



DIAM Program – Desktop and Tablet

Application to investigate and mitigate problems in Nuclear Power Plants

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Background



- Energiforsk Vibrations R&D program
- Participants from Nordic NPP operators
- Idea for DIAM Excel tool by Paul Smeekes from TVO
 - Systematical problem solving approach
 - Increase and knowledge transfer
- Master's thesis and R&D projects developing the Excel tool
 - Pipe vibration Mikko Merikoski
 - Turbine and generator vibrations Rainer Nordmann
 - DIAM-matrices for EDG vibrations Antti Kangasperko and Wärtsilä
- After these projects the matricies were tuned by the Energiforsk Vibration group



DIAM Description



- General problem solving process
- DIAM stands for:
 - Detection
 - Investigation
 - Analysis
 - Mitigation
- Provides systematic approach to investigate anomalies
- Probability based suggestions for further actions are based on the weight function method





Responsible party:

Power plant personnel

Supplier / 3rd Party



DIAM Problem solving with Excel



- One excel covers one type of component or problem
- Each step is associated with a matrix
- During a step necessary markings are made
- Markings affect the probabilities in current and further steps
- 1) Detection: Indicate anomalies
- 2) Investigation: Study suggested methods, perform investigations and indicate findings
- 3) Analysis: Study suggested analysis methods
- 4) Mitigation: Based on the analysis indicate the root cause of the problem. Possible mitigations are suggested.





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	А	В	С	D	Е	F	G	Н	1	J	Κ	L	М	Ν	0	Ρ	Q	R	S	Т	U	V	W	Х	Υ	Ζ	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AL	AM	AN	AO	AP
1				Anom	Anomalies detectable by sensors						Anomalies detectable by human senses							Anomaly location																							
2			•																																<	Mark	here '	'x" if not	used in	the plar	nt
3					x																														<	Mark	here '	'x" if det	ected		
4		Detection	Anomaly / symptom description	Vibration amplitude has changed	Vibration frequencies have changed	Boost pressure monitoring	Cylinder pressure monitoring	Electric power monitoring	Unstable engine running speed	Bearing temperature increase	Exhaust temperature change	Oil monitoring	Narrowband noise	Broadband noise	Continuous noise	Transient noise	Amplitude modulating noise	Intermittent / hammering noise	Low frequency noise	High frequency noise	Crack	Leakage	Wear dust or wear marks	Component failure	Visible or noticable vibration	engine + mounted components	erator + mounted components	Turbochargers	Base frame	Coupling	Bearing housing	otating auxiliary component	Piping	Vot applicable or uncertain	Commonness	Severity	probabilities, if no blanks	obabilities	ess & Severity weighted probability	ess	
5		Phenomenon / Cause of vibration	Section	6.1.1.1	6.1.1.2	6.1.1.3	6.1.1.4	6.1.1.5	6.1.1.6	6.1.1.7		6.1.1.8	6.1.1.9	6.1.1.10	6.1.1.11	6.1.1.12	6.1.1.13	6.1.1.14	6.1.1.15	6.1.1.16	6.1.1.17	6.1.1.18	6.1.1.19	6.1.1.20	6.1.1.21	Diesel	Gene					Ř		2			Product of	Relative pr	Commonn	Commonn	Severity
6		Mass forces	4.1.1							0	0		1	2		2		0	4		4	2	2	3	4	5	4	5	5	5	3	4	5	1	5	2	0				
7		Gas forces	4.1.2							0	4			3	5	3		0	5	2	5	3	3	4	5	5	4	5	5	5	3	4	5	1	5	3	0				
в	engine	Crankshaft torsional critical speed	4.1.5	2	2				2	0	0	2	1	3	2	5		0	2	3	5	2	4	5	1	4	1	0	1	4	1		1	1	1	5	2	3 %	2 %	1%	5 %
9	sel	Misfiring	4.1.7	4	5	5	5	4	5	1	5	1	1	3	2	3	3	5	5		2		3	4	4	5	3	5	5	5	1		5	1	3	2	5	8%	5 %	8 %	5 %
0	Die	Diesel knock	4.1.8	1	2	1	4	1	2	1	3	3		2		1		4		3			2	1	1	3		2		2			1	1	1	2	2	3 %	1%	1%	2 %
1		Piston slap	4.1.9	2	2				1	0	0	5	3	1		5		3	4	4			5		1	4	1	1	1	2	1		1	1	2	1	2	3 %	1%	2 %	1%
2		Governor hunting	4.1.11	3	4	2	1	2	5	0	1		3	1	3	2	5	3	3				4	1	3	5	3	5	3	5	1		2	1	2	4	4	6 %	6 %	4 %	8 %
3		Magnetic forces	4.2.1							0	0		3	1	3		2	0		4	3	1	1	1	2	2	5	0	3	2	3		2	1	5	1	0				
4		Static eccentricity	4.2.3	3	1			3		3	0	2	3	1	1		3	0	1	2	4		2	3	1	3	5	3	4	3	4		3	1	3	4	1	2 %	2 %	2 %	2 %
5	×	Dynamic eccentricity	4.2.4	4	1			3		3	0	3	3	1	1		3	0	1	2	2		2	2	3	3	5	3	3	2	5		3	1	2	3	1	2 %	1%	1%	2 %



Integrated Desktop and Tablet Application



	Excel	Application
Data Storage / Database	Fragmented	Organized
Maintainability	Fragmented	Robust
User Guidance	None/Manual	Active
Visible Information	All	Significant only
Workflow	Simple	Flexible
Use of Historic Data	Difficult	Easy
User	Expert	Expert & Inspector

Application Workflow





V Preparations







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Hardware

- Dell Tablet
 - 2-in-1
 - Can act as tablet or laptop
 - Standalone
 - Connectivity







Technical details



- Windows based software
- Written in C# programming language
- Database agnostic
 - Can be used and integrated with existing databases
 - SQLite was used in the pilot project





Exit Tablet View

Route 1 - EDG Inspection

 \odot Component 1 - EDG 1

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Inspection Location	Component	Found	Anomaly	
Location 1	EDG1 Wärtsilä F216V		>	
Location 2	EDG1 Wärtsilä F216V			

 \odot Component 2





Exit Tablet View

Route 1 - EDG Inspection

⊙ Component 1 - EDG 1



_					
	Inspection Location	Component	Found	Anomaly	
	Location 1	EDG1 Wärtsilä F216V	<	~	
	Location 2	EDG1 Wärtsilä F216V		Vibration amplitude has changed	
(2		Vibration frequencies have changed	
`	Component	2		Boost pressure monitoring	
				Cylinder pressure monitoring	
				Electric power monitoring	
				Unstable engine running speed	
				Oil monitoring	



Route 1 – EDG 1:

Detection 1: Anomaly: Vibration Am Detection 2: Anomaly: Leakage

> Investigation 1: Finding: Vibration at 25 Hz

Detection				symptom des eciplitude has ch econcies have soure monitoring				ssure monitorir d	er monitoring			1			
Phenom	Invest find	tigatio dings	on	westigation objectives	reases with engine spee	eonenon increases with ad	appears when electric p	ion only on certain spee		appears when mounting	appears when the gover	orsional vibrations	ine-/resilien mountine		
Mass for Gas force	c Po	A	naly	/sis		nalysis method	n at arc		and to be	raiisuucers	nrohes		rom at a c		
Cranksha Misfiring Diesel kr Piston sl Governo Magnetic	M Phenomenon / Mass forces Gas forces Crankshaft tors -speed Misfiring Diesel knock	Reco Rec E Phenoment	r	Vitig	ati	on		Mitigation method	Balancing	Aligning	Replace / repair defected component causing the excitat	Replace coupling rubber	Improved control sequence	Isolate the source of excitation	Isolate a component from vibra
	Piston slap Governor hunti	Coupling r Stator end	R		Easine nded	ess method			2 0	3 0	3 0		3 0	2 0	2
	Magnetic force	Aging of fl			endec	d metho			_				-		_
	Static eccentric	Mechnical Change of	Phenor	menon / C	ause o	of vibratio		ection	6.4.1.1	6.4.1.2	6.4.1.3			6.3.1.4	6.3.1.5
			Mechn structu	ical loos re	eness	in			1	1	3	0	0	0	3
			Change	e of stiffr	ness (d	cracks)			1	3	3	0	0	0	3
			Rotati	ng unbal	ance		-	4.3.1	5	-	4	1		3	3
			Mecha	nical loc g compo	senes	ss of		4.3.2 4.3.3		5	5	4		1	1
Rot		Rotor r	Rotor rub						4	3	1		-		





Thank you

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