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Equipment Criticality Tutorial

This is a brief tutorial on doing an equipment risk assessment to identify equipment criticality. It is a summary of the complete Operating Risk Assessment Tutorial available to buy at the Lifetime Reliability Solutions online Web store.

Developing an equipment risk profile is known as Equipment Criticality. It uses the risk formula to identify the business financial impact if an equipment failure was to happen – it is a risk rating indicator.

Equipment Criticality = Failure Frequency (/yr) x Cost Consequence ($) = Risk ($/yr)

The 'cost consequence' is usually the costs of lost production plus the costs of repair which, Defect and Failure True Costing warns us, is often well short of the true business-wide cost. The 'failure frequency' is from the company's maintenance history, or industry norms for a similar situation.

Standard equipment criticality is also used to rate equipment in priority order of importance to the continued operation of a facility. Equipment that stops production, or that causes major production costs when failed, is considered most critical. Once criticality is known the facility's resources, engineering effort, operations practices, maintenance and training are matched to the priority and importance of the item's continued operation. The Plant and Equipment Wellness approach to equipment criticality differs from the standard approach by using the business-wide Defect and Failure True (DAFT) Costs, and not only production impact, to gauge business risk from equipment failure.

A key premise of the Plant and Equipment Wellness is that we are building a world-class business, and to make the right business decision it is necessary to know the business-wide losses, and not simply the production losses, of a failure. Unless the true and total business-wide costs are included in determining equipment criticality, the full risk of an equipment failure to the business is not recognised. Using DAFT Costing gives a more accurate value of consequential loss to the whole business and so a truer business risk is determined.

A competent team of people is drawn together to identify the equipment criticality for a facility. Normally a database of DAFT Costs is first developed. The database is used to populate calculation spreadsheets and makes the analysis quicker and easier. Typically the review group consists of the operators, maintainers and designers of the plant who contribute their knowledge and experience.

The group reviews drawings of the facility's processes and its equipment. Equipment by equipment they analyse the consequences of failure to the operation and develop a table showing each equipments criticality rating. It is the practice that the final arbiters of a choice are the Operations or Production Group, since they must live with the consequences and costs of a failure.

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Risk Matrix Calibration

The persons involved with the risk assessment need to -

a. Understand the equipment operation and design – operator manuals, maintenance manuals and design drawings contain this information.

b. Understand the impact on production of losing the equipment. The information is in plant drawings, Process Flow Diagrams (PFD), Process and Instrumentation Diagrams (P&ID).

c. Know the business-wide financial loss from a forced outage. The DAFT Cost losses for a typical downtime period must be quantified.

d. Know the effects on business reputation and the impact on Clients of forced outages.

e. Review and adopt the risk control methodology in international risk management standards, such as ISO 31000 – Risk Management, or its other international equivalents.

f. Calibrate the consequences on the Risk Matrix using the information developed from the above and the advice of experienced and senior persons in the operation under review.

Asset Assemblies and Components

In order to understand the knock-on consequences of failed assemblies in the equipment, whose failure may have little effect or may contribute major cost, each asset is subdivide into its major assemblies. If major assemblies contain substantial numbers of individual equipment, then these are further divided into sub-assemblies.

Risk Assessment

The Risk Identification and Assessment Template is used to find and list the operating risks to each equipment, assembly and sub-assembly. Alternately, a spreadsheet is developed to replace the template. The risk matrix shown in Table 1 is an example and you will need to develop a risk matrix specifically applying to your business. For equipment and assemblies under assessment use the calibrated Risk Matrix to categorise Consequence (1-5), Likelihood (1-6) and Risk Level (L, M, H, E) from each risk.

Risk Management

For High and Extreme Risk Levels use the Risk Treatment Schedule and Action Plan Template to list actionable activities that will reduce risk by at least two levels. For Medium Risk Levels identify actions that will reduce them to Low. A Failure Mode Effects Analysis or Reliability Growth Cause Analysis is used to identify required risk management activities to sufficiently lower the risk levels of individual parts.

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The Risk Matrix

Knowing the ‘consequence’ and ‘frequency’ allows development of a risk ranking table for an operation. Table 3 is a risk matrix used to gauge the level of risk in a business. It is developed using the recommendations of international risk management standards.

RISK MANAGEMENT PHILOSOPHY	Business-Wide Consequence					
E – Extreme risk – detailed action plan approved by CEO **H – High risk – specify responsibility to senior manager** **M – Medium risk – specify responsibility to department manager** **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**	**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	**$5K**	**$50K**	**$100K**	**$250K**	**$500K**
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**

Historical Frequency:			1	2	3	4	5
Event will occur at this site annually or more often	6	**Certain**	**M**	**H**	**H**	**E**	**E**
Event regularly occurs at this site	5	**Likely**	**M**	**M**	**H**	**H**	**E**
Event is expected to occur on this site	4	**Possible**	**L**	**M**	**M**	**H**	**E**
Event occurs from time to time on this site	3	**Unlikely**	**L**	**M**	**M**	**H**	**H**
Event occurs in the industry, and could on this site, but doubtful	2	**Rare**	**L**	**L**	**M**	**M**	**H**
Event hardly heard of in the industry. May occur but in exceptional circumstances	1	**Very Rare**	**L**	**L**	**L**	**M**	**H**

Table 1 – Risk Matrix for determining the Risk Level

The business-wide consequences for people, reputation, business processes and systems, and financially are explained and scaled to reflect the organisation under review. The methods and principles to apply in addressing risk can be advised in the Risk Management Philosophy box to the left of the matrix. The risk matrix is used to gauge whether an item or situation is at low, medium, high or extreme risk. Extreme and high risk are reduced to medium and low

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respectively, and medium level risk is reduced to low. The numbers corresponding to each level of likelihood and consequence can be added together to provide a numerical indicator of risk. This is often useful for comparing dissimilar risks to set priorities, and when a simple means, not involving mathematical calculation, is needed to give each risk a representative value.

Identifying events and grading their risks is done using Table 2.

Equipment or Assembly	**The Event or Failure** *What can happen?*	**Source** *How can this Happen?*	**Impact** *from event happening*	**List Current Control Strategies** *and their effectiveness* (A) –Adequate (M) – Moderate (I) – Inadequate	**Current Risk Level**			**Acceptability (A/U)**
					Likelihood	**Consequence**	**Current Risk Level**	
1	2	3	4	5	6	7	8	9

Table 2 – Risk Identification and Assessment

Table 3 is used to find strategies and actions to mitigate the risk, and to judge their effectiveness. At the end of the review the risks and the mitigation actions are transferred into a Risk Management Plan spreadsheet, such as that for plant and equipment available with the full Operating Risk Assessment Tutorial.

Equipment or Assembly Risk	**Potential Treatment Options**	**Costs & Benefits**	**Additional Treatments to be Implemented** (Y/N) *and their effectiveness* (A) –Adequate (M) – Moderate (I) – Inadequate	**Risk Level After Implemented**			**Responsible Person**	**Timetable** *to implement*	**Monitoring** *strategies to measure effectiveness of risk treatments*
				Likelihood	**Consequence**	**Target Level**			
1	2	3	4	5	6	7	8	9	10
		FINAL Cumulative Risk Level after Treatment							

Table 3 – Risk Treatment Schedule and Action Plan

Table 4 shows a criticality rating for a family car which uses the Plant Wellness equipment criticality method. The analysis starts by identifying the DAFT Costs for a total failure of each major assembly and its main sub-assemblies. It is also useful to note the length of time taken to recover from an incident. Often the opportunity loss caused by the downtime is a more critical factor than the cost of repair. For this example the risk matrix of Table 1 is recalibrated at $20 for 'Insignificant' and increasing in multiples of ten. The risk matrix is used to determine the risk rank and a total risk number. For example, the fuel system has a

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moderate cost of $1,500 if it fails (nearest consequence value is 3), with a rare chance of failure (frequency value 2).

In the table there is a DAFT cost of $20,000 for damage to the car body that is a substantial cost to its owner. It is also the highest risk number because road accidents are possible (frequency value 4). Damage to the chassis, from road accidents or running over curbs, comes next at $15,000 to repair. Broken suspension cost of $8,000 is third. The engine at $6,000 is not the most expensive failure, but there is an annoying time delay in getting the car back on the road if key engine components are damaged.

The standard equipment criticality rating would not have produced such a thorough understand of the failure consequences to the organisation (a family in this example). Having a real cost of failure provides greater insight into the full impact of a risk. The biggest risks are from car accidents and uncaring drivers who do not respect the vehicle. The best strategy to minimise risk is to ensure drivers have high driving skills, along with good road sense and attitudes. They could be sent to a defensive driving school to learn accident evasion techniques. The mechanical and electrical equipment in the car is best protected from failure by good driver education of how a car and its parts work, along with regular servicing and inspection. The service organisation will need to do a wide range of inspections and the selection of the service provider is based first on how comprehensive and competent is the service they offer, followed by their cost.

Component	**Sub-Component**	**DAFT Cost Rating**			**Criticality By Risk**		**Criticality by DAFT Cost**	**Required Operating Practice**	**Required Maintenance**
		System Loss Cost $	Assembly Loss Cost $	Time to Recover Days	Rank	Number			
Engine		6000		21	Medium	6	6000		
	Fuel system		1500	3	Medium	5	1500	Monitor operation	Regular service of parts
	Crank and pistons		3000	21	Medium	5	3000	Monitor operation	Replace at end of life
	Engine block		3500	21	Medium	5	3500	Monitor operation	Replace at end of life
	Cooling system		1500	5	Low	5	1500	Monitor operation	Regular service of parts
	Oil system		1000	5	Low	5	1000	Monitor operation	Regular service of parts
	Ignition system		1500	5	Low	6	1500	Monitor operation	Regular service of parts
Gearbox		5000		28	Medium	5	5000		
	Input shaft		1000	5	Low	4	1000		Regular service of parts
	Internal gears		2500	28	Low	4	2500		Regular service of parts
	Output shaft		1500	5	Low	4	1500		Regular service of parts

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	Casing		3000	28	Low	4	3000	Monitor operation	Regular Inspection
Drive Train		2500		28	Medium	7	2500		
	Drive shaft		1000	14	Low	4	1000	Monitor operation	Regular Inspection
	Differential		2500	28	Medium	5	2500		Regular service of parts
	Axel x 1		1500	14	Low	4	1000		Regular Inspection
	Wheel x 1		1000	3	Medium	5	1000	Monitor operation	Regular Inspection
Car Body		20000		54	High	8	20000		
	Dash display		4000	28	Medium	5	4000	Monitor operation	Regular Inspection of condition
	Electrical system		4000	14	Medium	6	4000	Monitor operation	Regular Inspection
	Lights		1000	5	Medium	6	1000	Monitor operation	Regular Test
	Window x 1		1000	5	Medium	6	1000	High driving skills	Regular Inspection
	Door x 1		2000	14	Medium	6	2000	High driving skills	Regular Inspection for corrosion
	Panel x 1		3000	14	Medium	6	3000	High driving skills	
	Chassis		15000	54	High	7	15000	High driving skills	Regular Inspection for corrosion
Suspension		8000		28	Medium	5	8000		
	Shock absorbers		1000	3	Medium	4	1000	Monitor operation	Replace at end of life
	Springs		1000	5	Medium	3	1000	Monitor operation	Replace at end of life
	Assembly x 2		5000	28	Medium	5	5000	High driving skills	Regular Inspection for damage

Table 4 - Plant and Equipment Wellness Criticality Analysis for a Motor Car

Using DAFT Cost shows that the failure cost of parts not considered important by the standard equipment criticality rating methods is actually very high. These parts received little attention in the standard criticality rating method because a low frequency implies few failures. People consider them as a lower importance because of their supposedly low risk. The DAFT Cost approach warns that though the equipment may not fail often, when it does, it will be expensive and have destructive consequences for the owner. By reviewing the cost of failure independently of the chance of the failure, the DAFT Cost equipment criticality approach makes clear just how bad each failure would be unless adequately prevented from happening.

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The Plant Wellness equipment criticality process also determines where responsibility lays for protecting equipment from harm. From the type of failure it is clear if the operator or maintainer needs to conduct mitigation. Management of the risk by proper operation, or by proper maintenance, or by re-engineering becomes self-evident. In the car example, only the driver (the operator) can prevent an accident. Only the driver can steer the car so that it does not go over a curb and destroy the suspension. The maintainer cannot prevent such failures. Only for preventive maintenance, or after equipment damage, is the maintainer involved. For the family car, the risk management plan involves having a skilled operator (the driver) who knows how to drive well and does not put the car into situations risking damage. Regular servicing of the car and its systems are important, as well as the driver noticing when things are not working properly and reporting them for rectification before a full failure develops. Knowing the full and real cost of a failure can help validate additional training, the purchase of new test equipment and changes to procedures not justifiable with traditional equipment criticality rating methods that under value risk.

You can get the complete Equipment Criticality and Equipment Risk Assessment Tutorial at the Enterprise Asset Management Online Store.

If you have any questions please contact us.

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