Part 4 of the Eight Critical Elements of Asset Management Survey.

Critical Element 8.

Maintenance Strategies

A strategy is the who, what, when where and how of maintaining your assets. Strategies are not “set and forget”, they are living documents that should be reviewed and improved continuously. What methods do you use to review strategies? Do the strategies address the failure modes of your assets? Who is involved in the review process? The review and development of strategies is a critical component of Asset Management.

In years gone by, when maintenance labor was plentiful, there were some very extensive Planned maintenance programs in place, with most being based on the “best guess” of the experienced people in the business. The results were often a plant that was being over serviced or the servicing was occurring on equipment that had very low failure rates. In the last 20 years there has been a significant movement to actions being based on the mitigation of failure modes. Some of these tools are breifly described below.

Tools for Improving Maintenance strategies.

A tool is anything used as a means of accomplishing a task or purpose. The following generic tools are used widely in determining new or revising existing Maintenance Strategies.

Reliability Centred Maintenance. RCM

Reliability Centred Maintenance is defined by John Moubray as “a process used to determine what must be done to ensure that the physical asset continues to fulfil its intended functions in its present operating context” (1993, pg.7). RCM was born from the airline industry in the US in the early 70’s in response to the statutory maintenance requirements that had to be applied to larger aircraft such as Boeings 747. It was determined that the cost of applying the standards to these aircraft would make them uneconomical to operate (Smith and Hinchcliffe, 2004). The basis of RCM is to ensure equipment maintains its function and the process requires that the following seven questions be answered (Moubray, 1993).

1. What is the function of the equipment and what are the required performance standards?
2. In what ways can it fail to perform its function?
3. What could cause each functional failure?
4. What happens when the failure occurs?
5. In what way does the failure matter?
6. What can be done to prevent the failure?
7. What has to be done if the failure can't be prevented?

Smith and Mobley (2008) highlight the following types of asset management strategies that may be developed from an RCM process.

1. Condition based tasks. E.g. Oil is sampled from a transformer and the results of the analysis determine if further maintenance is required.
2. Scheduled restoration. E.g. A Sheave bank running in a corrosive environment that requires overhaul at fixed intervals.
3. Scheduled Discard. E.g. The replacement of oil in a combustion engine.
4. Failure finding task. E.g. Calibration of instrumentation. The fault may not be discovered until the calibration is done.
5. One-time change. Typically a one off redesign.

RCM in its pure form is a resource hungry process that should only be applied to the most critical of assets. The results from the process if performed properly and coupled with assessment of historical failures will produce efficient and effective maintenance strategies, but this will be at the expense of a significant amount of time for plant staff and the project analyst.

Failure Modes and Effects Analysis. FMEA.

A Failure Mode and Effects Analysis is an integral part of the RCM process and deals with questions 2, 3 and 4 of the 7 RCM questions listed above. Teng and Ho (1996) define FMEA as a technique that identifies the potential failure modes of a device or product, determines the effects of these failures and assesses the criticality of the failure. The Teng and Ho model is shown in figure 83.

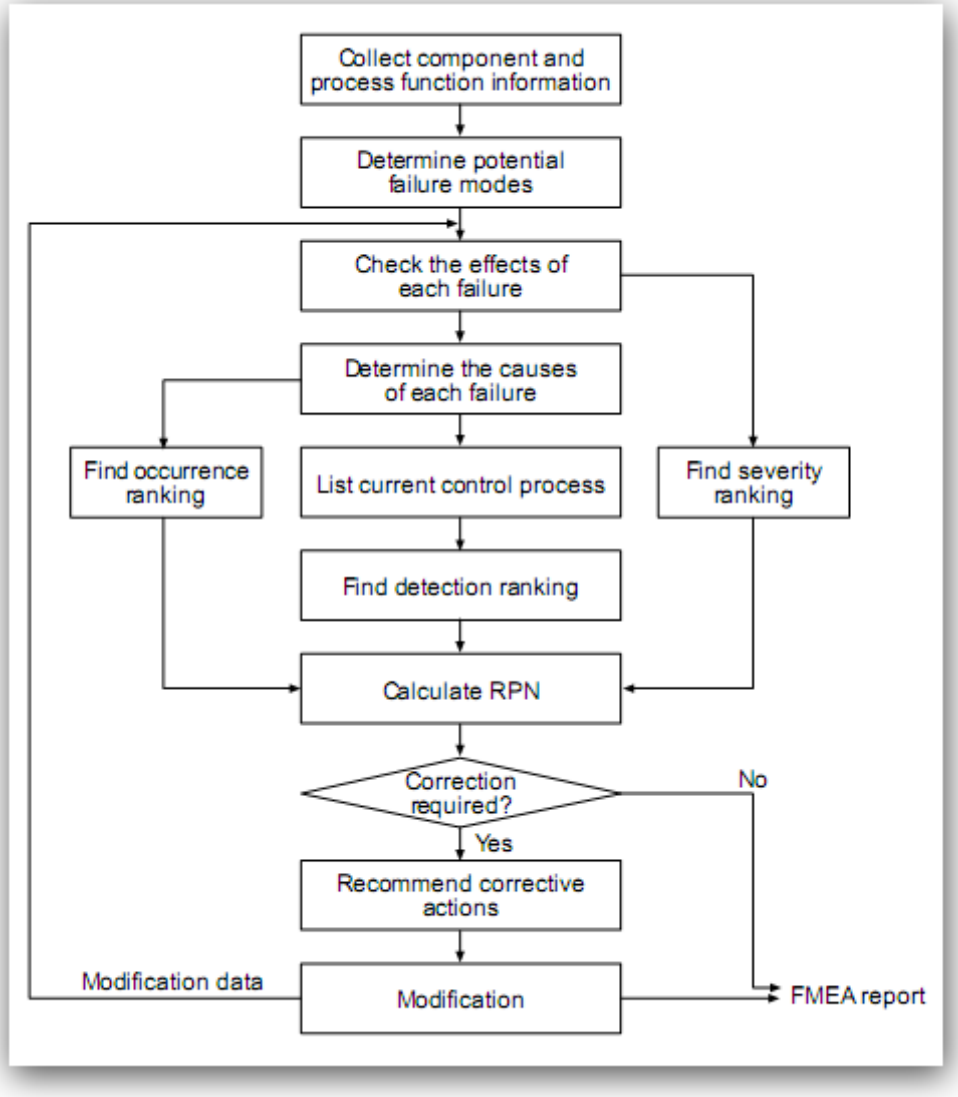


Figure 83. FMEA flowchart.

An FMEA completed on DC machines in an Australian Steel mill revealed the following most likely causes of DC machine failure to be:

1. Contamination of motor by Dust, Dirt fumes etc.
2. Inadequate maintenance practices. (Internal and contract)
3. Inadequate brush tension
4. Over tensioning of belts or shaft misalignment.
5. Overheating due to ineffective ventilation
6. Neutral axis and compounding issues.
7. Overloading.
8. Inadequate lubrication (Too much or not enough).
9. Incorrect or ineffective protection devices.

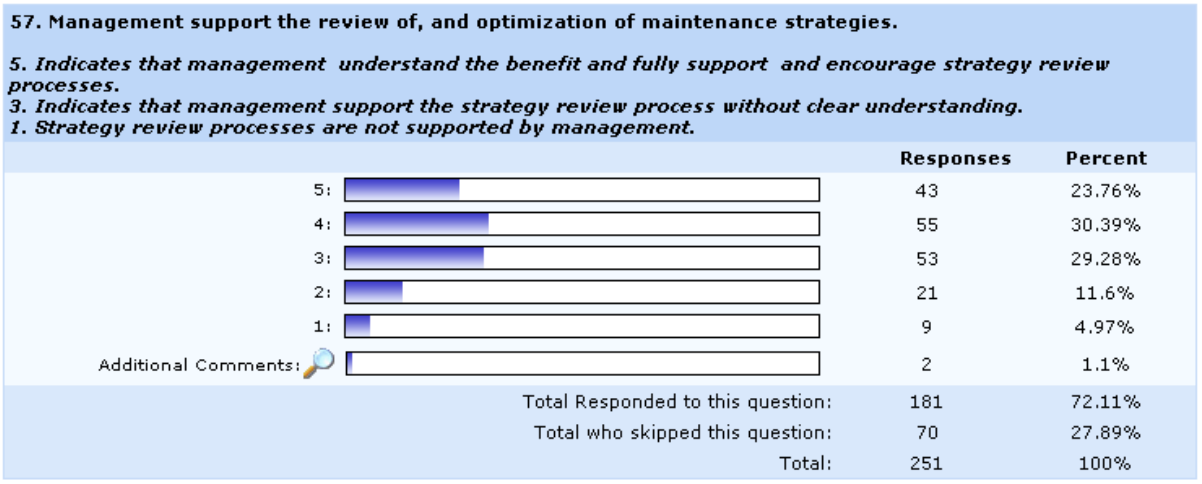
These findings were used to improve the existing PM's with excellent results. Over a 3 year period there was a 70% reduction in DC motors that failed in service.

Planned Maintenance Optimisation. PMO

Planned Maintenance Optimisation is a process where existing PM inspections and failure history are used to form the basis of a new set of strategies. This can provide a similar output to classical RCM in far less time. As unknown failure modes are not addressed in the first instance the process allows for input of potential failure modes after the initial assessment. This process couples the PMO top down approach with the RCM bottom up approach and in many cases will be the best option for mature businesses with existing PM systems and access to failure history. New businesses with no existing systems or failure history will need to apply more classical methods such as a RCM or a knowledge based process.

Management support of strategy optimization.

The most significant step related to gathering management support for a strategy review process is educating them in the critical elements of asset management. It is common for managers to see maintenance as a cost that can be cut, and not an investment in the future of the operation. **Question 57** is aimed at gauging whether management support the review of, and optimization of maintenance strategies.



57. Management support the review of, and optimization of maintenance strategies.

5. Indicates that management understand the benefit and fully support and encourage strategy review processes.
3. Indicates that management support the strategy review process without clear understanding.
1. Strategy review processes are not supported by management.

	Responses	Percent
5:	43	23.76%
4:	55	30.39%
3:	53	29.28%
2:	21	11.6%
1:	9	4.97%
Additional Comments:	2	1.1%
Total Responded to this question:	181	72.11%
Total who skipped this question:	70	27.89%
Total:	251	100%

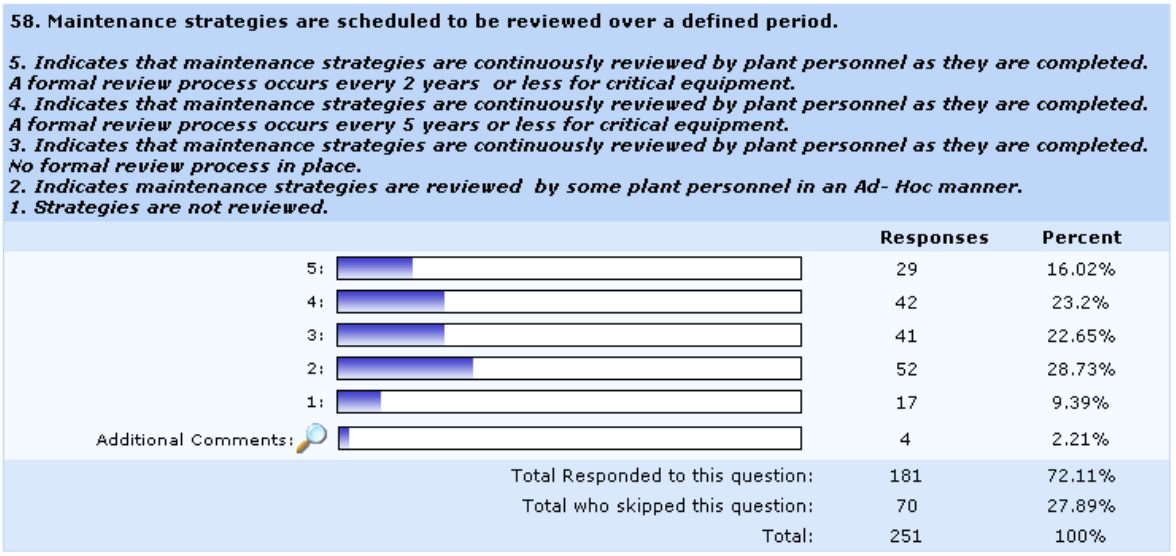
Figure 84. Question 57.

The results here were surprising with 54% rating a 4 or a 5. This indicates management have a clear understanding of the importance of optimisation of maintenance strategies. A further 30% support strategy review but do not have a clear understanding of the benefits. With this high level of management support there should be little reason not to progress with improvements.

Scheduled review of strategies.

How many businesses have been using the same strategies with little or no review processes in the last 10 years? When your tradesmen suggest a change to a strategy is there a system in place to review the suggestion for suitability? There needs to be a systems in place to review older PM's to determine if they are still relevant and are addressing known or potential failure modes.

There also needs to be a system in place to capture and review feedback gathered from the tradesmen who are doing the task. One of the most significant contributors to work instructions not having any feedback left on them is that when comments had been made before, no actions followed. This is an incredible demotivator for many. **Question 58** will determine how often maintenance strategies are reviewed.



58. Maintenance strategies are scheduled to be reviewed over a defined period.

5. Indicates that maintenance strategies are continuously reviewed by plant personnel as they are completed. A formal review process occurs every 2 years or less for critical equipment.
4. Indicates that maintenance strategies are continuously reviewed by plant personnel as they are completed. A formal review process occurs every 5 years or less for critical equipment.
3. Indicates that maintenance strategies are continuously reviewed by plant personnel as they are completed. No formal review process in place.
2. Indicates maintenance strategies are reviewed by some plant personnel in an Ad- Hoc manner.
1. Strategies are not reviewed.

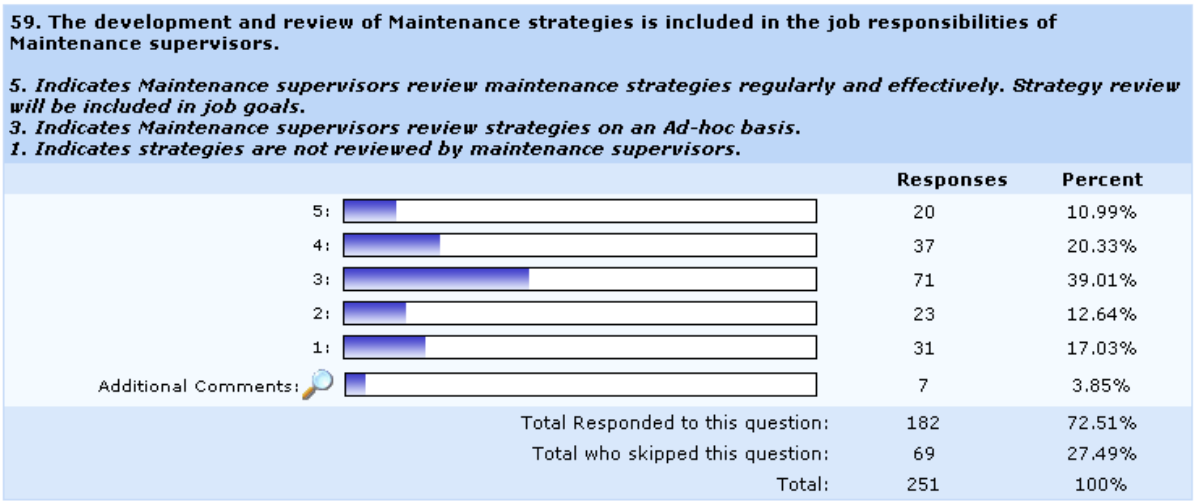
	Responses	Percent
5:	29	16.02%
4:	42	23.2%
3:	41	22.65%
2:	52	28.73%
1:	17	9.39%
Additional Comments:	4	2.21%
Total Responded to this question:	181	72.11%
Total who skipped this question:	70	27.89%
Total:	251	100%

Figure 85. Question 58.

With 39% of respondents scoring a 4 or a 5 the level of formal review of strategies was higher than expected. 52% of respondents indicated a less formal or more ad-hoc manner of strategy review, with 9% having no process at all. To remove the waste from maintenance strategies and ensure actions within these strategies are effective a process involving the identification and mitigation of failure modes must be applied. This can be in the form of FMEA, RCM, and PMO etc. The other point to remember is that strategies will need to be changed to accommodate changing production demands. For this reason, a formal review schedule should be put in place. This could be in the form of regular audits of work instructions or detailed reviews of total strategies.

Maintenance supervisors and strategy review.

With strategy review being a critical component of this element, it becomes clear that someone needs to be responsible for the review process. **Question 59** questions whether the development and review of Maintenance strategies is included in the job responsibilities of Maintenance supervisors.



59. The development and review of Maintenance strategies is included in the job responsibilities of Maintenance supervisors.

5. Indicates Maintenance supervisors review maintenance strategies regularly and effectively. Strategy review will be included in job goals.
3. Indicates Maintenance supervisors review strategies on an Ad-hoc basis.
1. Indicates strategies are not reviewed by maintenance supervisors.

	Responses	Percent
5:	20	10.99%
4:	37	20.33%
3:	71	39.01%
2:	23	12.64%
1:	31	17.03%
Additional Comments:	7	3.85%
Total Responded to this question:	182	72.51%
Total who skipped this question:	69	27.49%
Total:	251	100%

Figure 86. Question 59.

The telling result here is that 39% of maintenance supervisors that review their strategies in an ad-hoc manner and a further 30% that do little review or none at all. With only 31% scoring a 4 or 5 this is an area of significant opportunity for many businesses.
Include the review of maintenance strategies in the job goals of maintenance supervisors at all levels. The Maintenance Team Leader may be responsible for feedback on work instructions, the Area Supervisors could arrange regular work instruction audits, where the maintenance manager may include large formal strategy review processes in the maintenance budget. Making people responsible for strategy review will make it occur and the benefits will come.

Involvement in Strategy review.

An effective strategy review process will only occur if a representative of all stakeholders are involved in the process. This will gain a significant amount of local knowledge as well as building ownership of any revised strategy. **Questions 60** will determine to what degree operations and maintenance employees are involved in the development of strategies.

60. Operations and maintenance employees are involved in the development of strategies.

5. Indicates that operations and maintenance personnel are always involved in strategy review and development.
3. Indicates there is some input from Operations and maintenance in strategy review and development.
1. Strategy review does not occur.

	Responses	Percent
5:	29	15.93%
4:	35	19.23%
3:	58	31.87%
2:	32	17.58%
1:	28	15.38%
Additional Comments:	3	1.65%
Total Responded to this question:	182	72.51%
Total who skipped this question:	69	27.49%
Total:	251	100%

Figure 87. Question 60.

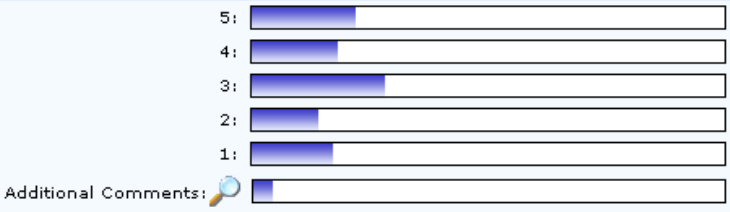
What is pleasing here is that 35% of respondents indicated that operations and maintenance personnel are regularly or always involved in strategy review. 32% of respondents indicated some input while 33% have little or no involvement. The aim here should be that there is always involvement with stakeholders. When strategy review processes occur in isolation it is unlikely that the outcome will be as best as it could be, as one persons view will be not uncover all possible failure modes or the actions that will prevent the failures. The ideal situation is to have a senior mechanical fitter, an electrician, an operator and maintenance leader involved in the review process. The important aspect here is to get a total understanding as to what failures occur and whether the actions currently occurring address these failures. If no actions are currently in place the group should decide on what actions to implement, and making these decisions as a group will build ownership of the strategy. It is worthwhile considering the use of a strategy review tool and experienced facilitator during these reviews.

Maintenance strategies and the CMMS.

If you have a CMMS, it will have the ability to store and manage the work instructions that are working documents of your asset management strategies. **Question 61** is aimed at understanding the level at which strategies and work instructions are stored in the CMMS.

61. Maintenance strategies and work instructions are stored in the CMMS.

5. Indicates all maintenance strategies and work instructions are stored in the CMMS.
3.Indicates some maintenance strategies and work instructions are stored in the CMMS.
1. No strategies and instructions are stored in the CMMS



	Responses	Percent
5:	40	22.1%
4:	33	18.23%
3:	51	28.18%
2:	26	14.36%
1:	31	17.13%
Additional Comments:	7	3.87%
Total Responded to this question:	181	72.11%
Total who skipped this question:	70	27.89%
Total:	251	100%

Figure 88. Question 61.

With only 40% scoring a 4 or a 5 in this question there is clear room for improvement. As your CMMS is generally made to manage your strategies it is the obvious this is where they should be kept. If there are some work instructions or operating procedures that are kept in other systems, then these should be linked to the CMMS. This may be the case if a third party is providing software tools to help with strategy development.

Segmentation Analysis of Strategy data.

The results of the five strategy 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.

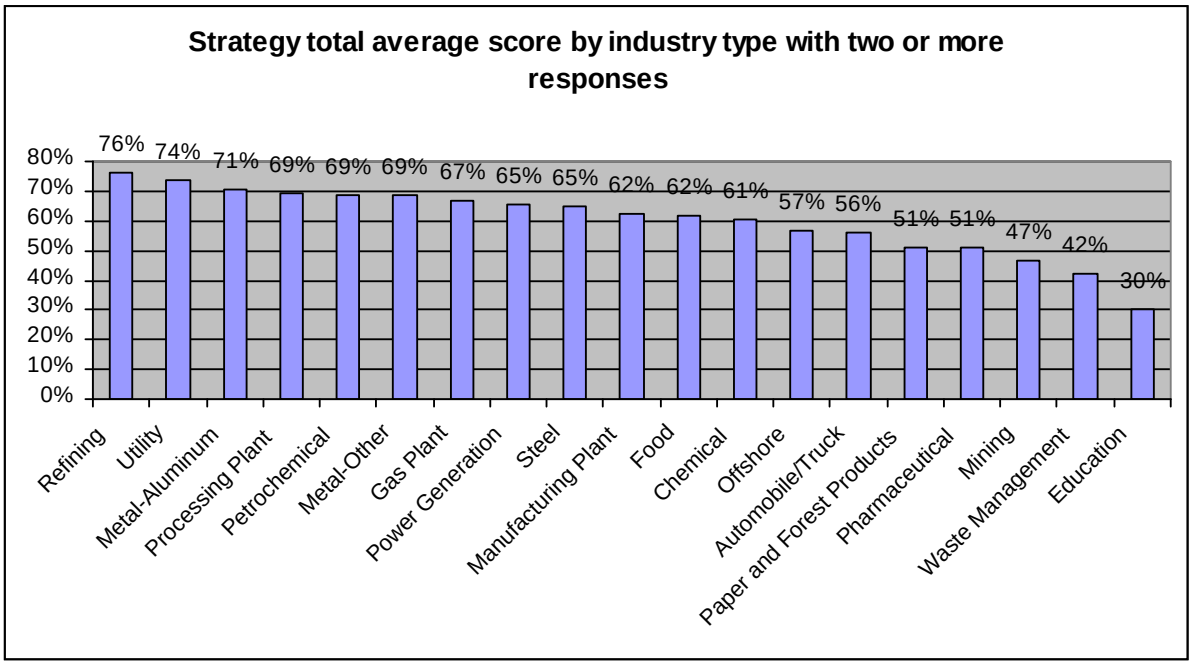


Figure 89. Strategy scores by industry type.

The strategy element was scored by all respondents at an average of 61%, which was at the lower end of the total average scores. The Refining group scored the highest in this element at 76%, with education again at the lower end. Following the previous trends we still find mining and offshore industries at the low end of the scale.

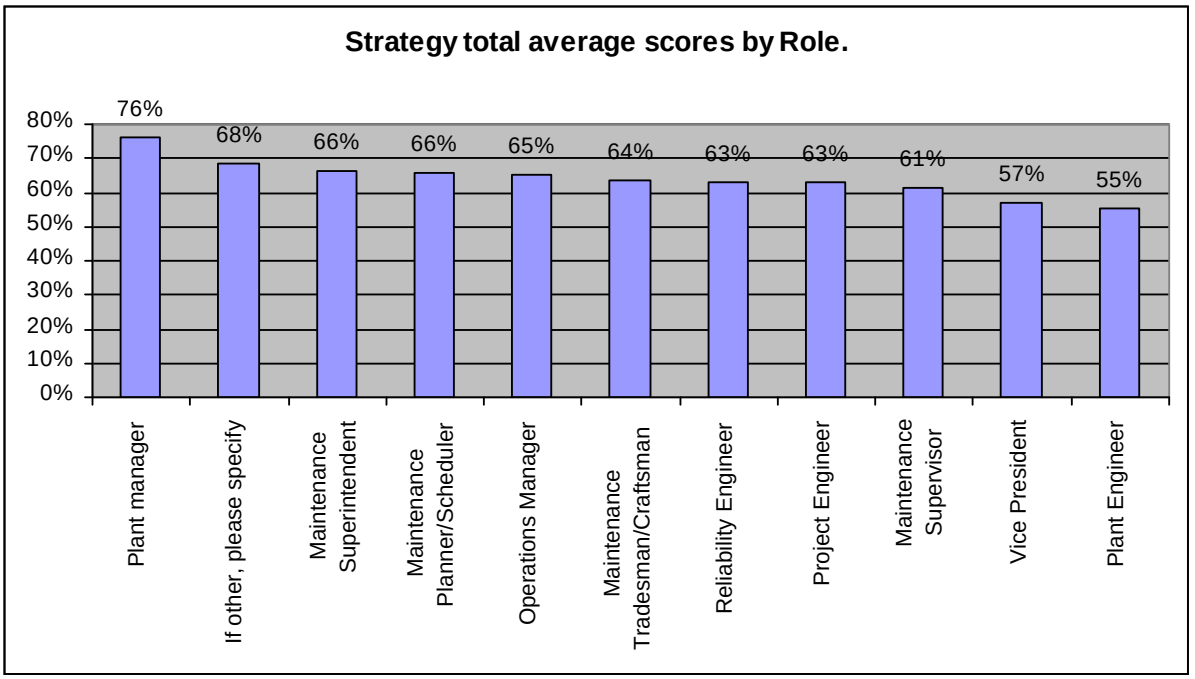


Figure 90. Strategy scores by role.

With the exception of the plant managers responses there was a close range of results here. With only one score over 70% this again supports the view that there is significant room for improvement in this element.

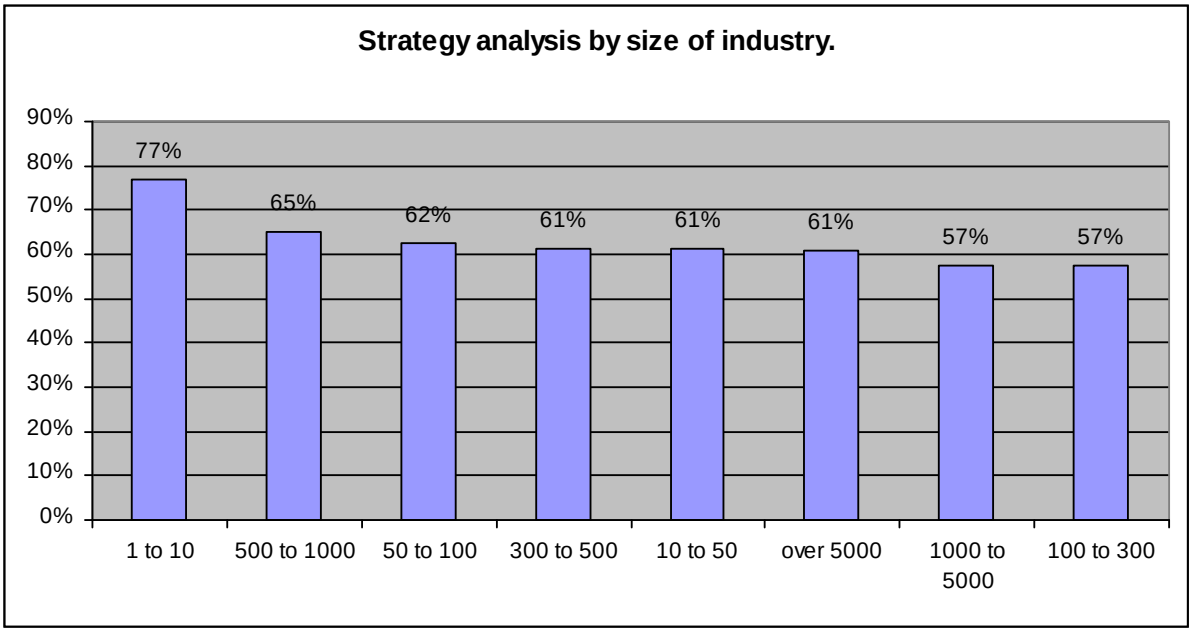


Figure 91. Strategy score by industry size.

In keeping with the trend through this survey the smallest business have rated themselves the highest in this element. At the bottom end we again find the largest of businesses.

Conclusions on the Maintenance Strategies Element.

Overall the scores were down in this element and this highlights business don't always value or understand the benefits that can come from a well run strategy review process. From the responses there is clear evidence avaliable that highlights management do or will support the review of maintenance strategies, even if the benefits are not totally understood. This indicates there is a certain amount of faith in the maintenance professional's point of view. Although there is some examples where strategies are reviewed on a regular basis, there was still more than 60% of respondents who can step up in this area. Where strategies have not been reviewed for many years, it should become a priority for these companies. There is a clear lack of clarity in relation to who is responsible for the strategy review process. Ensure your operation has strategy reviews included in position descriptions and set gaols for these people around improvement actions. Generally there is not enough involvement from people on the floor in the strategy review process and this needs to be considered as a matter of importance if your business goes done the path of strategy review. The use of the CMMS to store strategies and work instructions is also a potential area of improvement.

Further Segmentation Analysis.

The structure of this Survey has allowed for easily segmented results and some of these reports have been presented through the assessment. Question 62 asked respondents what type of reports they would like to see with some examples being:

- Comparisons between like industries.
- Your company against the rest of the respondents.
- Comparison of responses by role type.
- Comparisons of response by the size of the company

Reports already provided throughout this assessment include:

- Total no of Maintenance employees compared to business size in Chapter 1.
- Average overall score of all respondents by role type in Chapter 1.
- Total average overall score by industry type in Chapter 1.
- Average overall score by Country where the facility is based.
- The spread of and median scores for industries with 10 or more responses in Chapter 1.
- For each of the eight elements in Chapter 2 through to 9 the following reports were generated. Total averaged score by industry type, the position of the respondents and total number of employees.

Individual Scores by similar industries

Following are individual plant scores grouped by industry types. To protect the identity of the companies they have been named the country that the response came from. If there was more than 1 from that country then they will be called the country and a number, e.g., Australia 1, Australia 2 etc. In the responses for Steel, Onesteel has been named however the plants have not been identified. Of particular interest, is that in all of the data presented the trends are very similar. In every case there is a large variation between the highest and lowest scores no matter what data is presented. This means that there is no industry type that is better than any other and this is also the case when assessed by industry size.

What is a good score from the survey?

Scores of 75% or greater would indicate and excellent result, between 65% and 75% a good results with some room for improvement. Between 50% and 65% is an average result where there is significant opportunity to improve. If the score is less than 50% the result can be considered poor and your business has a long road to improvement.

Steel Industry

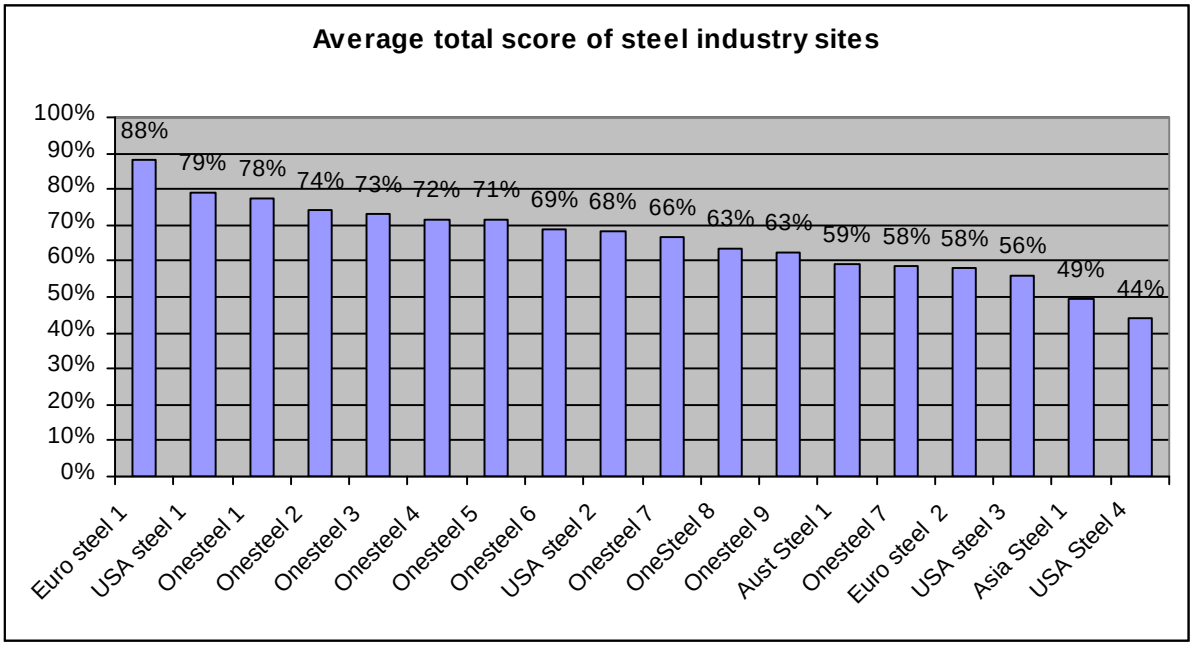


Figure 92. Steel industry individual scores.

A steel company in Europe rated themselves the highest in the survey with a total score of 88% which was 9% higher than the next highest which is a Steel Company located in the United states. The 7 scores from Onesteel in Australia were from different plants located in numerous places in Australia. The median score for the Steel industry was 67%.

Chemical Plants.

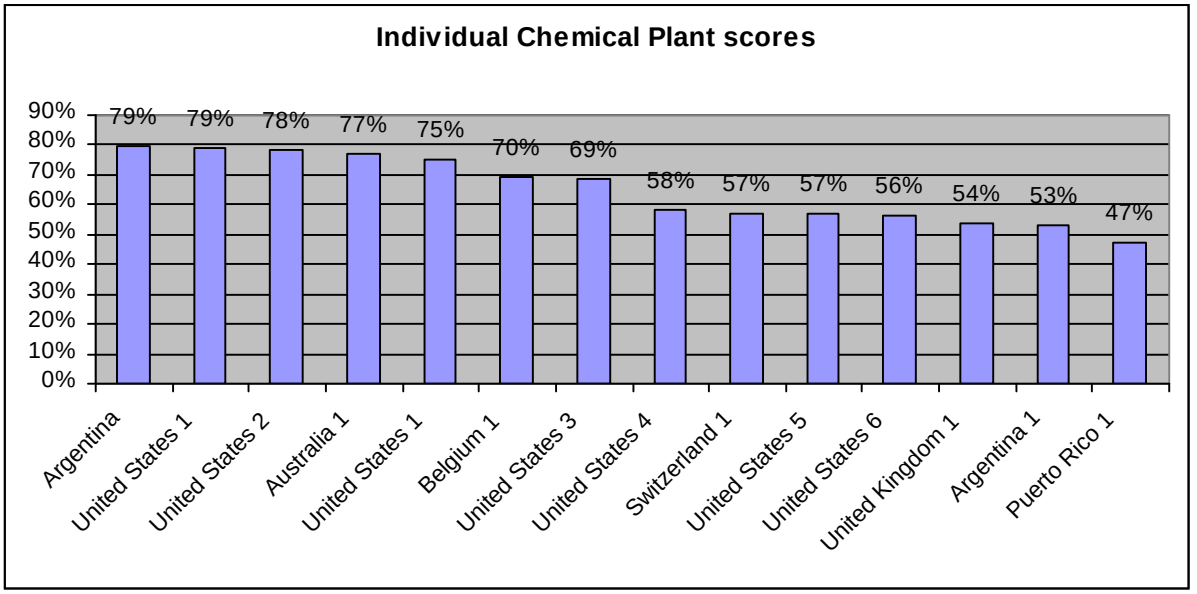


Figure 93. Chemical Plant individual scores.

Of the chemical plant results a two plants tied for first with scores of 79%, one being I Argentina and the other in the United States. The Median score for Chemical plants is 63%

Gas Plants

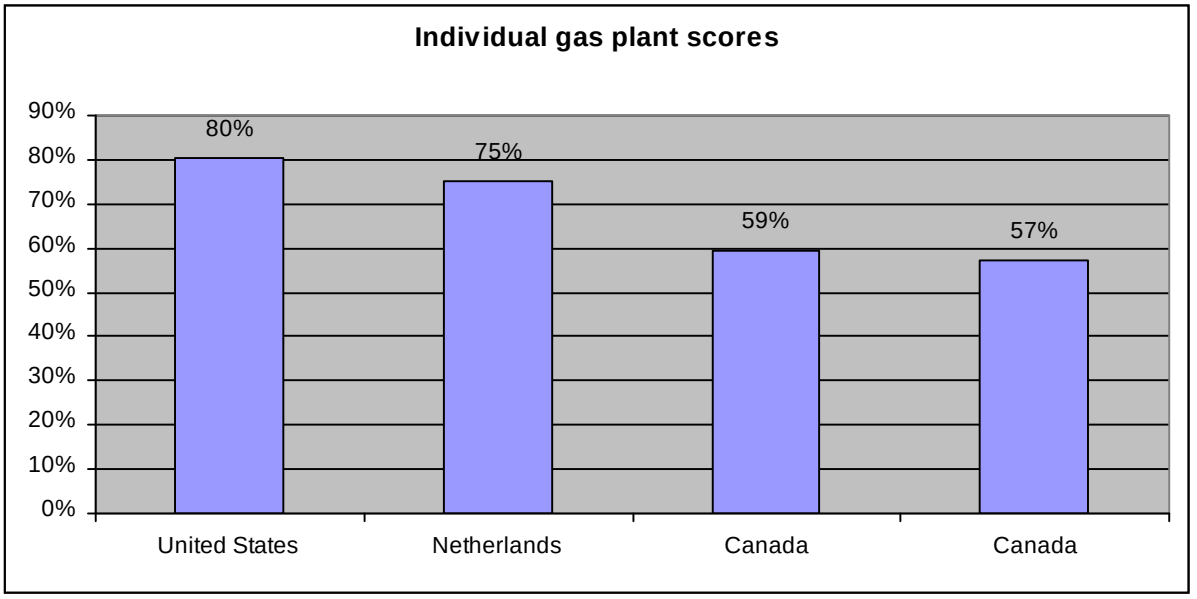


Figure 94. Gas Plant individual scores.

The highest score for gas plants came from a company in the United States at 80%. The median score for Gas plants was 66.5%.

Manufacturing Plants

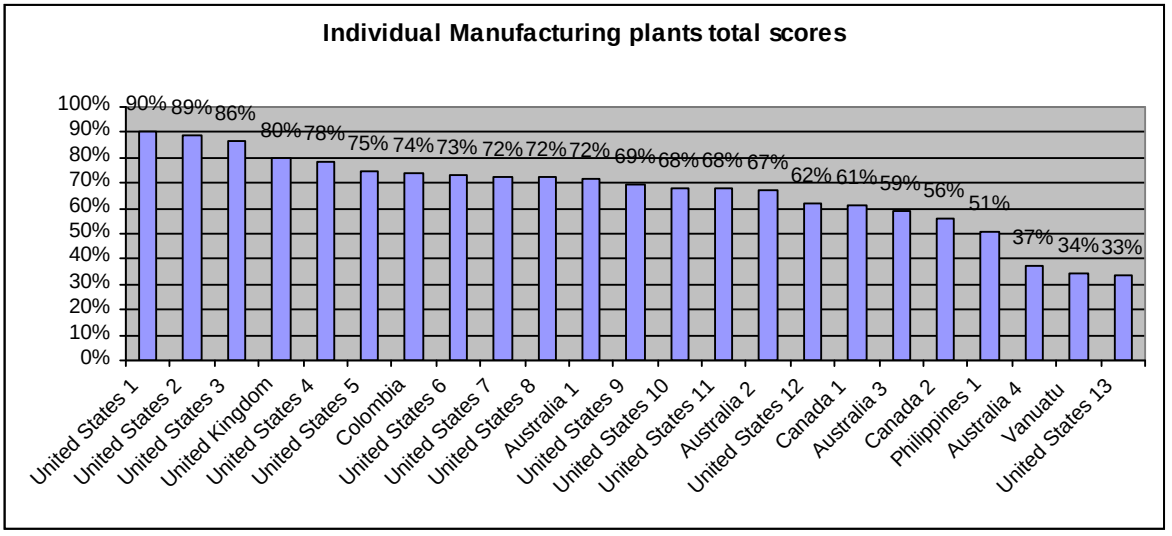


Figure 95. Manufacturing Plants individual scores.

Manufacturing plants cover many different types of manufacturing so it may be expected that there is a large variation in scores. There were three scores here higher than 80%, but at the other end of the scale there were three plants that scored below 40%. This sector had a large spread between the top and bottom scores, being 57%. The median score for manufacturing plants was 71%.

Aluminium Plants

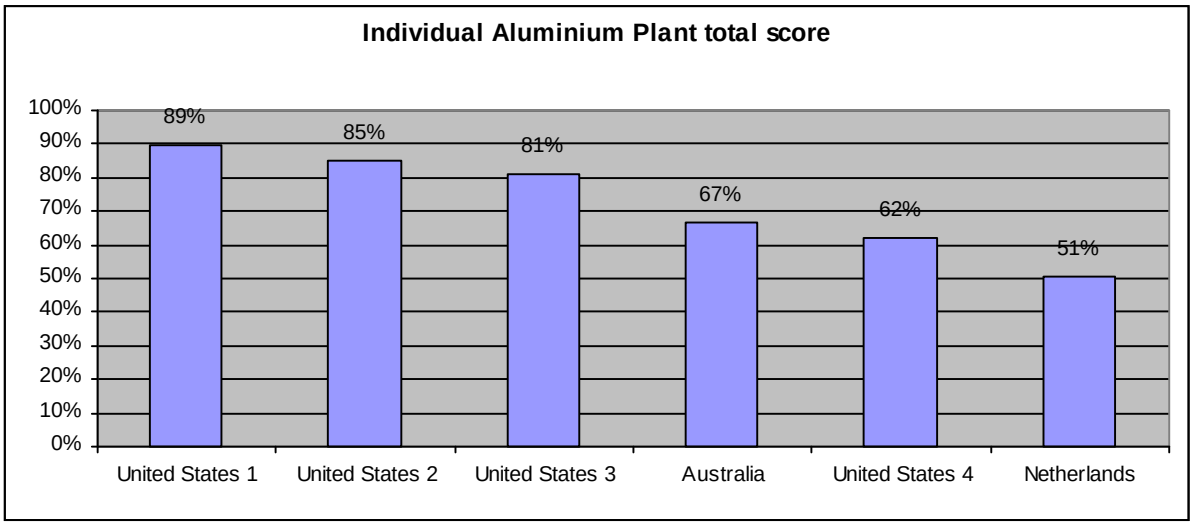


Figure 96. Aluminium industry individual scores

Again some high scores are offset by some very low scores. The Aluminium plants in the United States scored themselves the highest. The median score for this industry sector was 74%.

Offshore industries.

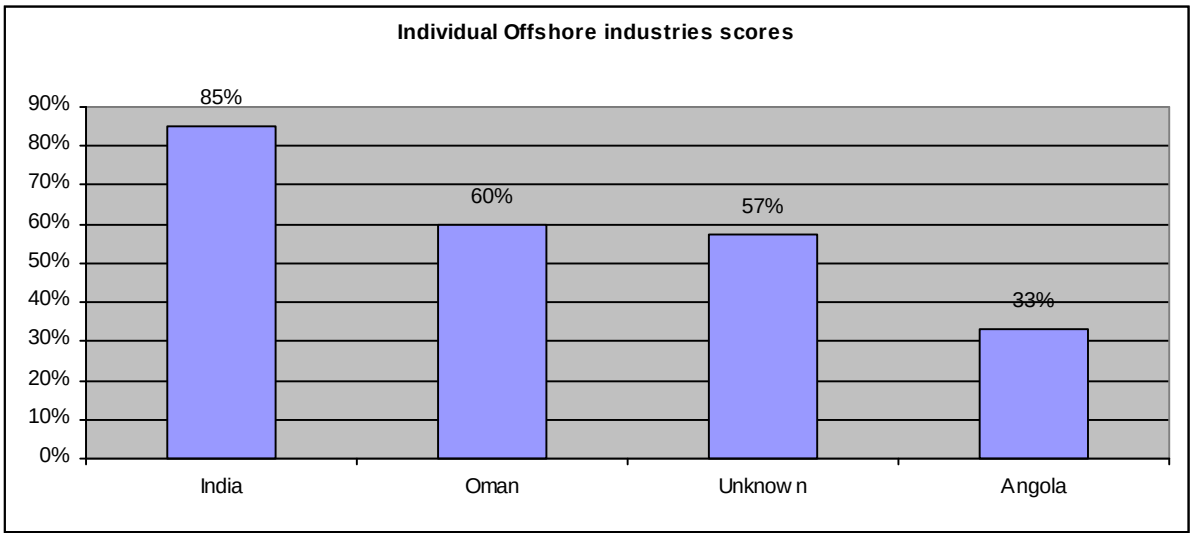


Figure 97. Offshore industry individual scores.

Another very large spread of scores in these results of 52%. The highest score came from a offshore industry in India with an extremely low score coming from an industry in Angola. The median score here was 58.5%.

Paper, Pulp and Forestry industries

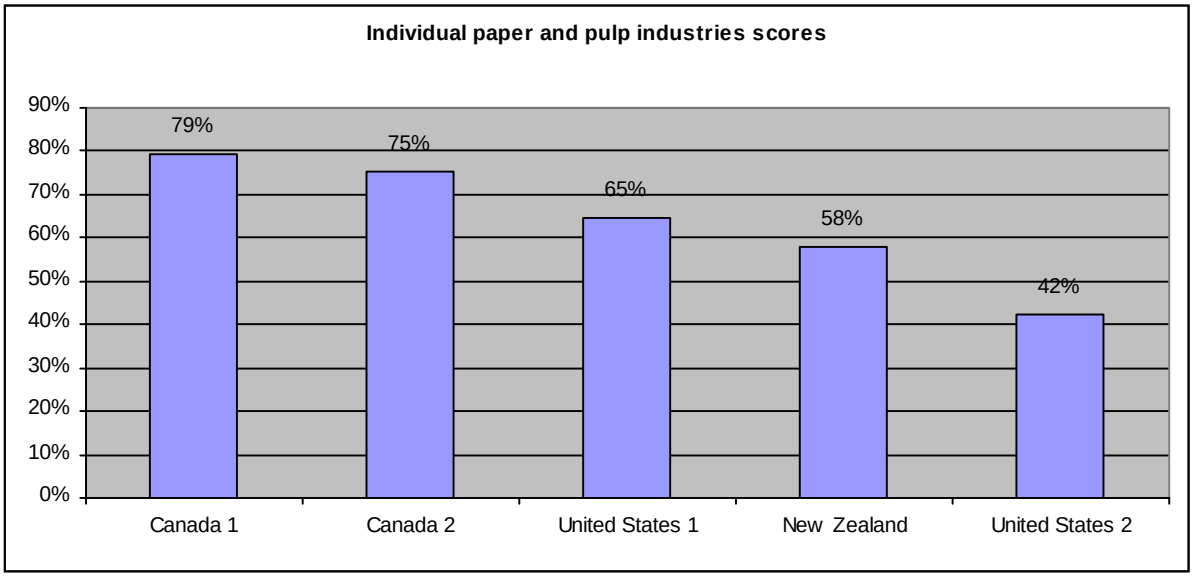


Figure 98. Paper and Forestry individual results.

The best paper, pulp and forest industries according to the survey are located in Canada with scores of 79 and 75%. The median score in this sector was 65%.

Petrochemical

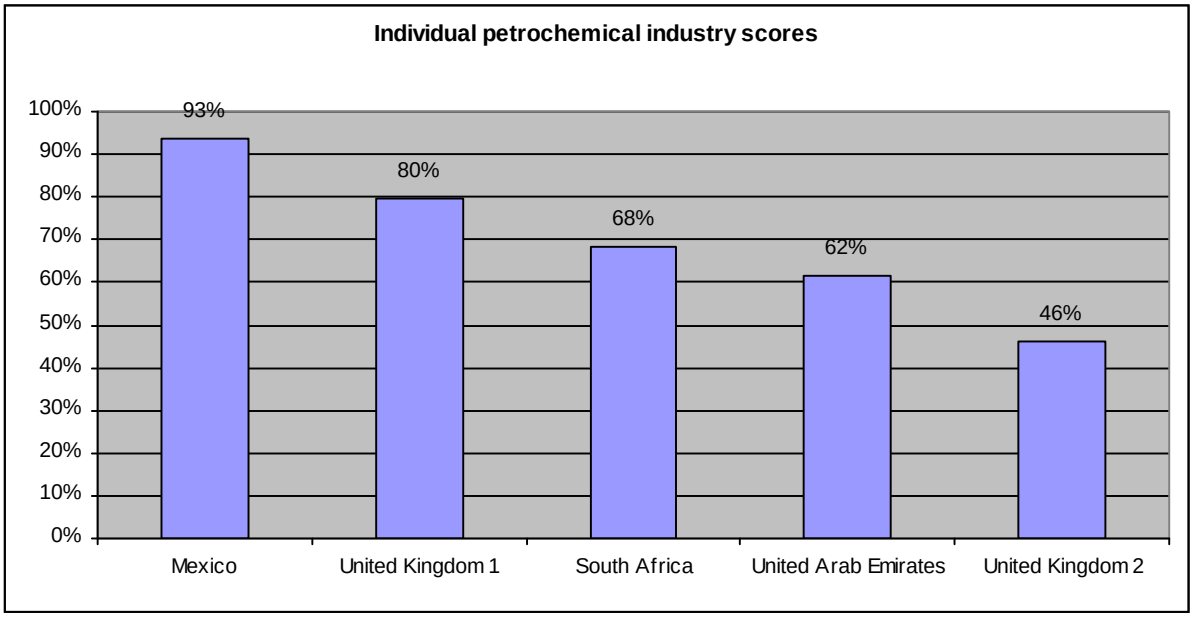


Figure 99. Petrochemical industry individual results.

The highest score for this industry sector came from a company in Mexico. The median score for this group is 68%.

Pharmaceutical industry

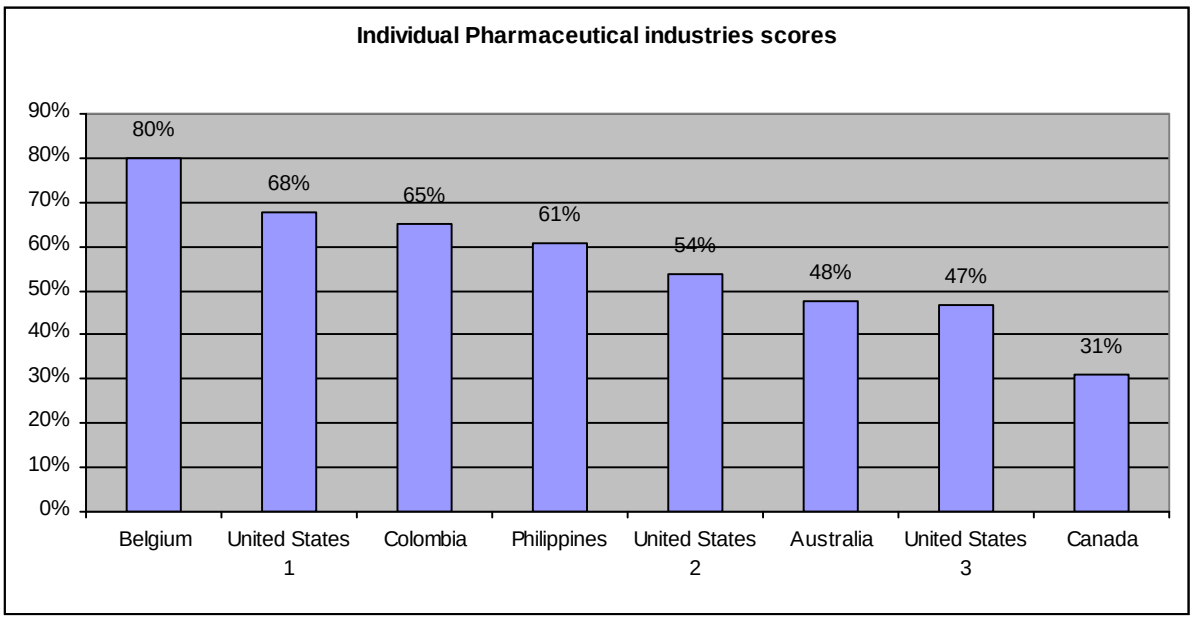


Fig 100. Pharmaceutical Industry individual scores.

The highest score in the pharmaceutical sector came from a company in Belgium with a score of 88%. There was a large gap to the next best at 68%.The median score is 57.5%.

Utilities.

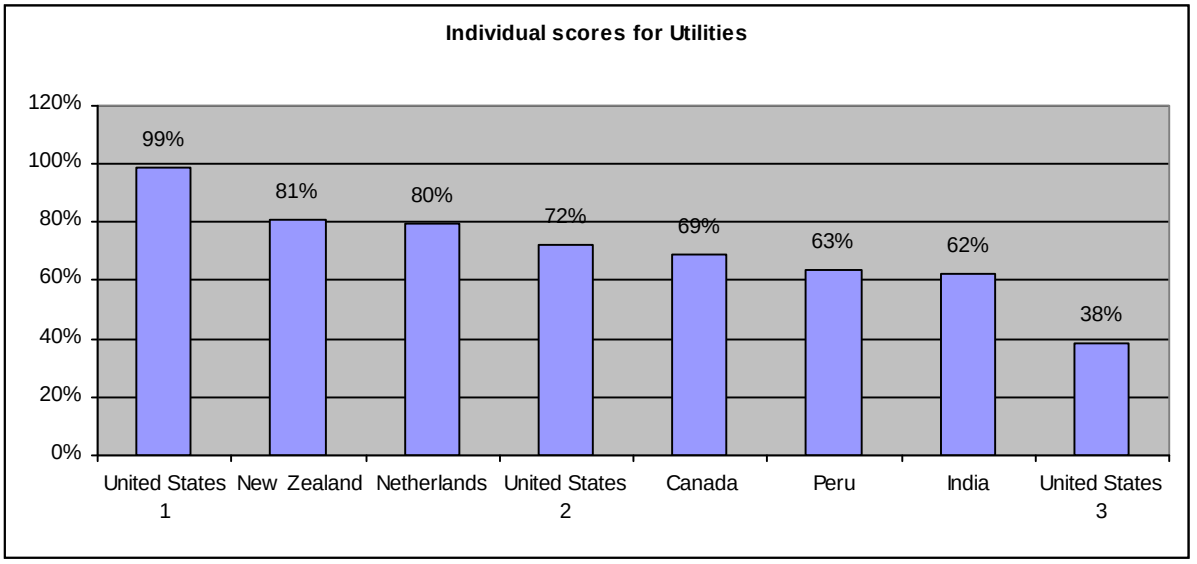


Figure 101. Utilities individual scores.

A utility company from the United States gave themselves a score of 99%, which was the highest in the survey. This sector had the single largest spread of scores, being 61% from the lowest to highest score. The median score here is 70.5%.

Power Generation

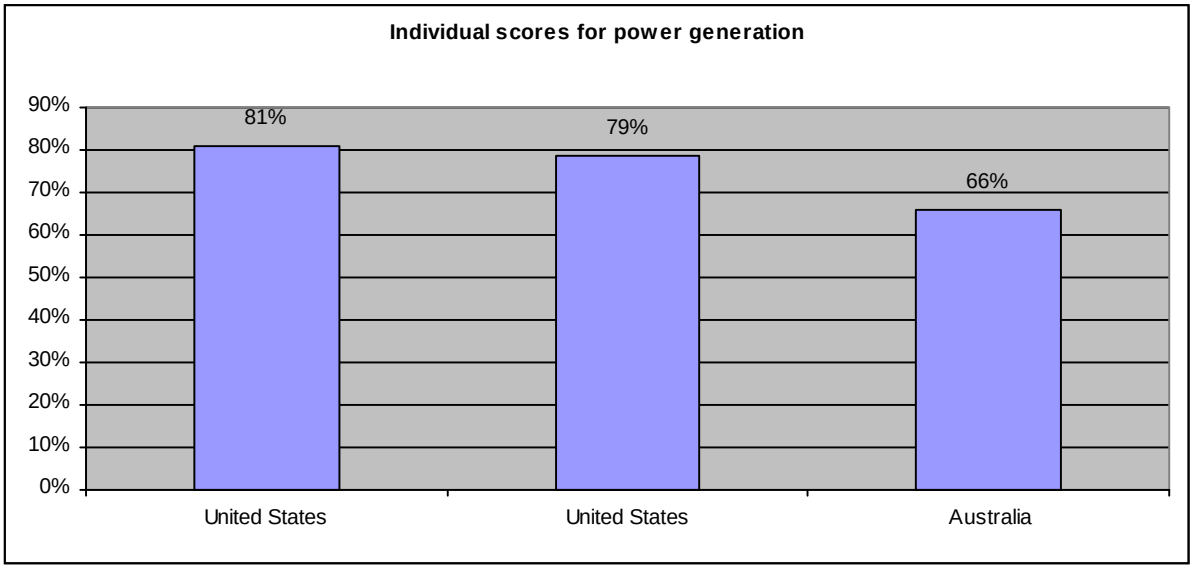


Figure 102. Power generation individual scores.

The highest of the 3 responses from the power generation sector came from the United States with 81%. The Median score for this group is high at 79%. This was the highest median score of the 13 industry types in this section of the survey.

Mining

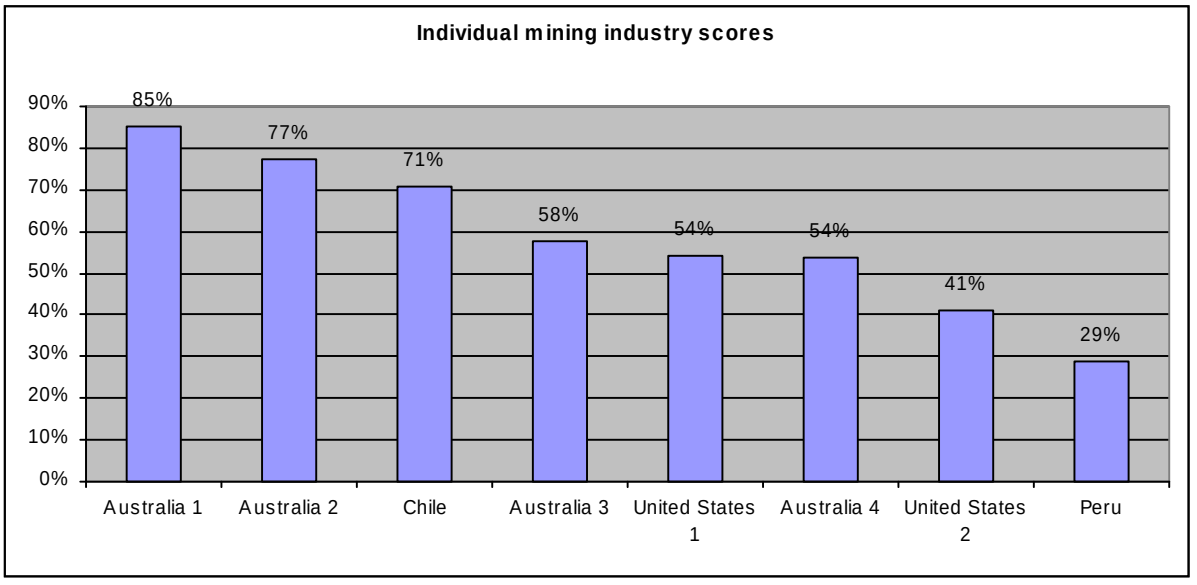


Figure 103. Mining Individual scores.

Again there is a significant variation between the scores of different mining operations. The Australian operations have scored the highest here but the median score has been dragged down to 58% by a number of results under 60%.

Food Industry.

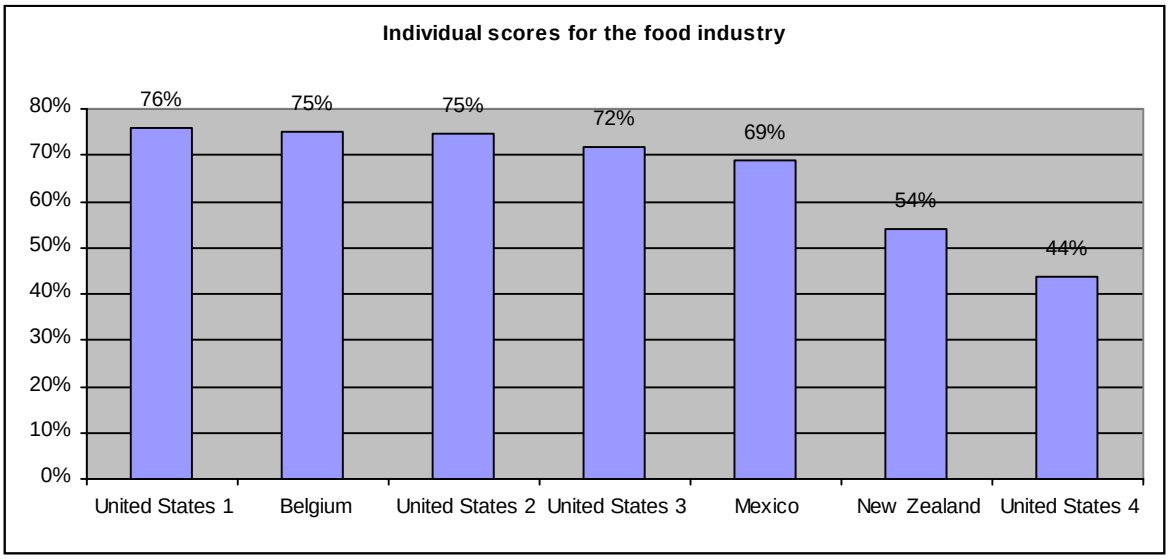


Figure 104. Food Industry individual scores.

The food industry scores were generally very stable with 5 out of the seven results being within 7%. The median score here is 72%.

Individual scores by industry size.

The trend of significant variation within groups continues when comparable size industries are compared.

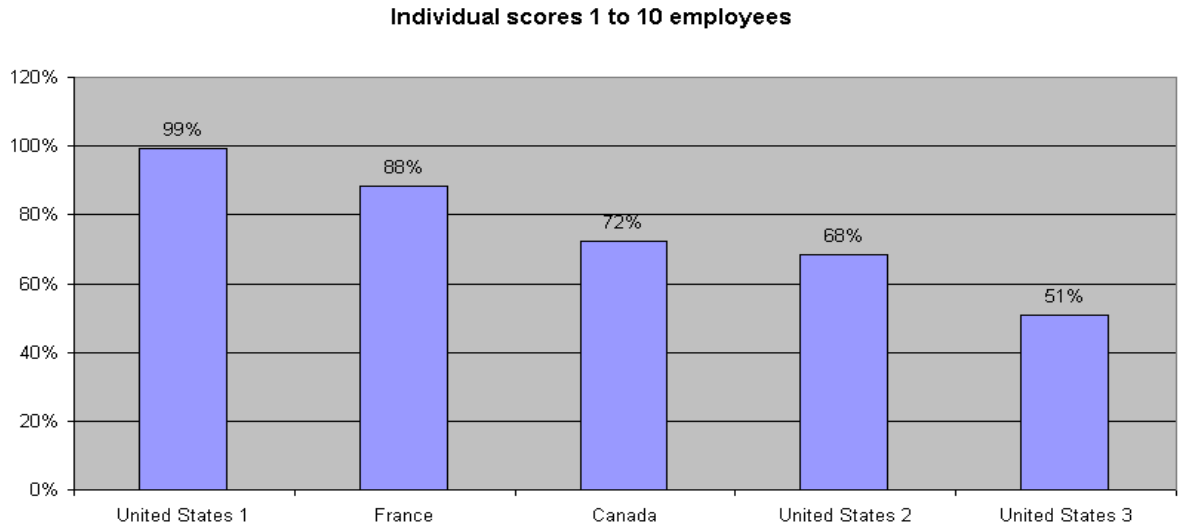


Figure 105. Individual scores 1 to 10 Employees.

Of the industries with only 1 to 10 employees a company from the United States scored the highest with almost a perfect score of 99%. The median score was the highest here at 72%

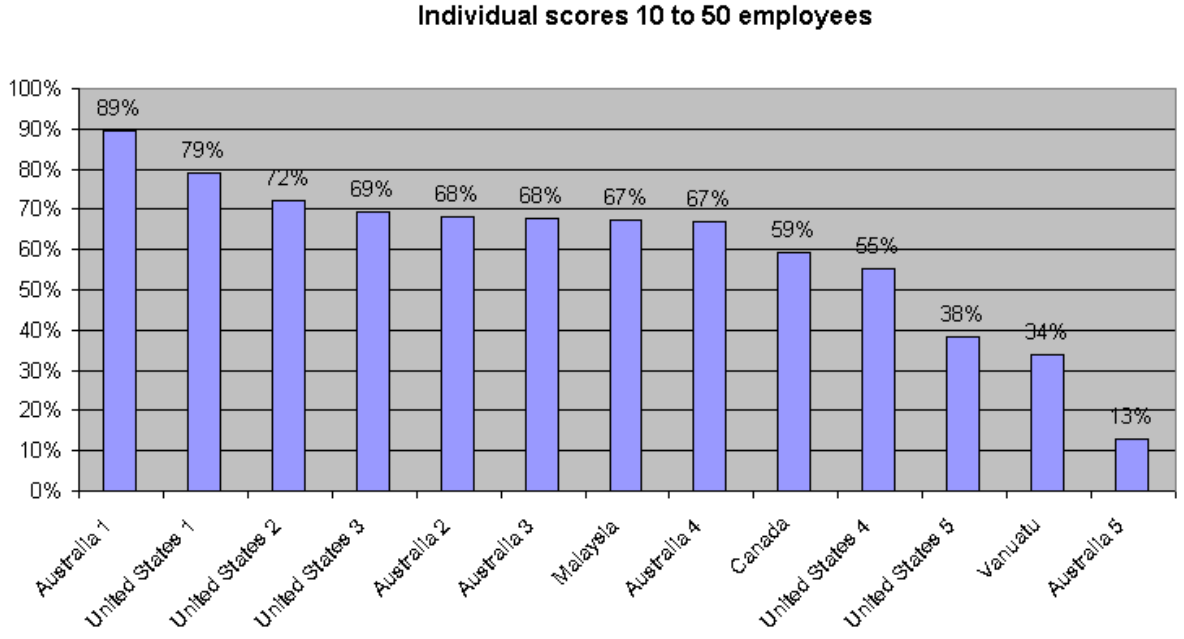


Figure 106. Individual scores 10 to 50 employees

The high score in these small companies with 10 to 50 employees was 89% with a low score of 13%. The median score is 67%

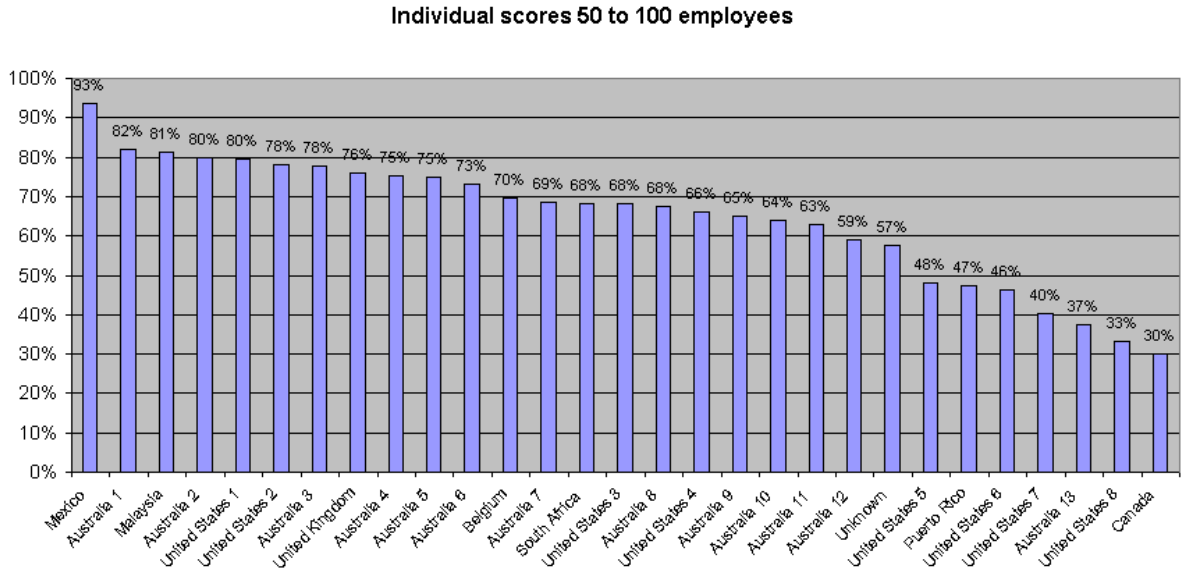


Figure 107. Individual scores 50 to 100 employees.

There was one standout company from Mexico in this group with a score of 93%. The median score for this group is 63%.

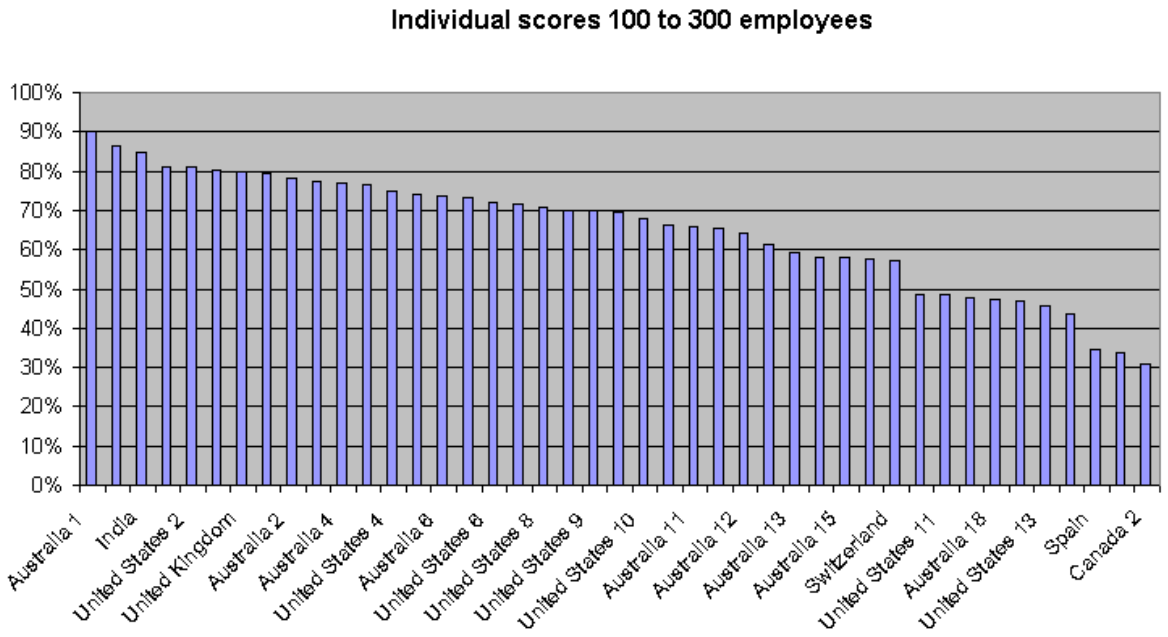


Figure 108. Individual scores 100 to 300 employees.

Companies or business units with 100 to 300 employees had the most responses in the part of the survey. The high score came from an Australian company that scored itself as 90% where at the other end of the scale is a Canadian company scoring 31%. The median score here is relatively high at 69%.

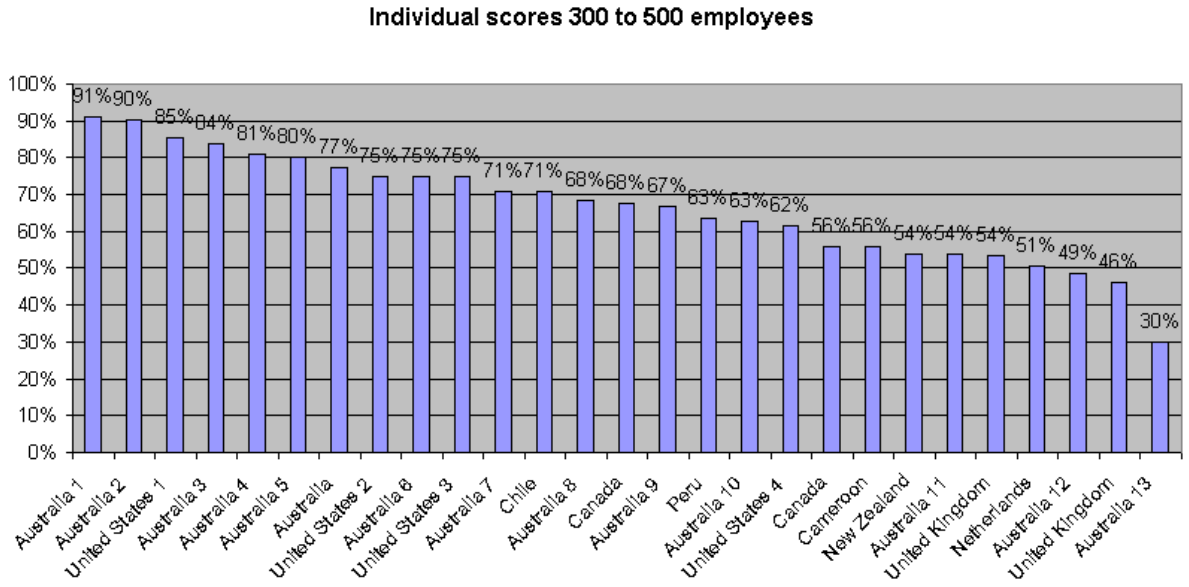


Fig 109. Individual scores 300 to 500 employees.

The highest score in this sector was an Australian company with a 91% rating. The median score for this group is relatively high at 68%.

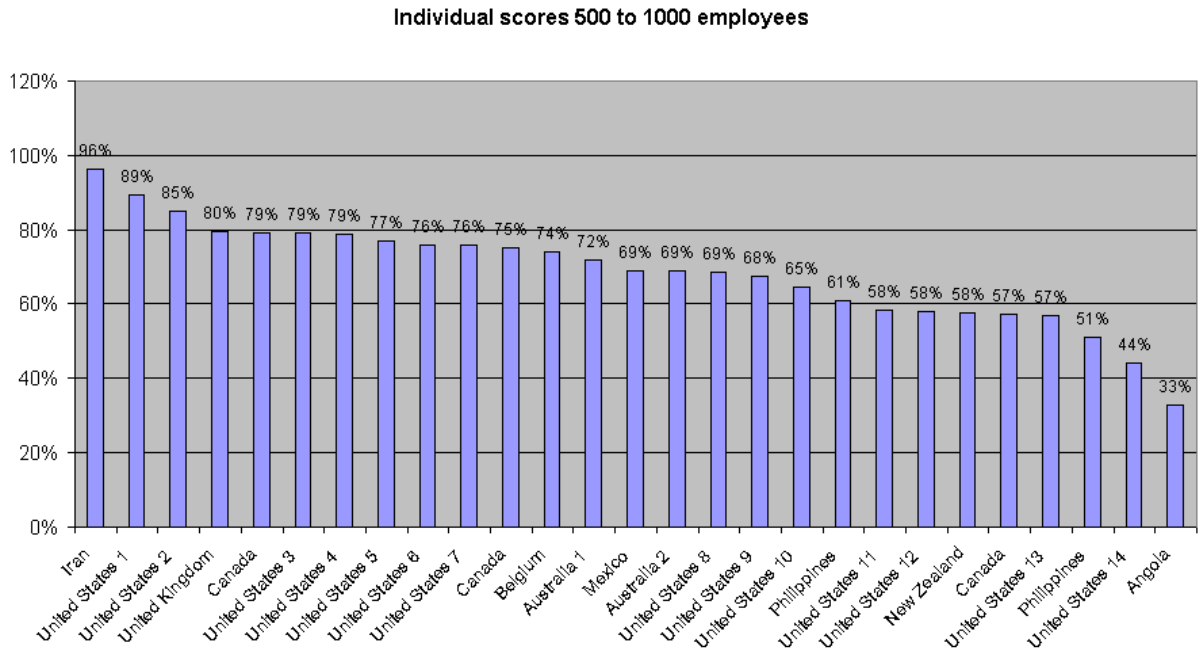


Figure 110. Individual scores 500 to 1000 employees

The highest score in this sector was from a company in Iran with 96%. The median score for this group was also high at 69%.

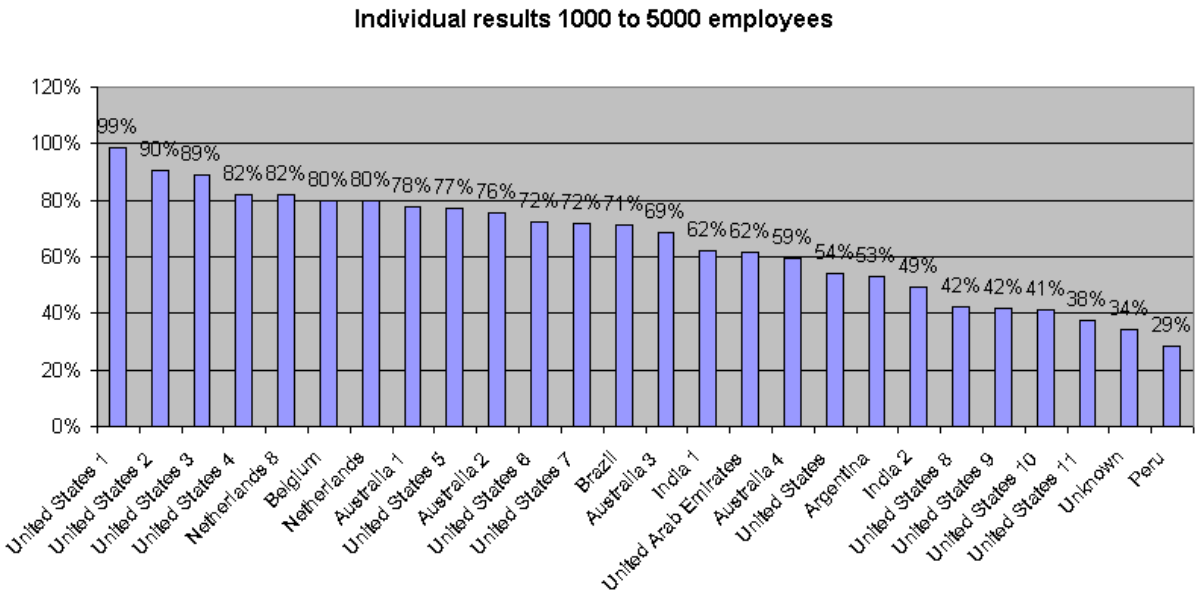


Figure 111. Individual scores 1000 to 5000 employees

The high score in this group was 99% and came from a company in the United States. The median score for this group was 70%.

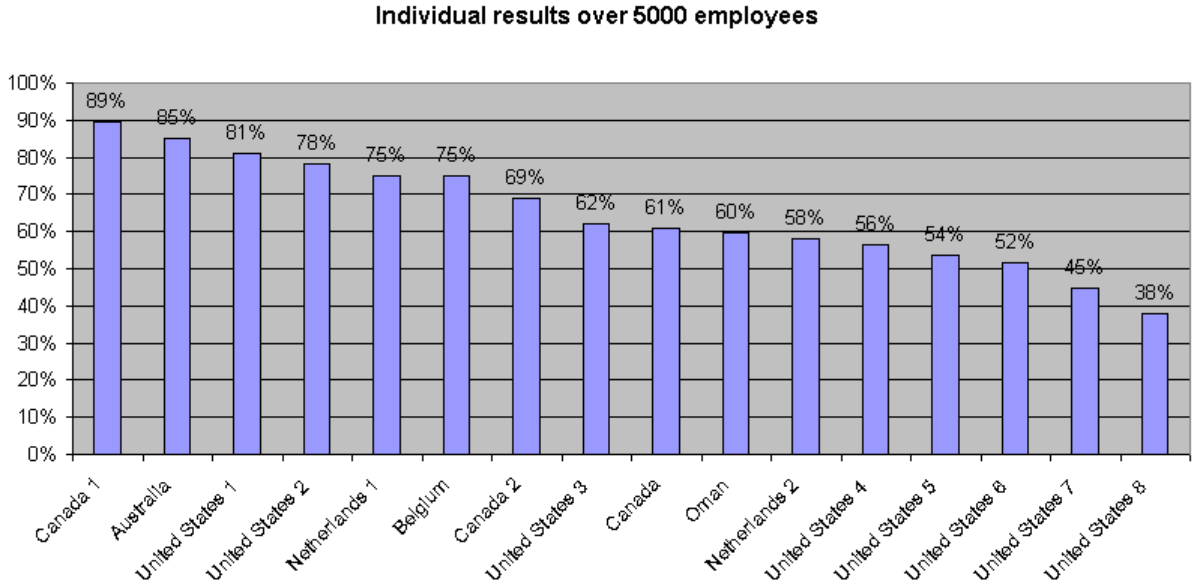


Fig 112. Individual scores over 5000 employees

The high score for the largest businesses was from a Canadian company at 89%. The median score was the lowest by far at 62%. Does this indicate that the largest of businesses are the least efficient at asset management?

Conclusions from Individual results analysis.

As mentioned in the beginning of this chapter the type of industry or size of industry does not make them any better than any other. There is a significant variation in scores regardless of the way the data is presented. To take this further business units within the same company also can have significant variation in how well they manage their assets. This can be seen in the Onesteel results where the scores ranged from 58% to 78%. So how do these results help the reader? It shows that any type and size of company can be excellent at asset management if the right conditions are in place to encourage it. So for all those who say, “We’ve tried that before but we’re different and it doesn’t work here”, It can be done with the right resources driving the Asset management Improvement process. The information contained in this survey should help each business understand where they can improve, and indicates that it can be done.

Assessment of Sub theme’s within the Survey.

Within each group of questions in the survey there were a number of sub theme’s within the question groups. The following assessment has been built from the following question types:

- Management.
- The Organisation Structure
- Plant Operations
- Materials management.

Assessment has only been completed on Industries types where three or more responses were gathered. This includes the following industries:

- Steel
- Power Generation
- Utilities
- Pharmaceutical
- Aluminum
- Petrochemical
- Manufacturing
- Offshore
- Automobile/truck
- Paper and forestry
- Mining.

Assessment of answers about management.

The following graph highlights the range of scores for the management questions within the survey. The management questions in the survey were gauging management support and understanding of lubrication, condition monitoring, the work management process, strategy development, the value of maintenance standards and practices, Process Audits, Shutdowns and maintenance KPI's.

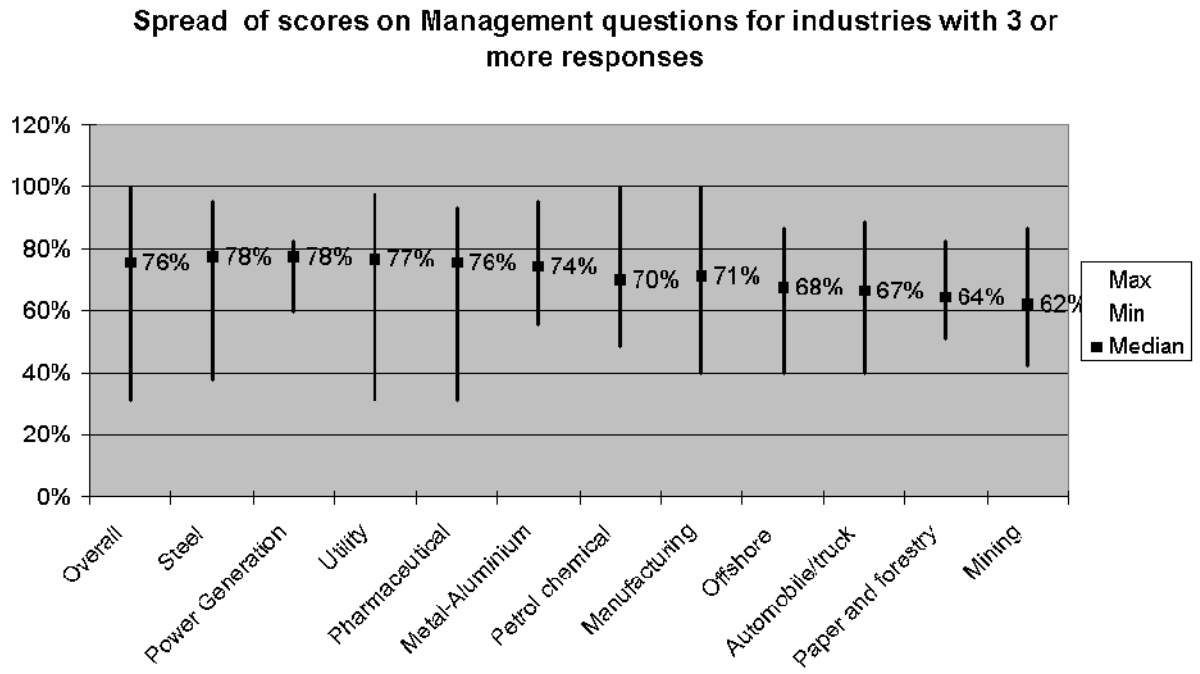


Figure 113. Management sub theme scores.

Although there was a large spread of responses between 31% and 100%, the total median score was 76%, with the highest score coming from the Steel industry at 78%. If there is any concern about not having management support then the results from the management questions should allay any fears. With median results ranging from 78% down to 62% there is clear evidence here that management understands the importance of Asset Management.

Assessment of questions about the Organisation.

The questions related to the organisation focus on having dedicated resources for lubrication, condition monitoring and shutdown management, the level of qualifications held by trades people, the level of training received in the use of the CMMS for operations and maintenance, the definition of roles and responsibilities in the work management process, and finally determining who is responsible for strategy reviews.

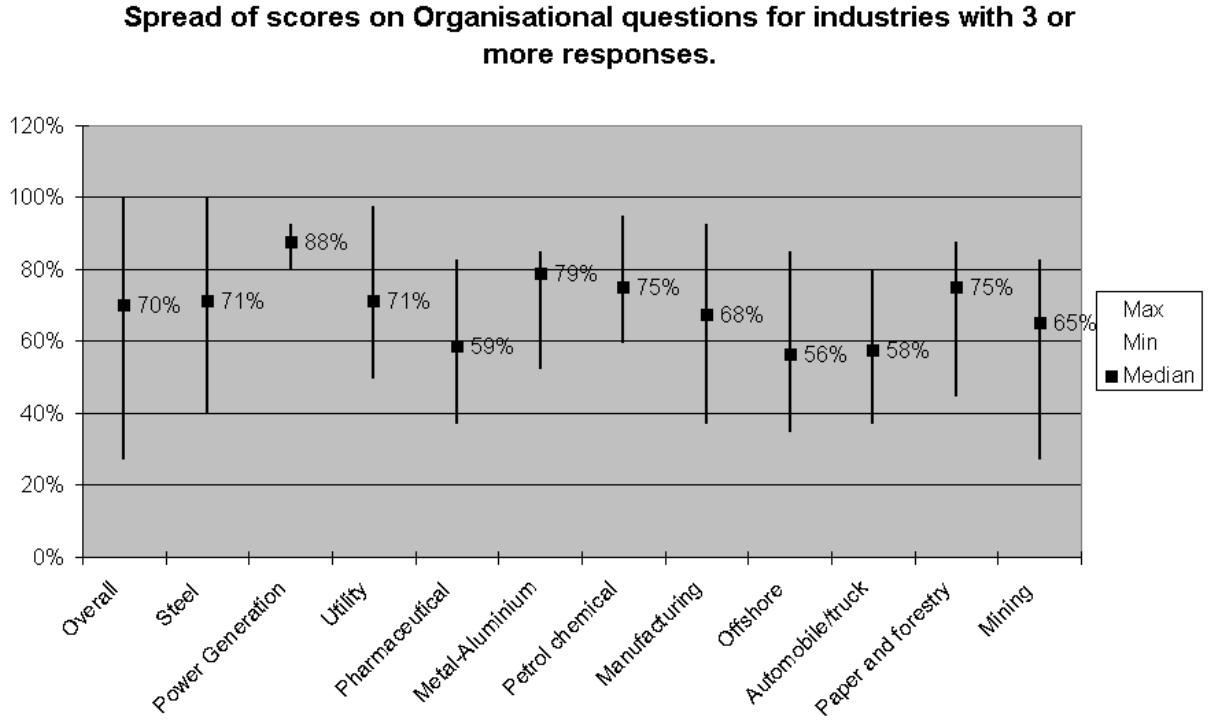


Figure 114. Organisation sub-theme scores.

There was a range of total average scores between 28% and 100% for these industry segments, with the median score being 70%. The highest median score here was 88% in the power generation sector with a low of 56% being obtained by the Offshore industries.

Assessment of questions about the Operations Departments.

The questions related to operations departments focus on the level of basic care completed by operations, operational practices, understanding and use of the work management process, understanding production losses, and the level of training in asset management processes.

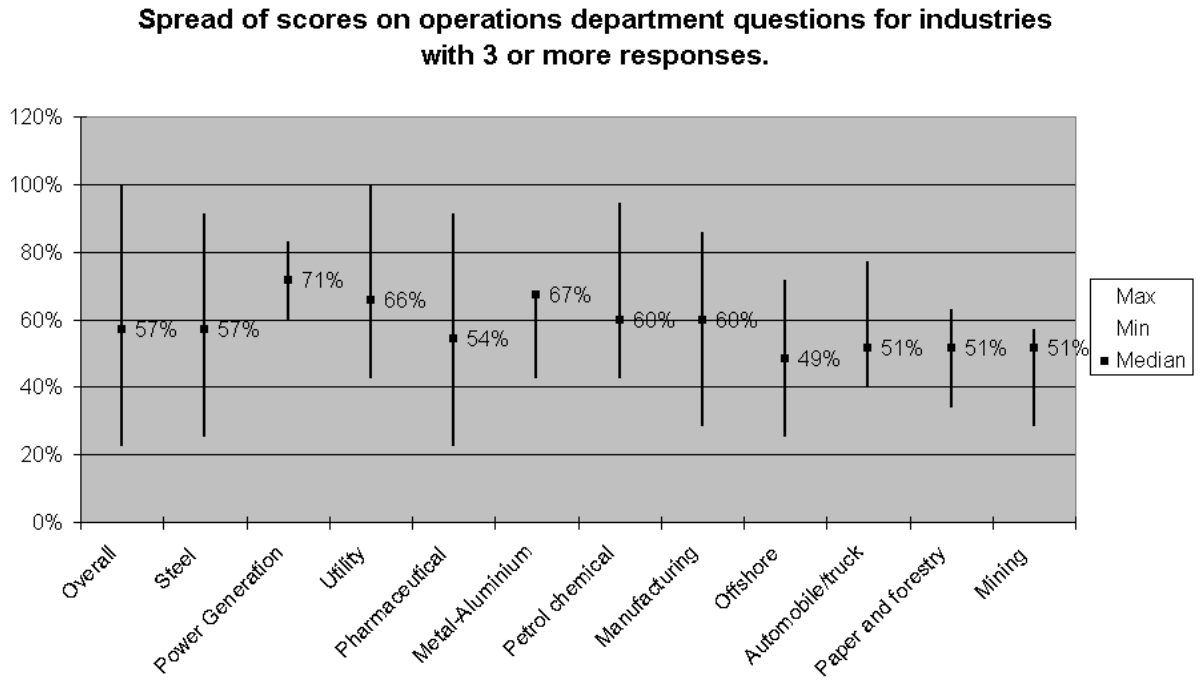


Figure 115. Operations Department sub-theme scores.

The overall scores in the operations based questions were very low with the overall median score being 57%. The only median score over 70% was in the power generation sector, with 6 of the eleven industry sectors scoring below 60%. These figures clearly point to Operations not valuing the reliability and maintenance of their assets. Considering all aspects of this survey this is the one area where significant improvements can be made in all industry sectors. Operations departments have to build ownership of both there process output and equipment reliability.

Assessment of questions about Materials Management.

The questions related to material management include issues related to storage and cataloguing of lubricants, storage practices and the building of Bills of Materials.

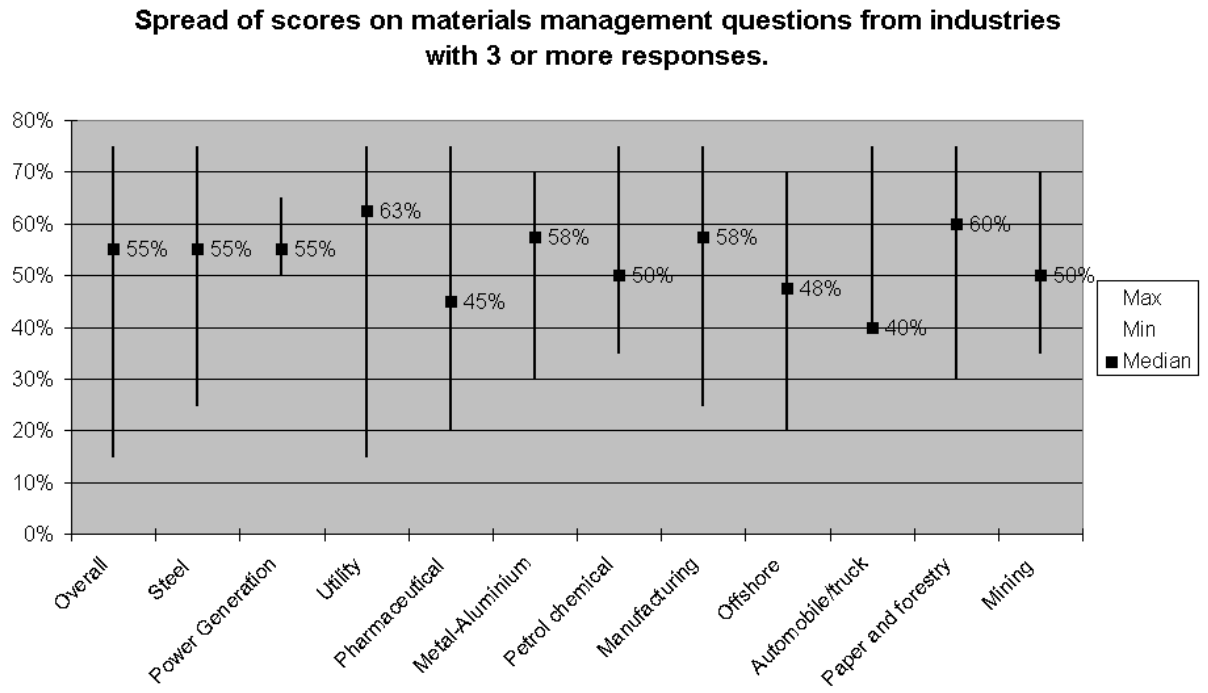


Figure 116. Materials Management sub-theme scores.

The median scores for the materials management questions were the lowest of all sub themes reviewed with a total score of 55%. There was no real stand out scores in any industry sectors with Utilities having the highest median score of 63%. This presents more opportunity for many industries in the areas of building on their bills of materials and improving storage practices, so stored equipment is fit for purpose. Improved bills of materials will improve the planning function, which will lead to more efficient and effective execution of maintenance tasks.

Feedback from the Survey.

The survey results were extracted from the survey software on the 3rd of September 2009 and at that time there had been 251 responses with a total completion ratio of 73%. Considering the survey was quite long this is considered a good result. The survey will be left open until May 2010, which will then be a total of 12 months. At that time the survey results will be reviewed to determine if there are any shifts in the trends. The survey can be taken at the following web address: http://www.surveymethods.com/EndUser.aspx?B793FFE2B4F3E1E6 **Question 63** of the survey asked for contact details of those that would like feedback from the survey. The respondent who left their email details will be sent a copy of the report and will be able to request specific details on how their company compared to all other respondents by direct request to the Author.

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

Mark Brunner
Oct 2009.

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