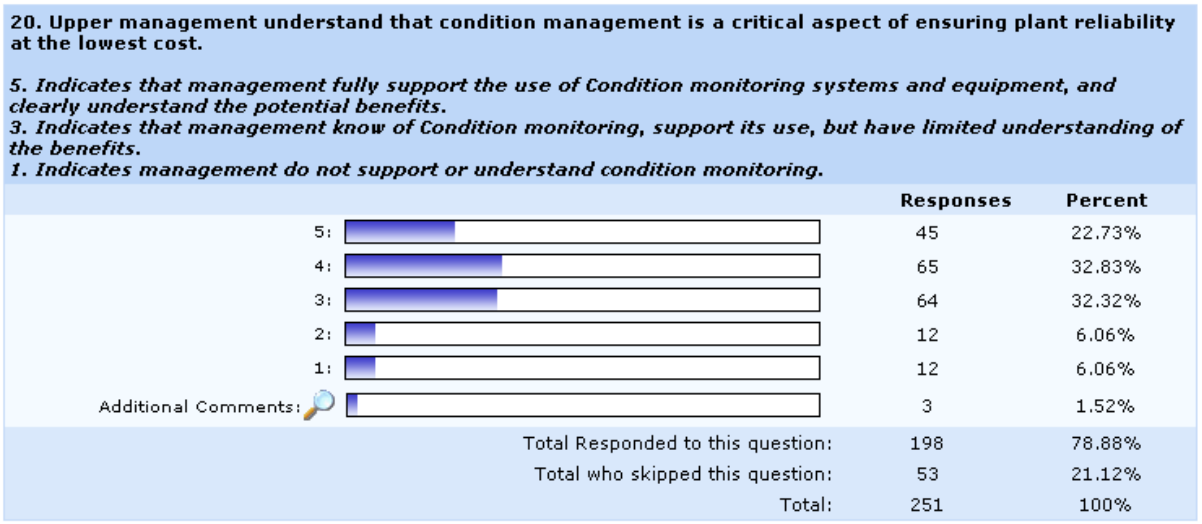
6. Physical inspections. Condition monitoring is not only about the greatest and latest technology. In some instances you cant beat the five senses for understanding condition and often the best people to apply the use of their senses are the people that operate the equipment. The odd sound, smell or change in operating characteristics will always be noticed by the plant operator first, and the key to improvement is making them aware of what to look for and giving them a method to report the issues.
The other side of physical inspections are the ones that are completed by tradesmen during the PM process. E.g. checking for blocked oil and cooling lines, measuring how much is left on a set of brake pads, measuring the length of carbon brushes in motors and reporting on

commutator condition. These are just a few examples. If you cant afford the expensive equipment then at least start at the basic but very effective level.

Assessment of condition monitoring data.

Management support of condition monitoring systems.

Question 20 asks if upper management understand that condition monitoring is a critical aspect of ensuring plant reliability at the lowest cost? As condition monitoring is not often well understood by many maintenance people, how can we expect non-technical management to understand its value? This question determines two specific answers, the first being, is condition monitoring supported by management, and the second being how well management understand the benefits applying and effective condition monitoring program.



20. Upper management understand that condition management is a critical aspect of ensuring plant reliability at the lowest cost.

5. Indicates that management fully support the use of Condition monitoring systems and equipment, and clearly understand the potential benefits.
3. Indicates that management know of Condition monitoring, support its use, but have limited understanding of the benefits.
1. Indicates management do not support or understand condition monitoring.

	Responses	Percent
5:	45	22.73%
4:	65	32.83%
3:	64	32.32%
2:	12	6.06%
1:	12	6.06%
Additional Comments:	3	1.52%
Total Responded to this question:	198	78.88%
Total who skipped this question:	53	21.12%
Total:	251	100%

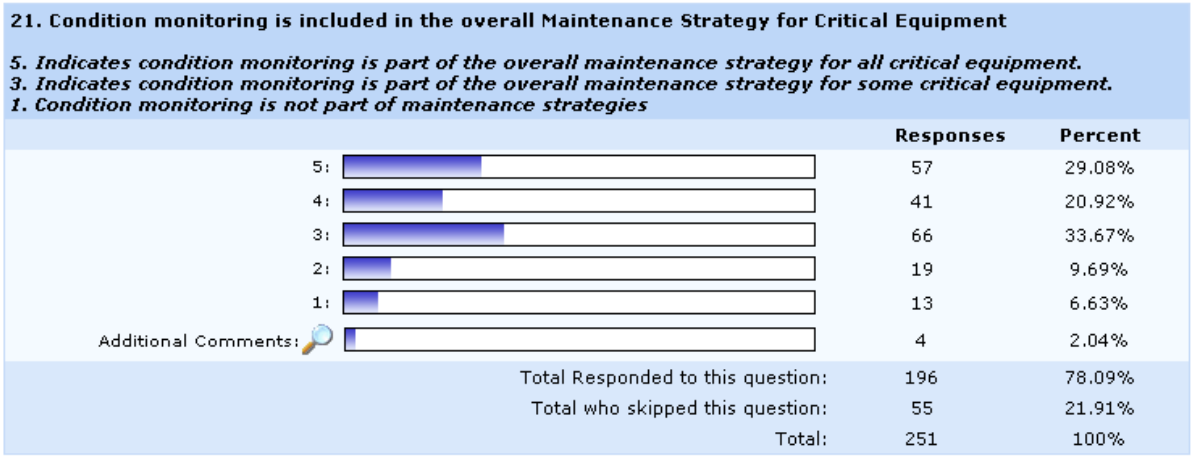
Figure 30. Question 20.

With over 55% of responses being rated as a 4 or 5 it shows that management generally have an understanding of the benefits of condition monitoring, with a further 32% being in support of its use, even if they don't totally understand the benefits. From these results there is no real excuse for the survey respondents not having an effective Condition monitoring system in place. One of the largest hurdles has already been jumped, being "Management support". This leads directly into the next question..

Condition Monitoring must be a part of the overall maintenance strategy.

Question 21 asks if Condition monitoring is included in the overall Maintenance Strategy for Critical Equipment. Ideally all maintenance tasks would based on the condition of the equipment, but often this can't occur due to equipment availability or statutory requirements.

To be an exceptional maintenance department condition based strategies must be applied where possible starting on your most critical equipment. This means don't just don't look at the machines that make the most money. You must include the effect on safety the environment as well as profit.



21. Condition monitoring is included in the overall Maintenance Strategy for Critical Equipment

5. Indicates condition monitoring is part of the overall maintenance strategy for all critical equipment.
3. Indicates condition monitoring is part of the overall maintenance strategy for some critical equipment.
1. Condition monitoring is not part of maintenance strategies

	Responses	Percent
5:	57	29.08%
4:	41	20.92%
3:	66	33.67%
2:	19	9.69%
1:	13	6.63%
Additional Comments:	4	2.04%
Total Responded to this question:	196	78.09%
Total who skipped this question:	55	21.91%
Total:	251	100%

Figure 31. Question 21.

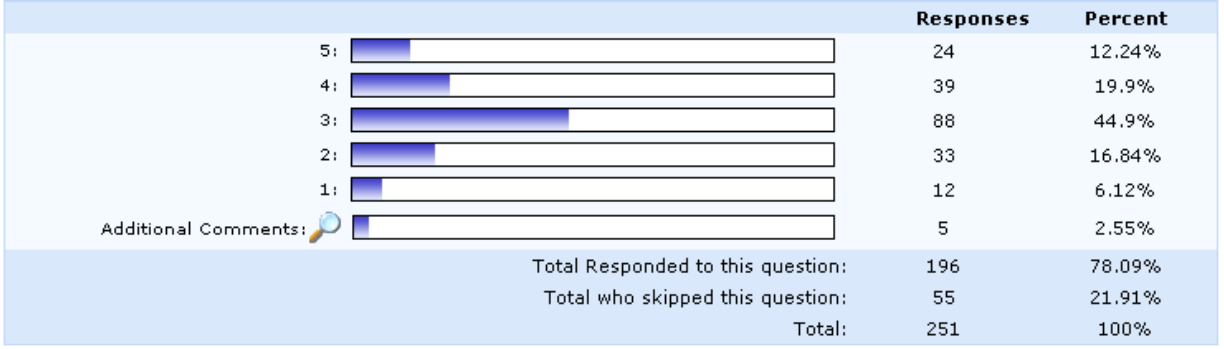
The answers in question 21 are very much in alignment with the answers in relation to question 20 on management support. This shows that implementation of CM systems has occurred when management support is in place. Ideally all businesses should strive for a score of 5 in this question. On the other side is the nearly 50% of respondents who use condition monitoring on only some or none of their critical equipment. The key to improved reliability lies in monitoring the condition of your equipment and effecting repairs in a planned and scheduled way.

Operations and Condition monitoring.

Question 22 was put in the survey to try and identify how well the operations personnel understand and hence care for their equipment. As mentioned in the opening of this chapter the operations personnel are in the best position to identify problems beginning to show in their equipment. If they are identifying, reporting and then helping to resolve functional issues, ownership will increase and output will improve.

22. Equipment operators are able to identify minor variations in the operation of their equipment.

5. Indicates any variations in plant operation will be identified by the operator in a rapid time frame.
3. Indicates any variations in plant operations may be identified by the operator in a reasonable time frame.
1. Indicates operators will continue to run a plant reguardless of condition.



	Responses	Percent
5:	24	12.24%
4:	39	19.9%
3:	88	44.9%
2:	33	16.84%
1:	12	6.12%
Additional Comments:	5	2.55%
Total Responded to this question:	196	78.09%
Total who skipped this question:	55	21.91%
Total:	251	100%

Figure 32. Question 22.

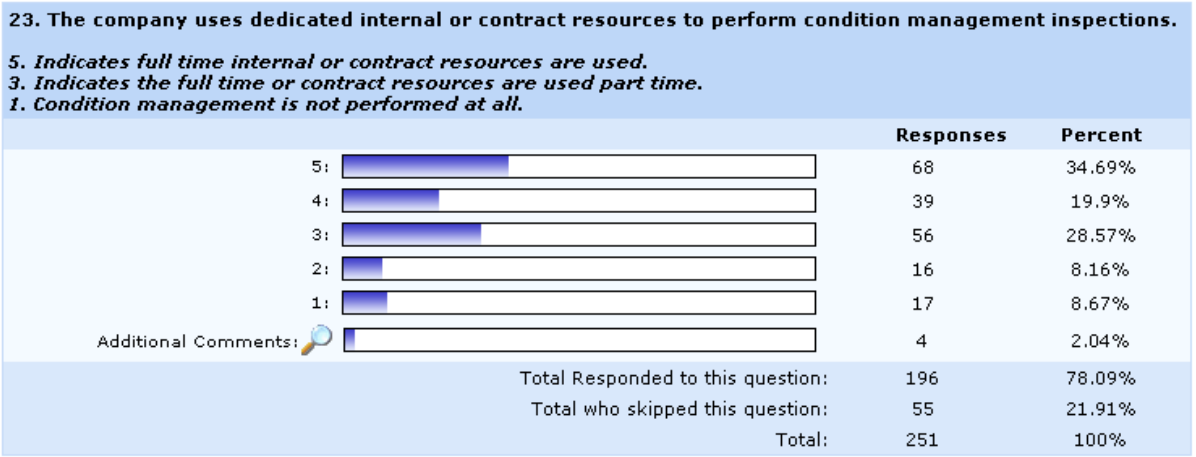
The word “may” in option 3 means that this result is not optimal. With 67% being scored as a 3 or less actions related to increasing the skills of operations personnel to identify process faults and variation will be of significant benefit to many industries. Give your operations personnel more responsibility for the basic machine care such as cleaning and lubrication as well as educating them to identify irregularities in machine operation.

Dedicated condition monitoring technicians

Question 23 is aimed at understanding the level of technical support dedicated to condition management. Having internal resources to take measurements, record and assess data is clearly the best option, as dedicated technicians develop an intimate knowledge of the plants they are working in. Realistically many companies will not have trained technicians and instrumentation required to perform this work internally, so the use of contractors is the next best option. A close relationship with condition management contractors can almost be as efficient and effective as having internal resources.

23. The company uses dedicated internal or contract resources to perform condition management inspections.

5. Indicates full time internal or contract resources are used.
3. Indicates the full time or contract resources are used part time.
1. Condition management is not performed at all.



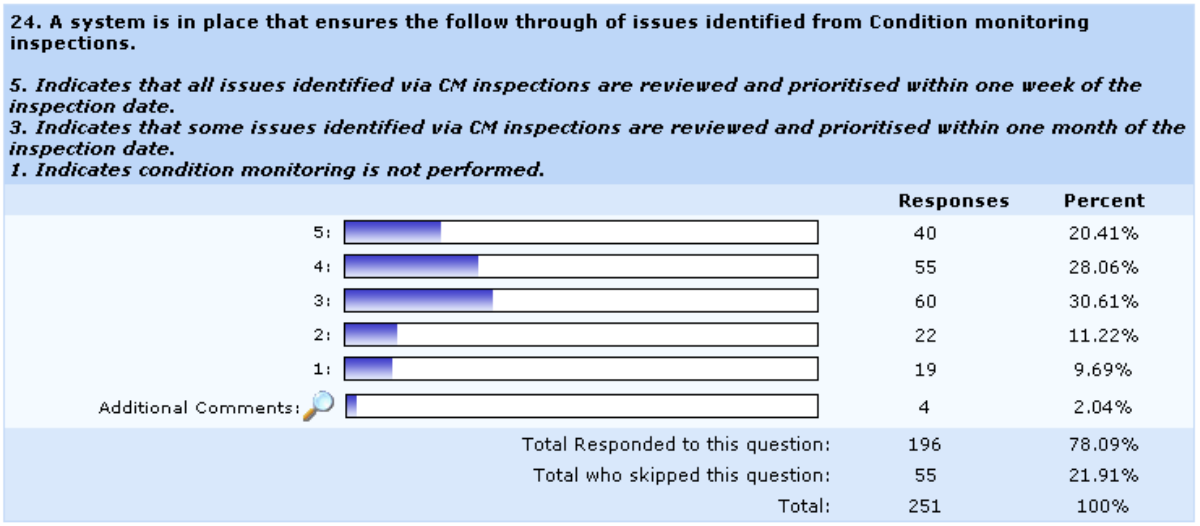
	Responses	Percent
5:	68	34.69%
4:	39	19.9%
3:	56	28.57%
2:	16	8.16%
1:	17	8.67%
Additional Comments:	4	2.04%
Total Responded to this question:	196	78.09%
Total who skipped this question:	55	21.91%
Total:	251	100%

Figure 33. Question 23.

With nearly 55% of responses to this question being either scored as a 4 or 5 there is a clear indication that most businesses understand the benefits of having an effective condition management system. The other pleasing aspect of this response is that only 17% of respondents rated themselves as having little of no condition management occurring.

Follow-up work from Condition monitoring inspections.

The aim of **question 24** is to determine how well issues identified through CM inspections are acted on. It may seem obvious, but if you are identifying issues and ignoring them or making poor decisions about rectifying the problems, you may as well stop measuring now. How often in your plant do inspections from PM's lead to further work being required? How often and how quickly is this acted on? It is common for businesses to do so much inspecting they have little time for the follow-up work. A system must be in place that ensures the follow through of issues identified from Condition monitoring inspections.



24. A system is in place that ensures the follow through of issues identified from Condition monitoring inspections.

5. Indicates that all issues identified via CM inspections are reviewed and prioritised within one week of the inspection date.
3. Indicates that some issues identified via CM inspections are reviewed and prioritised within one month of the inspection date.
1. Indicates condition monitoring is not performed.

	Responses	Percent
5:	40	20.41%
4:	55	28.06%
3:	60	30.61%
2:	22	11.22%
1:	19	9.69%
Additional Comments:	4	2.04%
Total Responded to this question:	196	78.09%
Total who skipped this question:	55	21.91%
Total:	251	100%

Figure 34. Question 24.

The results from this question are in alignment with the earlier questions with 48% scoring a 4 or 5. This is further proof of a commitment to condition monitoring systems. The 30.6% that rated a 3 is not really acceptable as it implies that not all important issues are dealt with in a timely fashion. If you are taking measurements to schedule repairs on condition, the follow up actions must occur in a timely fashion to mitigate unplanned failures.

Condition monitoring and the CMMS.

The aim of **question 25** was to determine how well a plants Condition Monitoring system is integrated into the CMMS. The CMMS is the database for all maintenance data. All condition

monitoring inspections and follow-up work must be managed through it. This allows for history collection and data assessment to help determine how well your system is working.

25. All condition monitoring scheduled work is generated from the CMMS.

5. Indicates all condition monitoring scheduled work is generated from the CMMS.
3. Indicates some condition monitoring scheduled work is generated from the CMMS.
1. No condition monitoring tasks come from the CMMS.

	Responses	Percent
5:	61	31.44%
4:	42	21.65%
3:	45	23.2%
2:	20	10.31%
1:	26	13.4%
Additional Comments:	5	2.58%
Total Responded to this question:	194	77.29%
Total who skipped this question:	57	22.71%
Total:	251	100%

Figure 35. Question 25.

Again the results from this question are positive with 53% of responses being either a 4 or 5. However, the only acceptable option to the question is a 5 so there is still plenty of room for improvement for many respondents. If you do not have all CM inspections coming from your CMMS you are not utilising it effectively.

Segmentation Analysis of Condition Monitoring Data.

The results of the six condition monitoring 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.

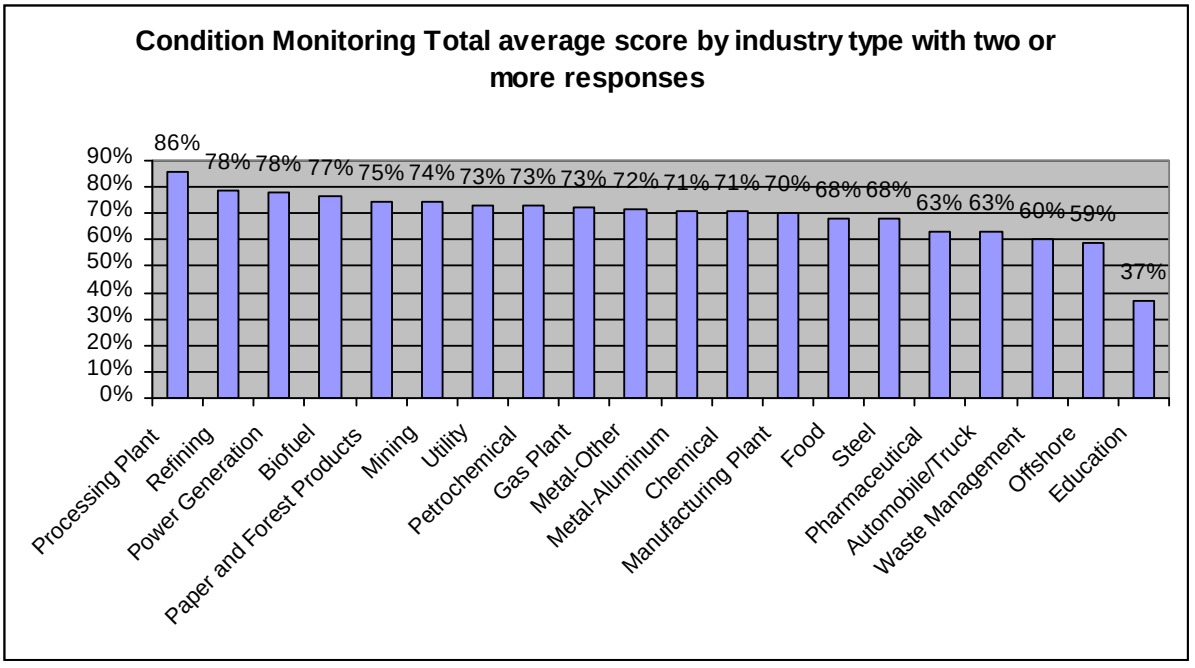


Figure 36. Condition-monitoring total average score by industry type.

As was the case with the Lubrication Element, Processing plants came out on top in the Condition Monitoring Element again with a total average score of 86%. There is a significant gap of 8% to the next industry sectors being Refining and Power generation. In line with the survey percentages above, the industry segment scores indicate significant support and application of condition Monitoring practices in most industry segments.

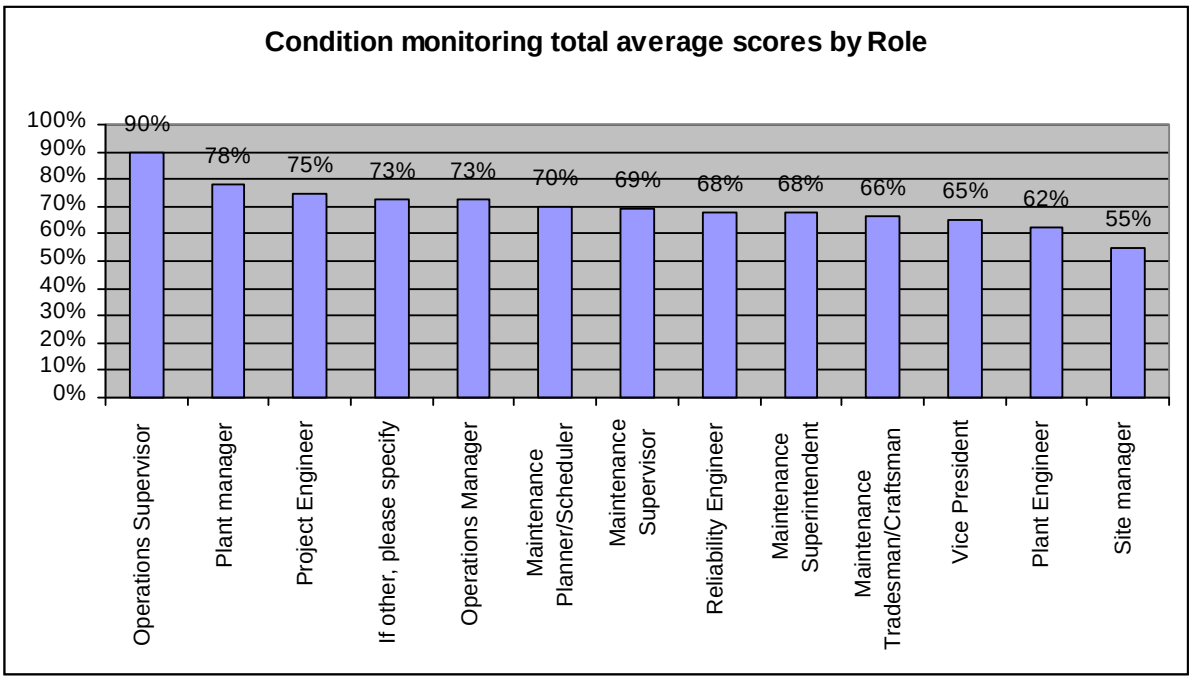


Figure 37. Condition Monitoring total average scores by role.

Of significant interest here is that operations personnel rated their condition monitoring systems higher than their maintenance counterparts. It could be deduced from this that the Management have a misconception of how effective their condition monitoring processes are.

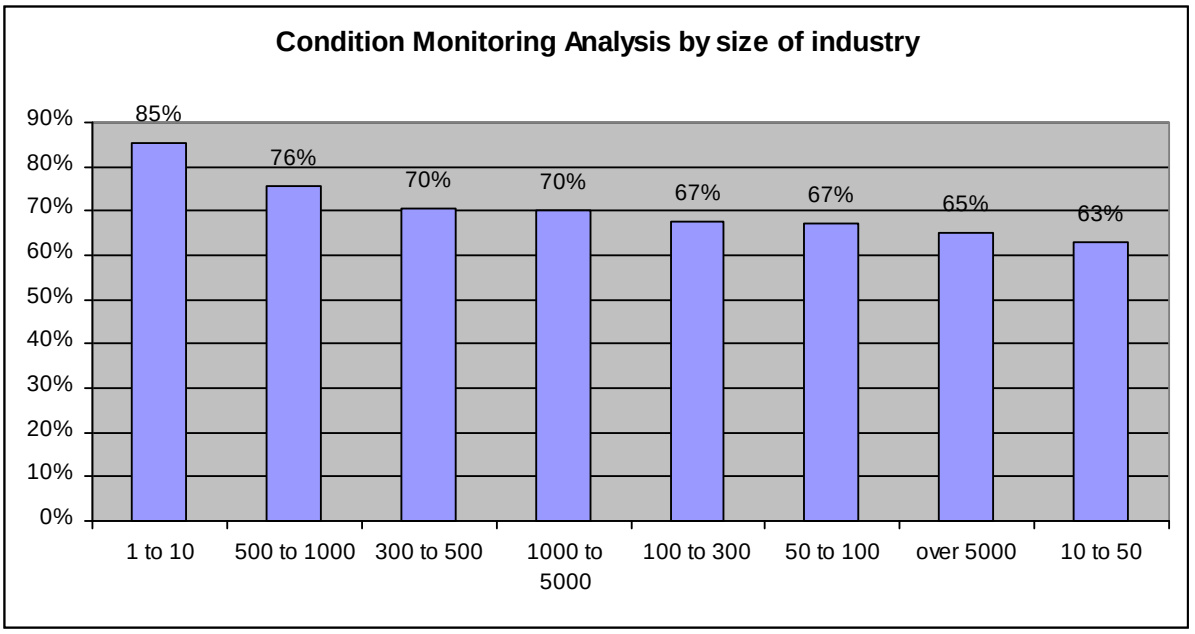


Figure 38. Condition monitoring analysis by size of industry.

As was the case with the Lubrication results, the smallest businesses rate themselves the highest with a total average score of 85%. The largest size respondents again rated themselves at the lower end of the scale. These results provide further evidence that small businesses know their equipment better and have a greater sense of ownership.

Condition monitoring Conclusion.

The overall results from the Condition Monitoring section of the survey were very encouraging with high levels of management support, and most respondents included CM in their overall asset management strategies. Many respondents were well resourced for condition monitoring and also used their CMMS to manage CM work.

Areas for improvement that can be derived from these results are:

1. The training of operators in condition monitoring techniques and general machine equipment care.

2. Improvement in systems related to follow up work from condition monitoring inspections. If you have a condition monitoring system in place, how well is the follow-up work performed? Measuring is of no consequence if actions are not put in place from inspections. Only 19% of survey respondents reported that issues identified via CM inspections were reviewed and prioritised within a week of the inspection.

3. Although many included CM in their strategies, there was still 50% that used CM on some or none of their critical equipment. Identify what equipment breaks down the most and costs the most to the company when it is down. Set up a condition-monitoring schedule for these plants. This does not just include the more costly technical aspects such as VA and

thermography. Start with the basics such as visual inspections as well as looking, listening and feeling while the machine is running. This only costs time and is relatively easy to implement.

Critical Element 3.

Maintenance Standards and Practices.

Maintenance tasks must be completed to a standard to ensure the long-term reliability of the equipment. An example of standards in this instance would be the application of the correct grease to a bearing or the calibration of a pressure switch to pre-defined requirement, whereas practices include things such using a torque wrench to tighten bolts to a standard and the use of specific PPE to ensure a task can be done safely. To maintain standards and practices effectively you need to have well written procedures in place that specify the following:

1. The scope of the task, which should set the boundaries of what is to be done. E.g. Remove Sheave Bank XYZ from Plant ABC and replace with spare bank.
2. References to any relevant documentation related to or required for the task. E.g. Refer to Drawing no. 2345.
3. A list or reference to the special tools and equipment required to a complete the task. An example of tools could be a bearing heater, torque wrench, whereas equipment may be and EWP or Crane.
4. A list of parts required to complete the task. It would be expected that the parts for this repair would be in the BOM that is logged against the functional location structure in the CMMS, but often only some of these parts are required to effect a repair, so here is the chance to list the required parts for the task.
5. Instructions related to how equipment should be set-up before the task begins. E.g., All produce removed from the machine, or guards left in the up position.
6. Hazards that will be encountered and safety instructions required to mitigate these hazards. What hazards have to be managed to complete the task? Is there lots of mobile equipment working in the area, is the atmosphere safe is the floor slippery?
7. A detailed isolation plan. Isolation plans need to be in place for all work regardless of the size of the task. The plan can either be a Standard Operating Procedure or a manually drafted

isolation. The plan should detail the name of the isolation point, the safe position of the isolator and how to lock it.

8. Permits and Clearances required to complete the task. Are you working at heights, working in a confined space, puncturing a surface, doing hot work? There are often statutory reasons for completing permits, as well as company policies.

9. Detailed steps on how to complete the task. The steps up to point nine are fundamentally planning actions. The detail in this point is the doing of the actual task. E.g.

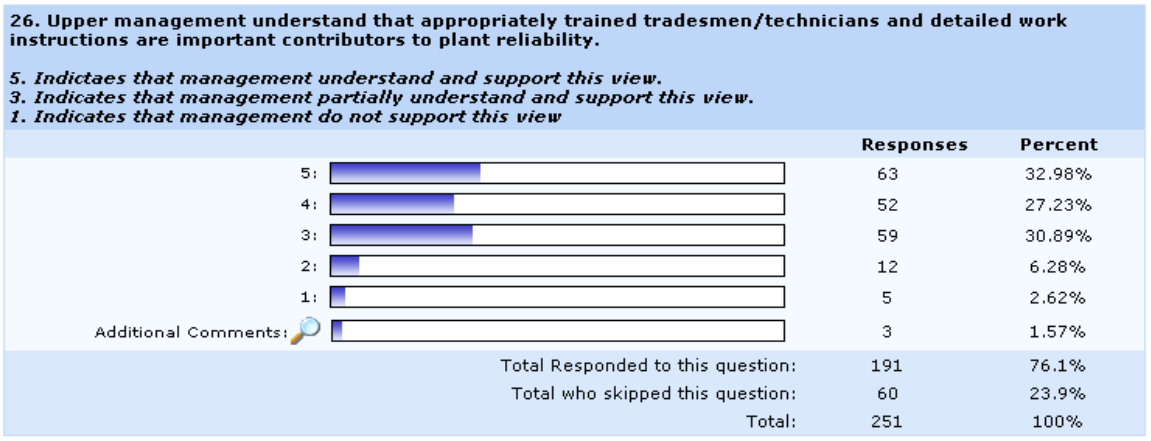
- Lockout Main Electrical and water isolators as per isolation plan ABC.
- Break Pump coupling and remove flange bolts.
- Unbolt pump base bolts using xx size spanner.
- Sling pump ready for lifting. (Note the pump weights 500kg. The pump must be slung by a qualified rigger)
- Lift pump using 2000kg over head crane and palletise ready for transport to the workshop.
- Etc……

10. Instructions for recommissioning. Is there a special way that the pump needs to be put back together? When back in place is there a test procedure? There should always be a recommissioning procedure in place and the machine should always be thoroughly tested before handing it back to Operations, as it is commonplace to find equipment not operating to specification after major maintenance work.

Complying to excellent work standards and practices ensures the right tools are used for the task, and the task is always completed the right way every time. The ultimate aim being to reduce the level of re-work. - Do it once, do it right.

Management understanding of trade competencies and the benefit of detailed work instructions.

Question 26 is aimed at understanding whether management understand that appropriately trained tradesmen/technicians and detailed work instructions are important contributors to plant reliability.



26. Upper management understand that appropriately trained tradesmen/technicians and detailed work instructions are important contributors to plant reliability.

5. Indictaes that management understand and support this view.
3. Indicates that management partially understand and support this view.
1. Indicates that management do not support this view

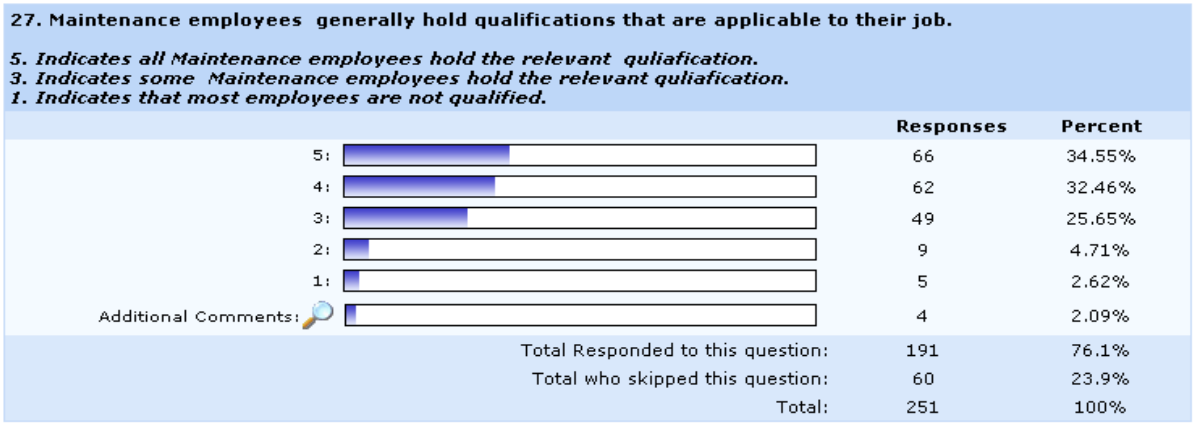
	Responses	Percent
5:	63	32.98%
4:	52	27.23%
3:	59	30.89%
2:	12	6.28%
1:	5	2.62%
Additional Comments:	3	1.57%
Total Responded to this question:	191	76.1%
Total who skipped this question:	60	23.9%
Total:	251	100%

Figure 39. Question 26.

The overall response to question was excellent with 60% of responses rated as a 4 or 5, with a further 30% rated a 3. With this level of management support, appropriate training for tradesman/ craftsmen should be relatively easy to justify.

Qualifications of Maintenance Employees.

Question 27 is aimed at determining if industries have maintenance employees that have the appropriate skills to maintain and improve asset reliability. In most cases tradesmen are only hired if they have the appropriate trade qualification, but do they have other specialised skills as well. Example of these could be Forklift driver's ticket, Pneumatic and Hydraulic system skills, PLC and drive setup, maintenance and modification skills.



27. Maintenance employees generally hold qualifications that are applicable to their job.

5. Indicates all Maintenance employees hold the relevant quliafication.
3. Indicates some Maintenance employees hold the relevant quliafication.
1. Indicates that most employees are not qualified.

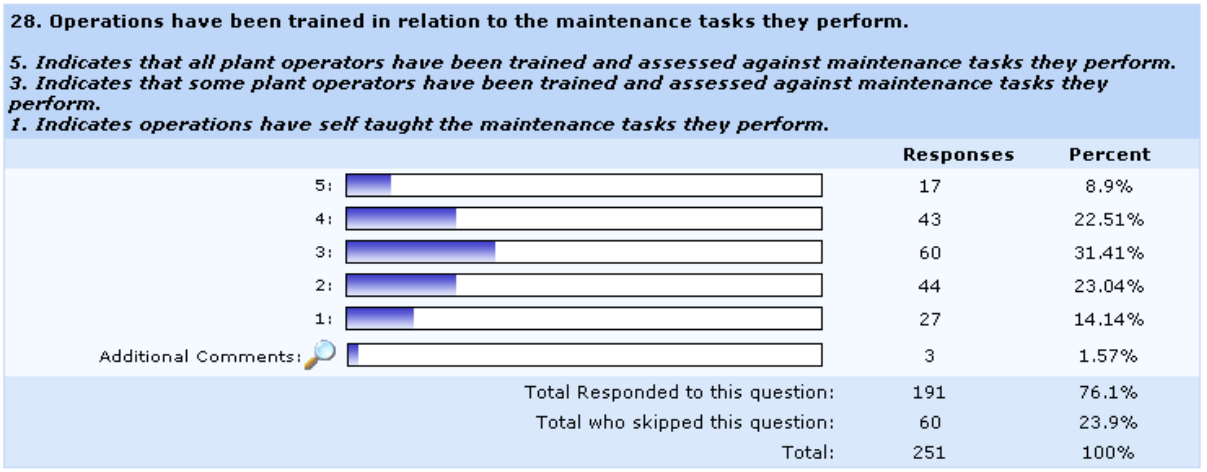
	Responses	Percent
5:	66	34.55%
4:	62	32.46%
3:	49	25.65%
2:	9	4.71%
1:	5	2.62%
Additional Comments:	4	2.09%
Total Responded to this question:	191	76.1%
Total who skipped this question:	60	23.9%
Total:	251	100%

Figure 40. Question 26.

With 66% of respondent scoring a 4 or 5 the results for this question were excellent however not surprising due to the reasons as mentioned above. Of concern is the 33% who rated 3 or lower. Are there unskilled workers working as Electricians? This would clearly not be acceptable due to the safety risk. Are unskilled workers completing fitting and machining tasks? If so how well is equipment being put back together? The infant mortality rate would have to increase. Another possibility is that the existing workforce has been around a while and has not kept up with technological advances. All industries need to be aiming for a score of 4 or 5 in this area.

Training of Operations Personnel.

Question 28 is aimed at understanding how well Operations have been trained in relation to the maintenance tasks they perform. This is assuming that operations perform maintenance tasks at all. Starting with the basics, do your operations personnel keep their work area clean? Do they check that the safety systems are operational on their equipment before they use it? These are basic items that operations employees should be responsible for. To go a step further do the operations personnel lubricate the parts of the equipment that they interact directly with? Are they able to identify when things are not quite right? Unfortunately there is a clear trend emerging throughout this survey that reflects a lack of operator care.



28. Operations have been trained in relation to the maintenance tasks they perform.

5. Indicates that all plant operators have been trained and assessed against maintenance tasks they perform.
3. Indicates that some plant operators have been trained and assessed against maintenance tasks they perform.
1. Indicates operations have self taught the maintenance tasks they perform.

	Responses	Percent
5:	17	8.9%
4:	43	22.51%
3:	60	31.41%
2:	44	23.04%
1:	27	14.14%
Additional Comments:	3	1.57%
Total Responded to this question:	191	76.1%
Total who skipped this question:	60	23.9%
Total:	251	100%

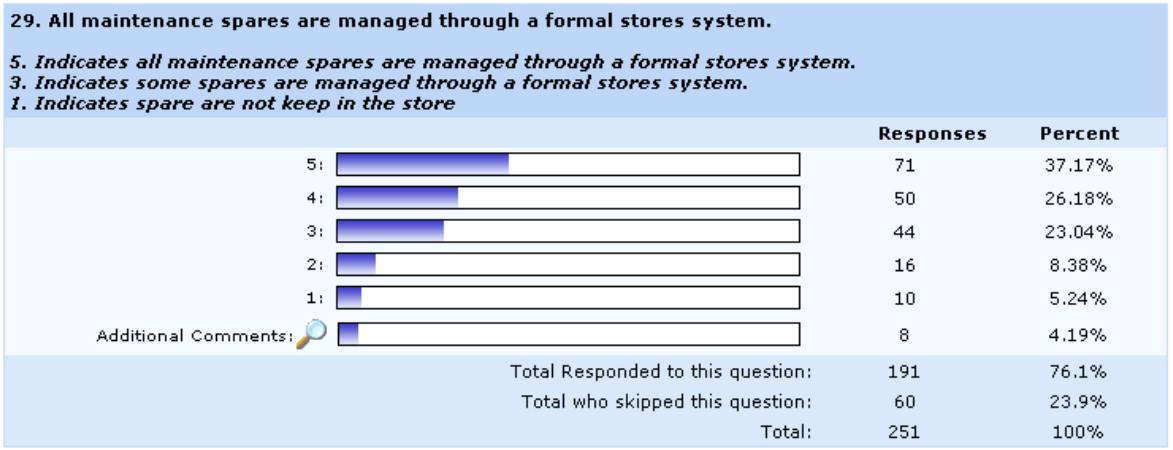
Figure 41. Question 28.

Only 32% of respondents rated a 4 or 5 in the survey. This is a good indication of the lack of value placed on operator care. Of the remaining 68% of respondents you would have to question if the programs they have in place are effective. For operator care to be of benefit to the bottom line they must understand the reasons as to why the tasks are required and they need to have standard work procedures to follow.

Maintenance Spares.

Picture this. Its 2am and your most critical machine has broken down. You are losing thousands of dollars an hour of saleable product. Your electrician has spent hours diagnosing an automation fault and finds that a critical PLC component has failed. You look in the stores system but find its not there. You then ring the local area expert who thinks there may be one on the self down in the workshop. Of course its not there. At 8am the next morning you finally reach the equipment supplier who tells you that the spare is not normally kept in the country and it will take 5 days to get one. Finally you chase up others within your own company, and find they have a spare component but you will have to wait for overnight delivery. Total lost production 36hours. This is a real situation. How often has it happened to you?

Question 29. is aimed at determining whether spares are managed through a formal stores system.



29. All maintenance spares are managed through a formal stores system.

5. Indicates all maintenance spares are managed through a formal stores system.
3. Indicates some spares are managed through a formal stores system.
1. Indicates spare are not keep in the store

	Responses	Percent
5:	71	37.17%
4:	50	26.18%
3:	44	23.04%
2:	16	8.38%
1:	10	5.24%
Additional Comments:	8	4.19%
Total Responded to this question:	191	76.1%
Total who skipped this question:	60	23.9%
Total:	251	100%

Figure 42. Question 29.

With 63% of responses at level 4 and 5 there is a clear indication that management of maintenance spares through a formal stores system is considered important. The example above highlights one reason as to why it is a good idea, however there are others such as timesaving related to automated stock replenishment, improvements in work planning with stock being visible and the optimisation of stock levels.

Maintenance Spares Storage Practices.

Question 30 is aimed at determining whether spares are stored in a way that ensues they are fit for purpose. All maintenance spares are to be kept in a clean environment and are fit for purpose. Have you taken an insurance spare out of your store and found it to be covered in

dust or heavily corroded? Was it not usable because of the condition? Do some items need to be stored in a controlled environment? E.g. temperature and humidity.

30. All maintenance spares are kept in a clean environment and are fit for purpose.

5. Indicates all maintenance spares are kept in a clean environment and are fit for purpose.
3. Indicates some maintenance spares are kept in a clean environment and are fit for purpose.
1. Indicates spares are no held in spares.

	Responses	Percent
5:	35	18.52%
4:	70	37.04%
3:	61	32.28%
2:	18	9.52%
1:	5	2.65%
Additional Comments:	2	1.06%
Total Responded to this question:	189	75.3%
Total who skipped this question:	62	24.7%
Total:	251	100%

Figure 43. Question 30.

With 56% scoring a 4 or 5 it can be assumed that in the majority of cases, spares will be fit for purpose when they are issued from the store. This is quite good, however with 44% being rated 3 or less it shows that although people believe spares should be kept in the store, many don't value keeping stores stock in usable condition. It may not be often that this leads to an extended delay, but it may, and it certainly is an undesirable cost if the item has to be scrapped or repaired to make it usable again.

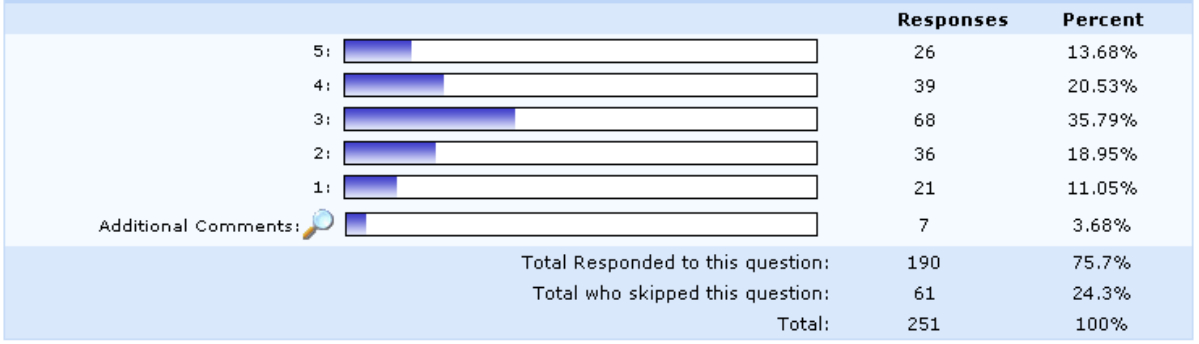
The Importance of Machine Cleanliness.

Question 31 is aimed at understanding whether equipment cleanliness standards are in place, whether the value of the standards is understood and whether they are adhered to. If maintenance and operations employees accept that equipment covered in oil, grease, dirt and process wastes is normal then they are not likely to treat the equipment with ownership and care. Cleanliness is the first step towards improved reliability. For example:
If a group of hydraulic valves is covered in oil and dirt, how can you find a leak? Consequently leaking valves don't get fixed and some dry-sorb gets put on the ground to capture the leaked oil. If there are no inspections of oil levels the hydraulic system runs dry and fails totally. If the same group of valves is kept to a cleanliness standard, the source of leaks can be identified easily. Because the plant staff are used to a high standard they will not accept a leaky valve as being acceptable, and repairs will occur in a suitable time frame,

effectively preventing a secondary failure.

31. Cleaning of equipment and work areas is part of the overall asset management strategy.

5. Indicates there is a standard in place related to the cleanliness of all equipment and workplaces. These standards are always maintained. Cleaning of equipment and work areas is part of the overall asset management strategy.
3. Indicates there is a standard in place related to the cleanliness of some equipment and workplaces. These standards are often maintained. Cleaning of equipment and work areas is part of the overall asset management strategy.
1. Indicates that there are no standards for cleanliness.



	Responses	Percent
5:	26	13.68%
4:	39	20.53%
3:	68	35.79%
2:	36	18.95%
1:	21	11.05%
Additional Comments:	7	3.68%
Total Responded to this question:	190	75.7%
Total who skipped this question:	61	24.3%
Total:	251	100%

Figure 44. Question 31.

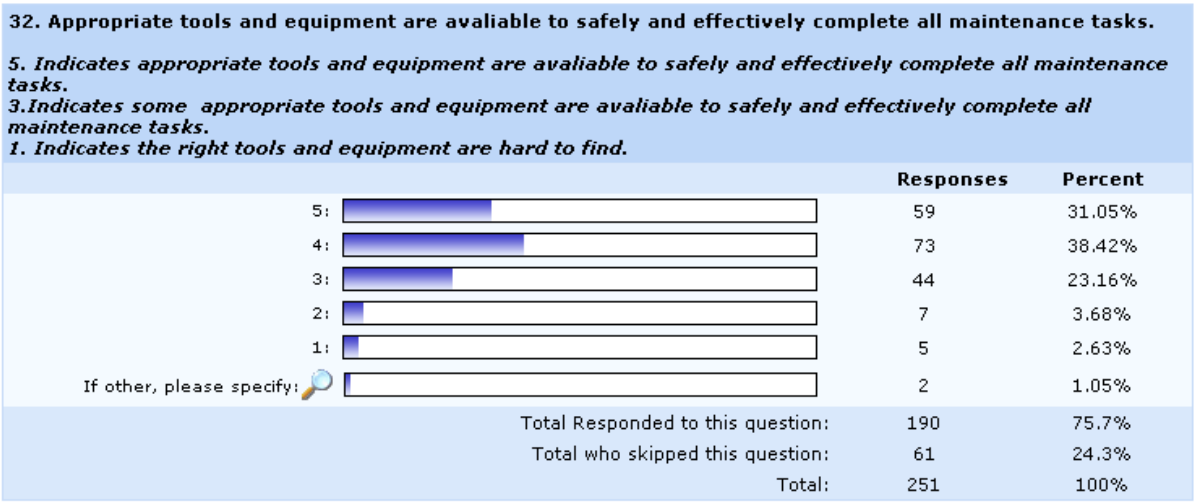
The results to the question were disappointing although not surprising. With only 34% of respondents rating themselves a 4 or 5. There is a clear need for improvement in building strategies based on machine cleanliness and basic operator care.

The right tools for the task.

Does your workplace have all the appropriate tools to complete tasks efficiently and safely? If you don't have the equipment can you gain access to it in a timely fashion? **Question 32** is aimed at understanding whether the business is geared up effectively. An enormous amount of time and money can be wasted if the right tools are not avaliable. A good maintenance planner will always ensure the right tools and equipment are avaliable before any tasks begin.

32. Appropriate tools and equipment are avaliable to safely and effectively complete all maintenance tasks.

5. Indicates appropriate tools and equipment are avaliable to safely and effectively complete all maintenance tasks.
3.Indicates some appropriate tools and equipment are avaliable to safely and effectively complete all maintenance tasks.
1. Indicates the right tools and equipment are hard to find.



	Responses	Percent
5:	59	31.05%
4:	73	38.42%
3:	44	23.16%
2:	7	3.68%
1:	5	2.63%
If other, please specify:	2	1.05%
Total Responded to this question:	190	75.7%
Total who skipped this question:	61	24.3%
Total:	251	100%

Figure 45. Question 32.

There were excellent results for this question with nearly 70% rated as a 4 and 5. Is a drive for reliability and safety improvements behind the great results here, or is the provision of tools and equipment just easier to manage than gaining efficiency in human output? After all the equipment can't argue with you and will only make an employee's job easier. I would hope the former but expect the later. Ultimately the driver behind why all the right tools are avaliable is not all that important. What is more important is that they are used the right way and make the maintenance processes more efficient.

Segmentation Analysis of Maintenance Standards and Practices data.

The results of the seven maintenance standards and practices 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.

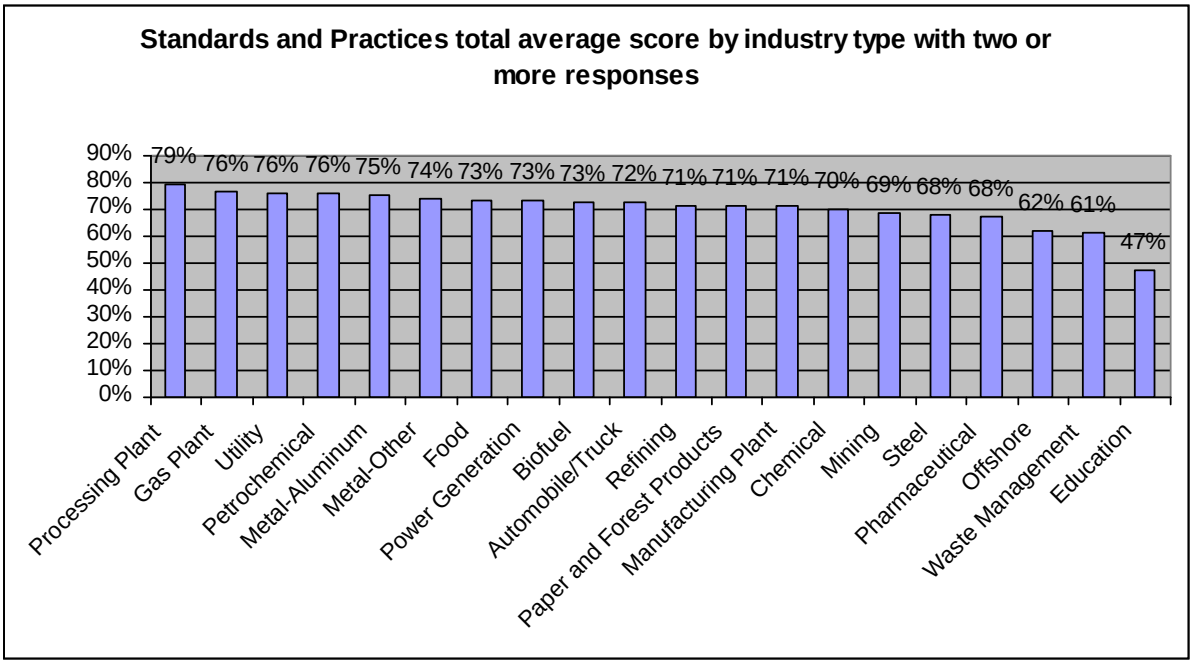


Figure 46. Standards and practices total average scores.

Of the eight elements this scored the highest overall average score of 70%. Processing plants scored the highest in the standards and practices element with a total average score of 79%. A number of other industries scored between 70 and 80% with only 3 industry types scoring less than 65%.

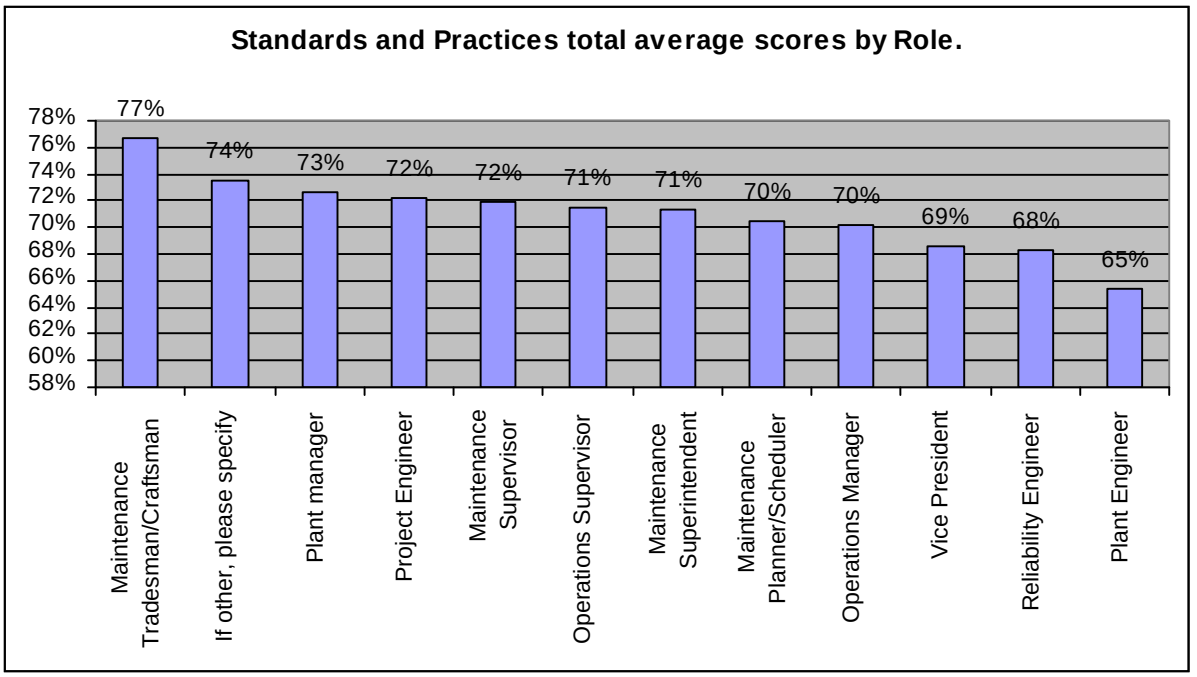


Figure 47. Standards and practices scores by role.

As the tradesmen/craftsmen are responsible for standards and practices on the equipment they maintain, it is not surprising that they rated themselves the highest in this element with a score of 77%. The overall results for this element are high and encouraging.

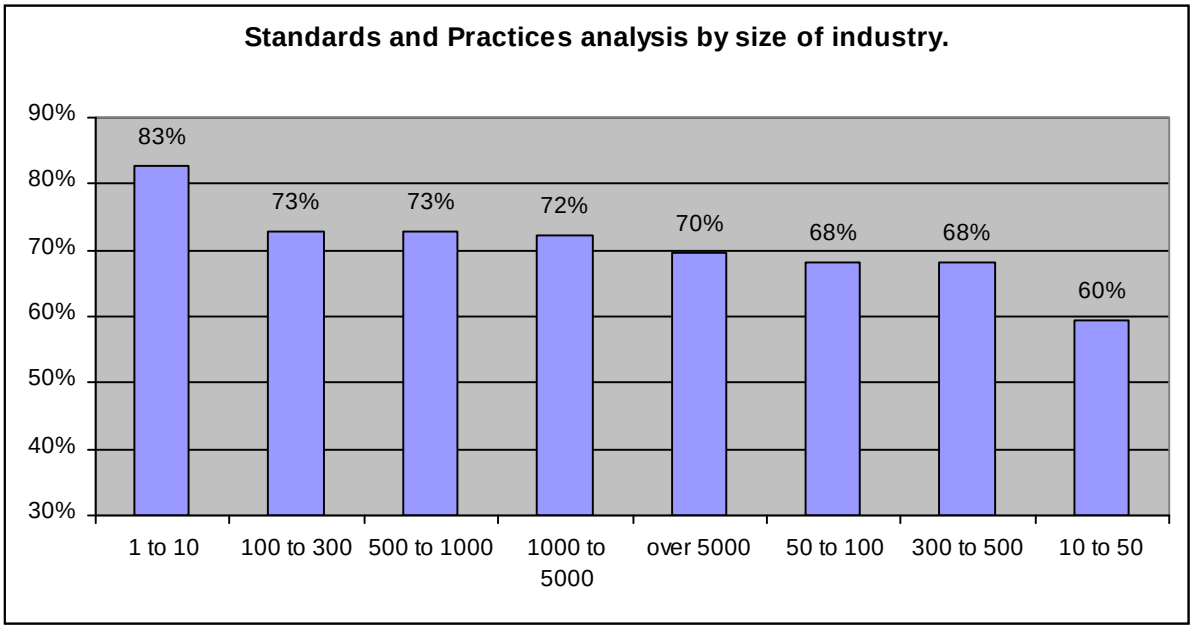


Figure 48. Standards and practices scores by industry size.

The smallest size business again have rated themselves the highest at 83%, and business with 10 to 50 employees the lowest with 60%.

Conclusions on Maintenance standards and practices.

The overall results of this section were on average the highest of the eight critical elements with a total average score of 70% for all respondents. Clear areas of strength in the element were the high level of management support, spares management and the use of correct tools for the task. Where there is some clear need for improvement is in the practices related to spares storage, training requirements for operators and tradesmen, with the clear stand-out being the absence of focus on machine cleanliness. With significant levels of management support for standards and practices you would expect that driving machine cleanliness should be relatively easy. While ever we do not hold people accountable for the cleanliness of their own work area, we will continue to operate in a less than optimum environment.

Critical Element 4.

The Work Management Process and Maintenance KPI's.

Work Management is defined at Onesteel as "a system that enables the delivery of effective and efficient maintenance by controlling and prioritising the maintenance workload." To break this definition down, effective means that the work completed meets a defined outcome. Efficient means that the tasks are completed safely in the most timely fashion for the least cost. Controlling refers to managing the work in a way where all aspects are understood over the life of the task. Prioritising is about doing the most important things first, and can be based on:

- Availability of the equipment.
- The value of a specific product either by profit margin or strategic importance.
- The effect on safety on employees or customers.
- The effect on the environment.
- The need to meet statutory requirements

From a practical perspective work management requires a process. A process could be, "When machine x breaks I will ring the plant maintenance supervisor". This process may be adequate for repairs in an office environment, but rarely would this be an adequate for an industrial environment. Effective management of work requires a documented process with defined roles and responsibilities. The process when put in place must be understood and

owned by all stakeholders as this will promote compliance, and allow fro improved planning and scheduling. The best organisations spend 80% of their time on planned and scheduled work, and planning and scheduling can only be improved if a well-defined work management process with measurable KPI's has been developed and is followed.

Key Performance Indicators are the measures that we use to determine how well we a tracking towards our goals. Common KPI's in maintenance management are:

- Planned maintenance compliance
- Planning Backlog
- Scheduling backlog
- Reactive vs Proactive work.
- Mean Time between failures
- Mean Time to repair.
- Labor utilisation.
- Planning accuracy
- Cycle time of work order completion.
- Maintenance costs

There are literally dozens of different metrics and only some may be relevant to your industry. An action from this is to determine what Asset management KPI's are relevant to your business.

The Work Management Process.

The Aim of **Question 33** is to identify what how many businesses have a prioritisation process for there maintenance work, and how many businesses follow the process.

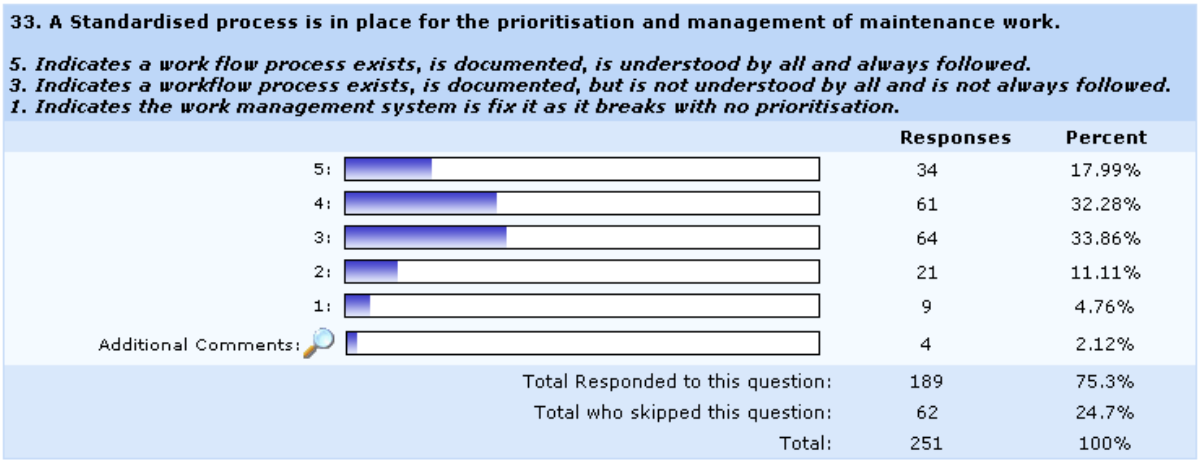


Figure 49. Question 33.

Results to the question were very promising with over 50% scoring themselves as a level 4 or 5, with a further 34% scoring a 3. This highlights a clear understanding of the importance of having a process with some improvement being required in the understanding of the process. To improve the Work Management process the maintenance and reliability groups need to actively involve operations and tradesmen in "work prioritisation". Explain the difference between a job that can be done now, and one that can be deferred with little or no negative effect. The maintenance people responsible for prioritising the work need to ensure that they discuss changes of priority with their customers. When all understand the process, everything will run far more smoothly.

Roles and responsibilities.

Question 34 is aimed at gauging how clearly Roles and responsibilities are defined. To have an effective work management process all involved have to understand what their role is. Examples could be:

- Who raises requests for work?
- Who is responsible for reviewing work requests, and who approves them?
- Who defines the scope of the task?
- Who is responsible for planning the work?
- Who is responsible for scheduling the work?
- Who is responsible for managing work execution?
- Who is responsible for recording follow up work from repairs or inspections?
- Who is responsible for closing off work orders?
- Who is responsible for breakdowns and how are they managed differently.

34. Roles and responsibilities are clearly defined and understood by all maintenance employees.

5. Indicates Job descriptions exist for all roles and they are understood by all.
3.Indicates the job descriptions exist for some roles and generally they are understood.
1. Indicates job descriptions do not exixst

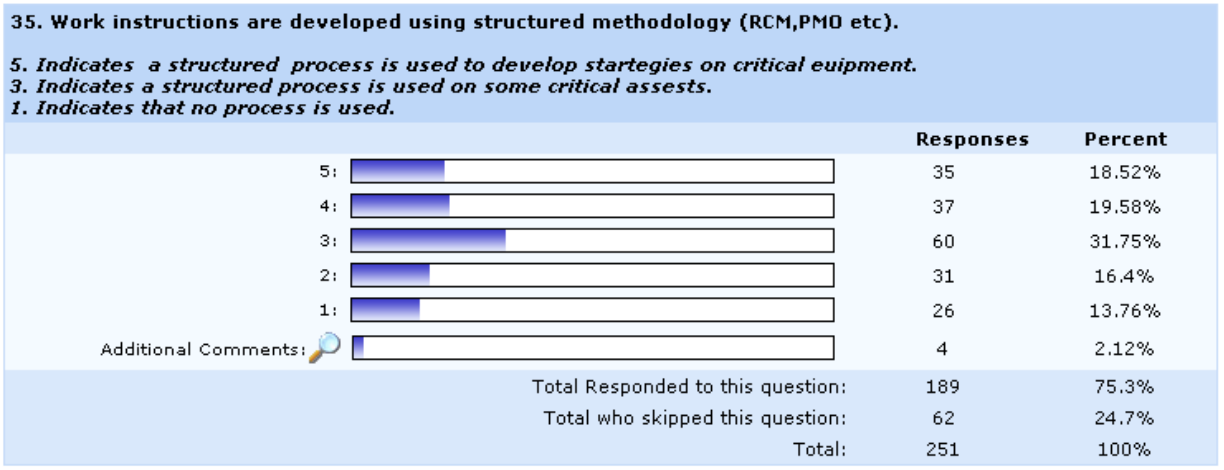
	Responses	Percent
5:	48	25.4%
4:	65	34.39%
3:	53	28.04%
2:	19	10.05%
1:	4	2.12%
Additional Comments:	3	1.59%
Total Responded to this question:	189	75.3%
Total who skipped this question:	62	24.7%
Total:	251	100%

Figure 50. Question 34.

The results from this question were very encouraging with 60% rated a 4 or a 5 and a further 28% rated as a 3, which is still a reasonable result. With roles and responsibilities defined in most cases actions could be based around ensuring that the roles fit effectively into the current systems in place.

The Development of Work instructions.

Have your work instructions been reviewed in the last few years? If so what method was used to review them? In years gone by most PM systems were developed by documenting what people thought was the right thing. Experience shows that this often leads to over servicing or the development of ineffective inspections that are often a knee-jerk reactions to a one-off events. Many maintenance professionals know of RCM and have heard horror stories of a time and resource hungry process, but the reality is that if you want to have an effective and efficient PM system and great work instructions, you must use a process based on addressing the failure modes of equipment. The level you apply this process should be dependant on the importance of the equipment, based on the impact on safety, the environment and output. It is not a prerequisite to apply RCM to all processes as there are many simplified variations of this process that are often more suitable. **Question 35** is aimed at determining what level these methodologies are used to develop planned maintenance schedules and work instructions.



35. Work instructions are developed using structured methodology (RCM,PMO etc).

5. Indicates a structured process is used to develop startegies on critical euipment.
3. Indicates a structured process is used on some critical assests.
1. Indicates that no process is used.

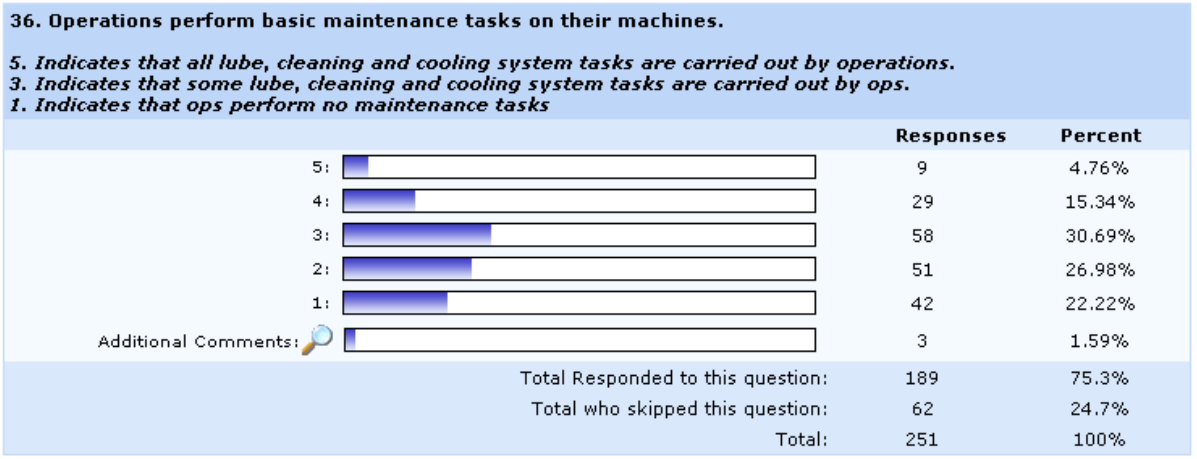
	Responses	Percent
5:	35	18.52%
4:	37	19.58%
3:	60	31.75%
2:	31	16.4%
1:	26	13.76%
Additional Comments:	4	2.12%
Total Responded to this question:	189	75.3%
Total who skipped this question:	62	24.7%
Total:	251	100%

Figure 51. Question 35.

The results for this question show a strong use of structure methodologies to develop strategies on critical equipment with 38% scoring a 4 or 5 and a further 32% with a partially acceptable score of 3. Best practice would be where all critical equipment strategies are reviewed as they are being applied with a formal review being completed every 2 to 3 years.

Basic Maintenance tasks performed by Operations.

The value of having operations employees made responsible for the basic care of their own equipment should not be underestimated. Responsibility breeds ownership and this will lead to improved reliability. When the machine basic care is the task of others the care factor reduces, after all, “someone else comes along and continues to put oil in the leaking hydraulic system and I don’t have to clean it because contactors do that. Also, the boss walks past the equipment everyday and he doesn’t care about it so it must be OK.” **Question 36** is aimed at determining what level of basic care the operations groups are responsible for.



36. Operations perform basic maintenance tasks on their machines.

5. Indicates that all lube, cleaning and cooling system tasks are carried out by operations.
3. Indicates that some lube, cleaning and cooling system tasks are carried out by ops.
1. Indicates that ops perform no maintenance tasks

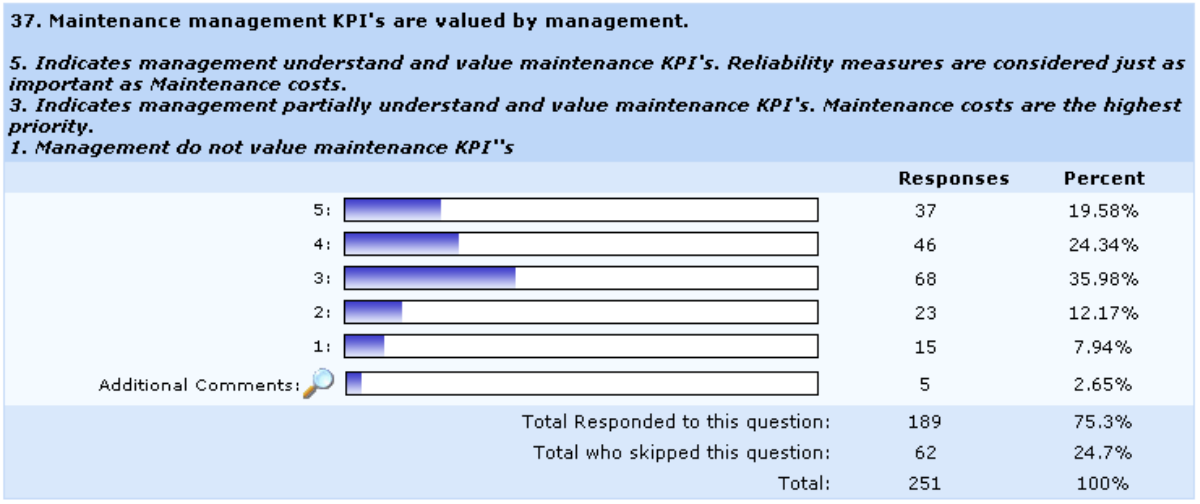
	Responses	Percent
5:	9	4.76%
4:	29	15.34%
3:	58	30.69%
2:	51	26.98%
1:	42	22.22%
Additional Comments:	3	1.59%
Total Responded to this question:	189	75.3%
Total who skipped this question:	62	24.7%
Total:	251	100%

Figure 52. Question 36.

The results of question 36 show a very clear trend against the concept of operator care. It would be fair to say that in some industries basic operator care is not practical but this does not account for 80% of responses recording a 3 or less. Often you here that these practices are not part the operator’s job, so if this is the case who is responsible for cleaning around the machine, checking safety systems and performing basic lube tasks where the products directly interact with the machine? The outcome is often no ownership and equipment being operated in poor condition.

The value of Maintenance KPI's

Question 37 is aimed at understanding the value that Upper level management place on Maintenance KPI's. Are your Maintenance KPI's driven from management and aligned with the business unit measures. For example Mean Time Between Failures and percent-unplanned downtime are directly linked to machine output. Does your management value these performance KPI's as much as maintenance costs or production based KPI's.



37. Maintenance management KPI's are valued by management.

5. Indicates management understand and value maintenance KPI's. Reliability measures are considered just as important as Maintenance costs.
3. Indicates management partially understand and value maintenance KPI's. Maintenance costs are the highest priority.
1. Management do not value maintenance KPI''s

	Responses	Percent
5:	37	19.58%
4:	46	24.34%
3:	68	35.98%
2:	23	12.17%
1:	15	7.94%
Additional Comments:	5	2.65%
Total Responded to this question:	189	75.3%
Total who skipped this question:	62	24.7%
Total:	251	100%

Figure 53. Question 37.

The results of this question clearly show that management still consider costs as the most important maintenance KPI, with 56% scoring 3 or less. When cost is the most significant KPI there will always be a tendency for the maintenance and reliability functions to be reactive. If reliability and PM compliance KPI's are valued, are coupled with well developed and justified strategies that are applied with the optimum level of resources, the total cost to maintain will fall.

Understanding the source of losses.

To improve in any endeavour you have to understand what requires improvement. This seems really obvious but often this is not clearly known. Everyone at your plant may have a view on what is the largest source of losses, but how often do they measure them? If they are not being measured then how can justification be built for improvement activities? **Question 38** is aimed at understanding if your business understands the causes of its losses related breakdowns.

38. Operations and Maintenance know what proportion of their losses are attributed to breakdowns.

5.Indicates that losses related to breakdowns are effectively measured and understood by operations and maintenance.
3. Indicates that losses related to breakdowns are partially measured and understood.
1. Losses related to breakdowns are not measured

	Responses	Percent
5:	48	25.53%
4:	47	25%
3:	54	28.72%
2:	20	10.64%
1:	19	10.11%
Additional Comments:	4	2.13%
Total Responded to this question:	188	74.9%
Total who skipped this question:	63	25.1%
Total:	251	100%

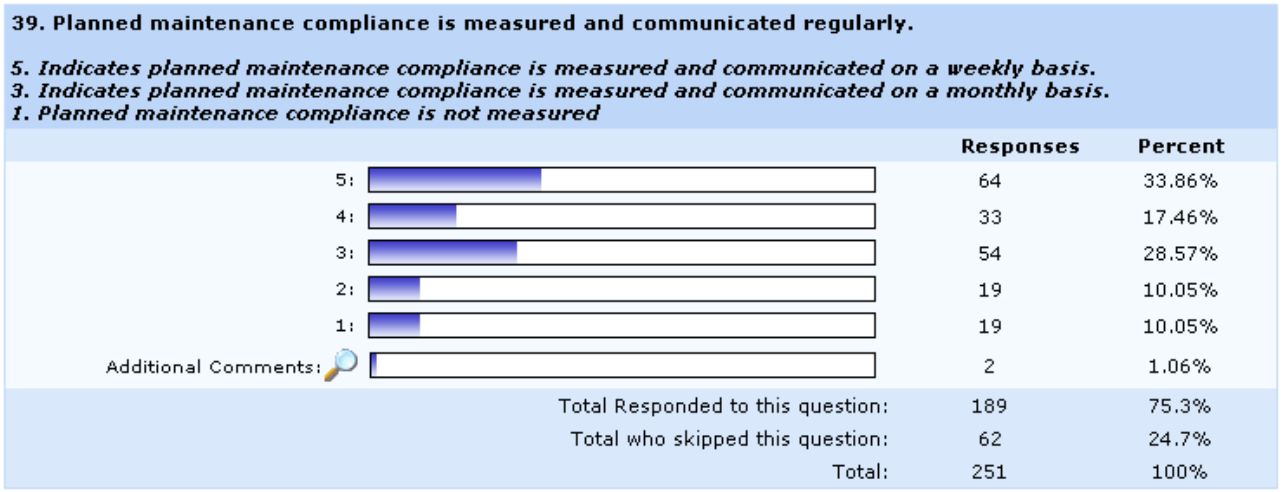
Figure 54. Question 38.

Overall response to this question was excellent with over 50% responding with a 4 or 5 and a further 29% partially understanding their losses. So with so many understanding their breakdown losses how many companies are doing something about them. Are breakdowns being assessed for effect on output, safety and environmental issues? Are they chronic issues or one off events? What is the real cost of the loss? When you start to ask these questions and investigate in depth, you will wonder why some of these issues haven't been dealt with before. Measure, Prioritise and then schedule your improvement activities based on your new understanding.

Planned Maintenance Compliance.

Planned Maintenance is the backbone of your reliability journey. If you have PM inspections in place now, at some time in the past some one has made a decision as to why a task is required. Until there has been some formal analysis of these inspections you must assume that they are all required and must be completed as closely as practical to the schedule. PM compliance is one of the most fundamental maintenance management measures and

Question 39 is aimed at understanding how many businesses consider planned maintenance compliance measures to be important enough to be communicated regularly.



39. Planned maintenance compliance is measured and communicated regularly.

5. Indicates planned maintenance compliance is measured and communicated on a weekly basis.
3. Indicates planned maintenance compliance is measured and communicated on a monthly basis.
1. Planned maintenance compliance is not measured

	Responses	Percent
5:	64	33.86%
4:	33	17.46%
3:	54	28.57%
2:	19	10.05%
1:	19	10.05%
Additional Comments:	2	1.06%
Total Responded to this question:	189	75.3%
Total who skipped this question:	62	24.7%
Total:	251	100%

Figure 55. Question 39.

Excellent results to this question with nearly 80% of respondents measuring compliance and communicating the outcomes to the workgroups on a monthly basis. This shows the value that is placed on this KPI from senior managers to tradesmen.

The Planning and Scheduling Backlog.

Businesses that have a well implemented planning and scheduling system will be providing a far more cost effect maintenance service as well as delivering higher plant reliability. Planning and scheduling makes better use of labor, allows machine downtime to be kept a minimum and provides detailed work instructions that can be captured and re-used for complex tasks. A well-implemented system will also have KPI’s developed to assist with understanding how well the process is working. **Question 40** is aimed at understanding whether the planning and scheduling backlog is measured and understood by operations and maintenance employees.

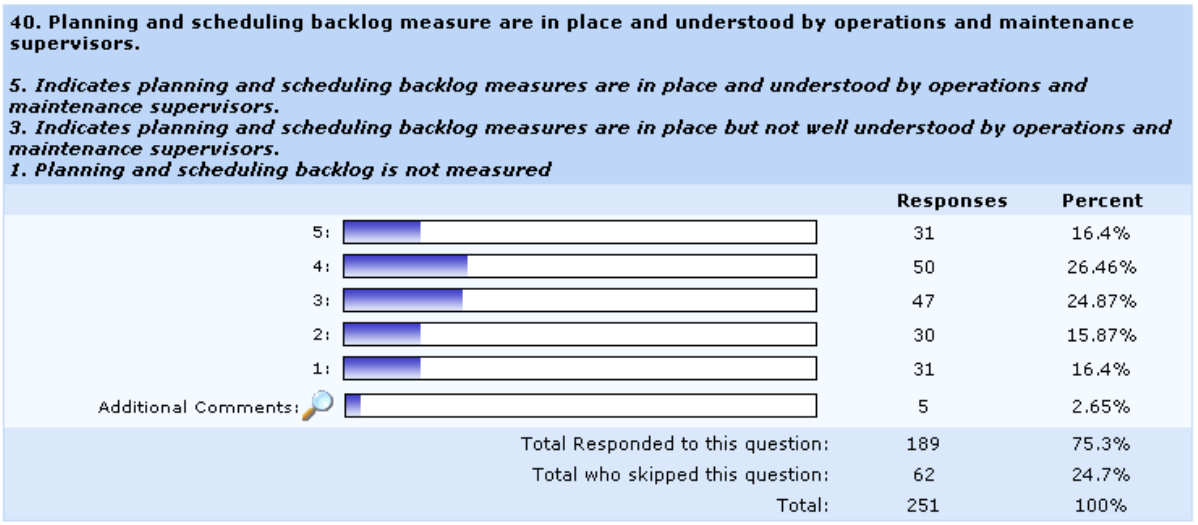


Figure 56. Question 40.

The results to the question were generally very good with 57% of respondents having the measures in place, but understanding of this measure is limited. Improvements could be made here in developing and understanding of the measures and the effects if defined targets aren't met.

To understand these effects you need to comprehend that planning and scheduling are two significantly different events. How often do you here someone say, "I've planned to do that on Monday". What they have actually done is scheduled the job. Planning is the What and How of a task, for example; I need two fitters and one electrician for 3 hours to replace a 75kw AC motor. As part of that task I will need isolation instructions, some special tools and equipment and some new coupling rubbers. Scheduling is the Who and the When of the task for example; John Joe and Fred will do this task at 1pm on Thursday afternoon. By understanding the difference it is easier to understand the effects of non-compliance. For example having a backlog of tasks not planned will lead to work not be completed in an acceptable time frame. A poorly planned job could lead to significant time wasting at the time the task has been scheduled or possibly rework related to incorrect instruction. Missing scheduled tasks may mean a critical task has to be rescheduled, putting the plant at risk of failure. It also means that labor has to be shuffled on the day to other tasks, while the original task has to be rescheduled. It is important that all stakeholders understand the significance of these measures.

Corrective vs planned, preventitive and predictive.

This measure is also known as Corrective vs Proactive. Why is it important that this measure is understood? The best organisations have a corrective workload of less than 20%, however it is common to find industries that have a corrective load of well over 50%. A reduction in the corrective workload indicates reliability improvements. **Question 41** is trying to gauge the extent of use of this measure as well as the comprehension of its significance.

41. The level of corrective, planned, predictive and preventitive work is measured and understood by operations and maintenance supervisors.

5.Indicates the level of corrective, planned, predictive and preventitive work is measured and understood by operations and maintenance supervisors.
3. Indicates he level of corrective, planned, predictive and preventitive work is measured but not well understood by operations and maintenance supervisors.
1. The level of planned, predictive and prevenititive work is not measured

	Responses	Percent
5:	25	13.23%
4:	36	19.05%
3:	70	37.04%
2:	29	15.34%
1:	29	15.34%
Additional Comments:	3	1.59%
Total Responded to this question:	189	75.3%
Total who skipped this question:	62	24.7%
Total:	251	100%

Figure 57. Question 41.

Like question 40 the response shows that this measure is in place in many companies but understanding of the measure is limited. How do you move from a primarily corrective environment to one that is proactive? There is no silver bullet here, as the move to a proactive culture will be a combination of actions many of which have been identified in this survey. To start on this journey, develop an understanding of your current reality and come up with a vision for the future.

A Vision is where you want to be and how you will operate into the future. For a Maintenance department this vision should be looking at around 3 years out. The vision can relate to physical issues such as, replacing redundant equipment, or it can be philosophy or cultural issues such as “We will follow the 80/20 principle”. The development of a vision will lead you into setting plans, objectives and measures which then becomes your business plan. If you don’t have this plan for the future then there will be no improvement. To remain competitive a culture of continuous improvement must be in place. What are the steps related to developing a vision and a business plan?

1. Understand the Vision goals for the overall business. Your vision should be aligned to this.
2. Review all of the components of maintenance management, understand your short fall in each area, and determine where you can make the largest improvements (Biggest bang for your buck). Be realistic about how much work you can take on over the life of the plan. Ensure your objectives can be met considering cost and labor constraints. Focus on improving systems as much as possible as often you get more gains by changing the way you do things. It's also usually a lot cheaper.
3. Tabulate your vision into categories related to your planned objectives, the strategies you are going to use to meet your objectives, who is responsible for each task and when you expect to have the task completed.
4. Write specifications for the tasks you are planning to complete over the life of the plan.
5. Review your plan regularly to make sure it is still relevant to your situation.

Segmentation Analysis of Work management and KPI's data.

The results of the nine-work management and KPI's 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

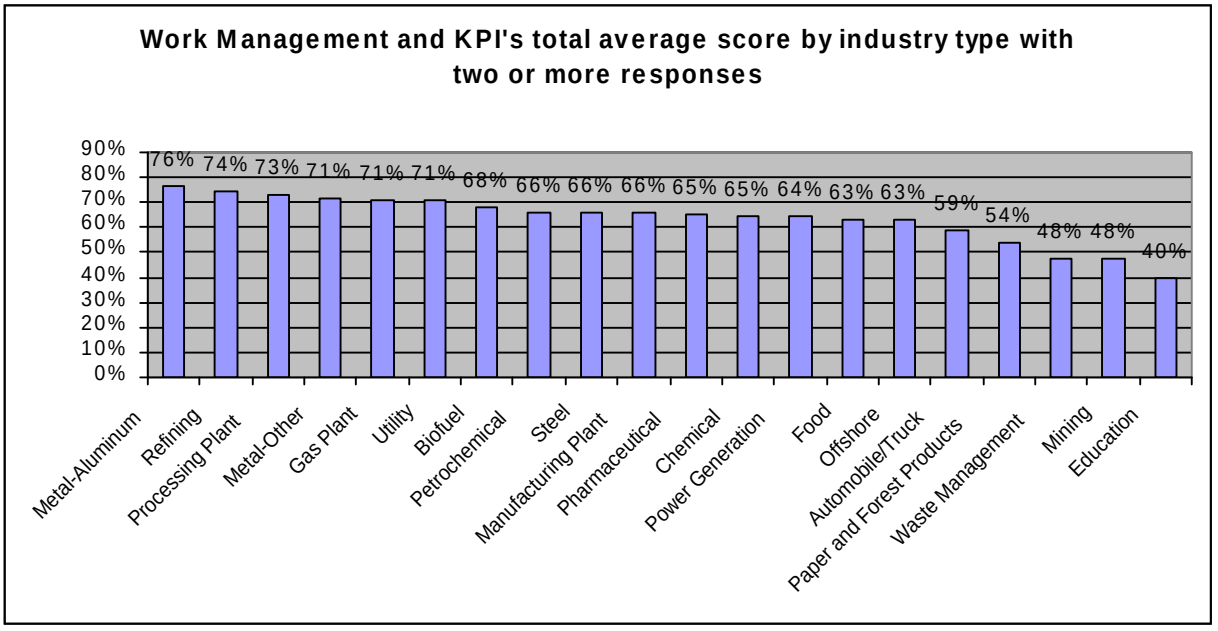


Figure 58. Work management and KPI's by industry type.

The Aluminium industry was a clear winner in this Element with a total average score of 76%, based on 6 responses, with refining a close second but only based on 2 responses. Of significant interest is the poor result from the mining sector of 48% based on 10 responses. A total average score of over 70% would be considered good, between 60 and 70% reasonable and below 60% poor. Businesses that scored lower than 60% will be primarily reactive in the way they manage maintenance, and these results should be ringing alarm bells.

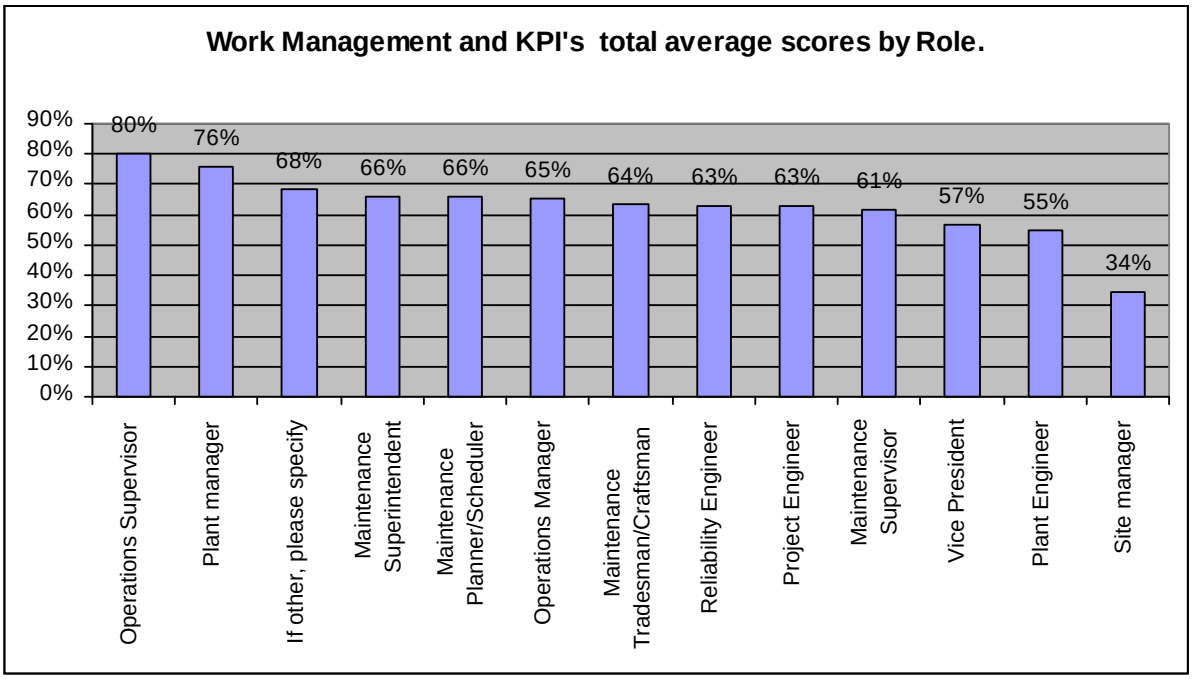


Figure 59. Work Management and KPI's by role.

It is of interest to note that the two highest average ratings here came from operations employees. In most instances people in these positions would not have an intimate understanding of the process and measures. Of the maintenance related employees it was the management side that rated this element highly. The doers in the process being the tradesmen, reliability engineers and maintenance supervisors have a different view. Does management in general think their businesses are generally better than what they really are? Does this show that management is often out of touch or are employee's expectations too high? The answers to this part of the survey do highlight significant differences in perceptions, and provide a basis for further investigation.

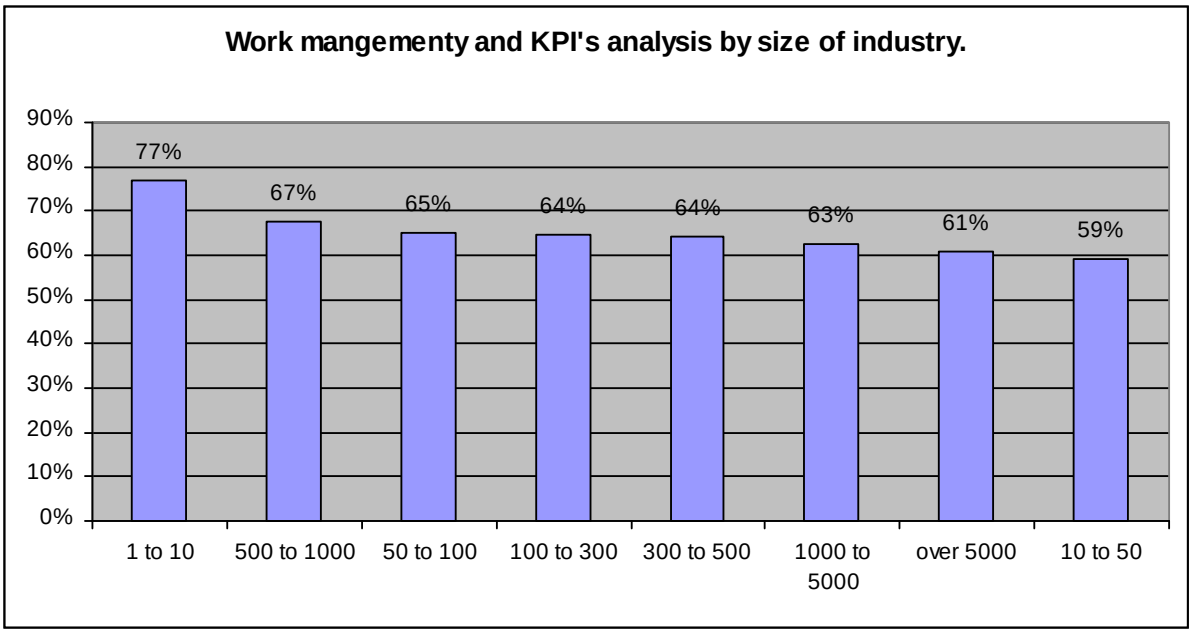


Figure 60. Work management and KPI's by industry size.

Throughout the assessment of the survey results there has been a trend towards the smallest businesses rating themselves the best and for work management the trend has continued with an average score from the 5 respondents in this sector being 77%. The larger businesses with over 1000 people are again found at the lower end of the scale. This indicates that larger businesses are not able to control their maintenance processes well.

Conclusions on the work management process and Maintenance KPI's.

Roles and responsibilities have been defined, and work management processes are effectively in use in the majority of respondents companies. Structured methodologies are used to develop strategies to some extent with most respondents. When considering KPI's the majority of management groups still see costs as the most important measure, however the understanding of unplanned loses due to breakdowns appears to be well understood. Of the questions based on KPI's, PM compliance is well understood and used as a KPI in most industries, however the application and understanding of planning and scheduling backlog and Corrective vs Proactive workload is limited and should be a focus for businesses that fall short here. The most significant learning from this section of the survey was the distinct lack of operator basic care on their equipment.

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

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