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Maintenance Planning and Scheduling Online Distance Education Training Course by Lifetime Reliability Solutions

Module 1 Assignment 2 – Introduction to Equipment Criticality

This assignment aims to introduce you to the concept of identifying and grading operational risk from plant and equipment failure. When the operating risk is too high it becomes necessary to reduce that risk. The process of identifying the operating risk is called Equipment Criticality.

You should do the assignment using one of your own machines and your company's real failure costs and historical failure rates. But if you cannot do that then use the example in the course book.

Once you have an Equipment Criticality rating that needs to be lowered you will use your experience, your network of people, and/or do extra research to select things to do to reduce the level of risk. But how do you know that what you chose to do will truly and honestly reduce that risk?

In creating this assignment I wanted to help you to learn 1) the basics of how to determine the current operating risk with acceptable accuracy, and 2) to give you a way to be confident that what you suggest as a risk mitigation or risk abatement will have the required effect in real life. Much of what we do in maintenance is totally a waste of time because it does not reduce the risk it is meant to address. I do not want you falling into the same trap of wasting time and money so many others have fallen into.

The course book presents you with the table in Figure 1 partially completed to give you an idea of what you will need to do in your assignment. Let me explain each column.

Activity 2 – Equipment Criticality

Using the risk matrix over the page, complete the criticality rate columns (E, H, M, L) for the mining truck and select the maintenance to apply and the operating practices to use.

Component	Sub-Component	DAFT Cost Rating			Likelihood	Criticality by Risk Matrix	Required Operating Practice	Required Maintenance	Criticality after Mitigation
		Total Loss Cost $	Partial Loss Cost $	Time to Rebuild Days	Failure Rate - MTBF From CMMS Equipment History				
Engine		500,000			1 in 20,000hr	E	Prevent overloading truck and over-revving motor	Oil/Wear Debris Analysis every 500hr	
	Fuel system		50,000	23	1 in 30,000hr	M	Fill with only clean and water-free fuel	Inspect and test fuel system at service, replace filters.	
	Crank and pistons		100,000	14	1 in 50,000hr	M	Prevent overloading motor	Oil/Wear Debris Analysis every 500hr	
	Engine block		250,000	28	1 in 100,000hr				
	Cooling system		50,000	15	1 in 10,000hr				
	Oil system		100,000	15	1 in 20,000hr				
	Ignition system		30,000	15	1 in 30,000hr				
Gearbox		100,000			1 in 50,000hr				
	Input shaft		20,000	15	1 in 100,000hr				
	Internal gears		55,000	38	1 in 10,000hr				
	Output shaft		15,000	15	1 in 20,000hr				
	Casing		50,000	60	1 in 30,000hr				

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Figure 1 – Maintenance Planning and Scheduling Course Book Equipment Criticality Table

Your operational assets are made of working systems that are made of assemblies of components. Once an assembly fails so does the asset (Actually the real event tree will be: individual part failure > sub-assembly failure > assembly failure > system failure > equipment failure > operation stoppage). To identify the risks

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your operating equipment carry's first needs you to identify the assemblies and sub-assemblies that will fail. Columns 'Component' and 'Sub Component' makes us break-down the operating asset into the bits of it that fail.

Secondly you need to determine the risks to your company when a failure happens. Risk is usually calculated from:

Risk $/yr = Consequence ($) x Frequency of Failures (/yr)

The equation can also be written as:

Risk $/yr = Consequence ($) **x Likelihood** (/yr) (of Failures)

In the course I mix up the versions of the risk equation on purpose so you see them and can recognise them as meaning the same thing. The full risk equation is:

Risk $/yr = Consequence ($) x [No of Failure Opportunities (/yr) x Chance of Failure]

Consequence ($) is the full business-wide cost impact calculated in a DAFT Cost table

Frequency (/yr) = **Likelihood** (/yr) = **[No of Failure Opportunities** (/yr) **x Chance of Failure** at each Opportunity**]**

Somehow we need to turn that equation into columns in a **Operating Asset Risk $/yr** table i.e. a Equipment Criticality Table. Hence the 'DAFT Cost Rating' and 'Likelihood' Columns are included in the table of Figure 1.

DAFT Cost is the cost that you must use for each equipment failure because your business will pay all that money once the failure happens. Determining DAFT Cost is a lot of work and unless your accounting system calculates it for you, you will never have time to identify the DAFT Cost for every sub-assembly failure. The easiest way is estimate DAFT Cost is to calculate the direct maintenance cost (spares, labour, freight, overheads) to repair, reinstall the sub-assembly and return the equipment to operational condition multiplied by a value by 10 times. (I have seen a ratio of Direct Maintenance Cost to DAFT Cost as high as 30 times; but times 10 makes calculation of DAFT Cost from Direct Maintenance Cost easy and the answer is adequately close for us to use in a risk matrix.)

Determining Likelihood value is the tricky part. Recall that Likelihood is Frequency (of Failure) and the Frequency is simply the number of times a particular assembly or sub-assembly has failed **in the operation** for which you are doing the Criticality Analysis. You get the Frequency from the historical records of failure kept by the operation—usually from the asset's work order history.

The Likelihood needs to reflect operating lifetime. A pump that runs 10 hours a week will clock up 520 hours of operation a year. If it historically fails once every ten years then the Likelihood of Failure is 1 in 5,200 hours (of operation), and also 1 in 87,600 hours of real time (24 hr/day x 365 day/yr x 10 yr). In the Risk Matrix of Figure 2 the Likelihood Scale uses 'real time'.

Your own company will have a calibrated risk matrix of its own, but if you do the assignment in the course book you can use Figure 2. With the DAFT Costs and the failure frequency known you can identify the current operating risk level for the asset on the matrix i.e. Extreme, High, Medium, Low.

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E – Extreme risk – detailed action plan required
H – High risk – needs senior management attention
M – Medium risk – specify management responsibility
L- Low risk – manage by routine procedures

Extreme or **High** risk must be reported to Senior Management and require detailed treatment plans to reduce the risk to **Low** or **Medium**

	Consequence				
People	Injuries or ailments not requiring medical treatment.	Minor injury or First Aid Treatment Case.	Serious injury causing hospitalisation or multiple medical treatment cases.	Life threatening injury or multiple serious injuries causing hospitalisation.	Death or multiple life threatening injuries.
Reputation	Internal Review	Scrutiny required by internal committees or internal audit to prevent escalation.	Scrutiny required by clients or third parties etc.	Intense public, political and media scrutiny. E.g. front page headlines, TV, etc.	Legal action or Commission of inquiry or adverse national media.
Business Process & Systems	Minor errors in systems or processes requiring corrective action, or minor delay without impact on overall schedule.	Policy procedural rule occasionally not met or services do not fully meet needs.	One or more key accountability requirements not met. Inconvenient but not client welfare threatening.	Strategies not consistent with business objectives. Trends show service is degraded.	Critical system failure, bad policy advice or ongoing non-compliance. Business severely affected.
Financial	$10K	$30K	$100K	$300K	$1,000K
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
	1	**2**	**3**	**4**	**5**

Likelihood	Probability	Historical	Time Scale						
	>1 in 10	Is expected to occur in most circumstances	Once per year	5	**Almost Certain**	**M**	**H**	**H**	**E**	**E**
	1 in 10 - 100	Will probably occur	Once every 3 years	4	**Likely**	**M**	**M**	**H**	**H**	**E**
	1 in 100 – 1,000	Might occur at some time in the future	Once per 10 years	3	**Possible**	**L**	**M**	**M**	**H**	**E**
	1 in 1,000 – 10,000	Could occur but doubtful	Once per 30 years	2	**Unlikely**	**L**	**M**	**M**	**H**	**H**
	1 in 10,000 – 100,000	May occur but only in exceptional circumstances	Once per 100 years	1	**Rare**	**L**	**L**	**M**	**M**	**H**

Adapted from AS 4360-2004 Risk Management ***(Now Superseded by ISO 31000)***

Figure 2 – Risk Matrix (Log-Log Scale)

At this point you have completed a Equipment Criticality. Though you have not done a thing to reduce the real operational risk, you at least now know your true business risk from an asset's failure.

In the assignment you next need to come up with ways to reduce the risk to each subassembly. As a consequence of removing risk to all sub-assemblies you also reduce risk to the major assembly they belong to and hence to the whole item of equipment. Anything above Low (L) needs to be mitigated and abated down to Low if possible (the rule of thumb is to get at least two levels of risk lower than where you are currently).

After having selected your mitigations and abatements you have to prove that they will actually be effective. The final 'Criticality after Mitigation' column is where you record the risk level that SHOULD result IF the abatements are actually done in the real world. For a mitigation to be claimed as truly effective it must deliver at least one of the following results (to gain ground in all four areas of improvement would be best, but to get any one of the gains is still a good outcome from your risk abatement activities):

a) Substantially lower the operating stress in the part (to me 'substantially' less stress means to reduce stress by more half the current stress level that is causing the part to be failed.)

b) Substantially remove the possibility for human error (to me 'substantially' less chance of human error is to reduce the chance of error by an order of magnitude, i.e. ten times less)

c) Substantially reduce consequential DAFT Costs (to me 'substantially' less DAFT Costs is to more than halve the consequential cost when a failure happens)

d) Substantially reduce the likelihood of a failure event arising in the first place (to me 'substantially' reduced likelihood is to reduce the chance of an event by an order of magnitude, i.e. ten times less)

The assignment does not introduce to all the detailed aspects of risk analysis and management. For that you should use the international standard 'ISO 31000 Risk Management—principles and guidelines' to learn how to do a fully encompassing risk assessment and analysis.

Good luck with the assignment and let me know if you have questions.

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May 2012