



Accident investigation and prevention

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Work is love made visible. And if you can't work with love, but only with distaste, it is better that you should leave your work and sit at the gate of the temple and take alms of the people who work with joy

Khalil Gibran



Agenda

Your journey as you embark on a career

Investigation of accidents

Prevention of accidents

Predictive maintenance



What

What is an accident?

- Unexpected
- Undesirable
- Injury, death, loss/damage of asset
- Loss of reputation





Why?

Why investigate accidents?

- International and national obligations
- Moral obligation
- Learn lessons





How?

What is the process?

- Notification → Preparation
- Deployment
- On site
- Evidence gathering including interviewing
- Analysis
- Report with recommendations





Unintended movement of the
ro-ro passenger vessel
Ben-My-Chree
during passenger embarkation

CASE STUDY 1

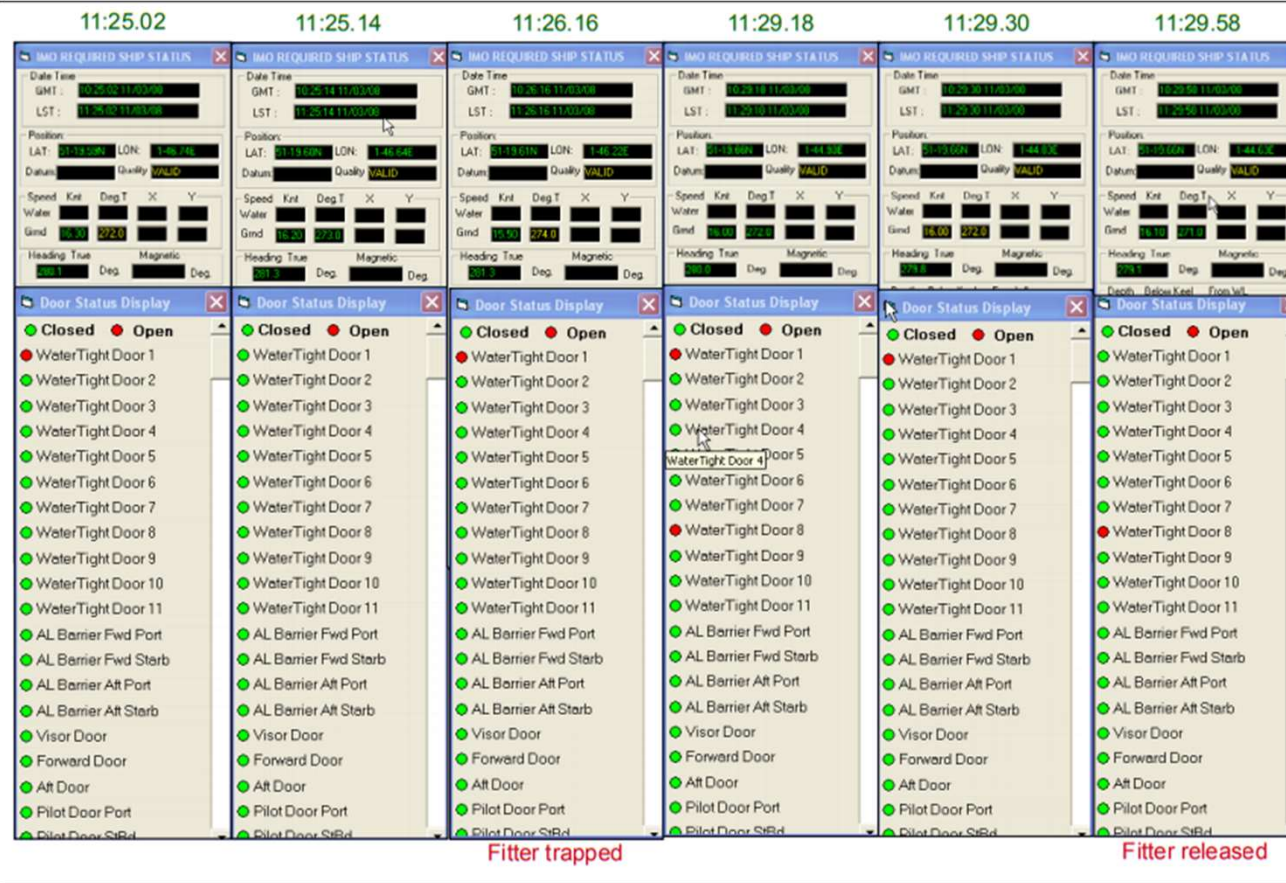




CASE STUDY 2

||| Entrapment of an engine room fitter
in a watertight door on board the
ro-ro passenger ship
Eurovoyager





CASE STUDY 3

|| Catastrophic engine failure,
resulting in a fire and serious
injuries to the engineer on board
Wight Sky





3a - Distorted big end bearing cylinder unit 4

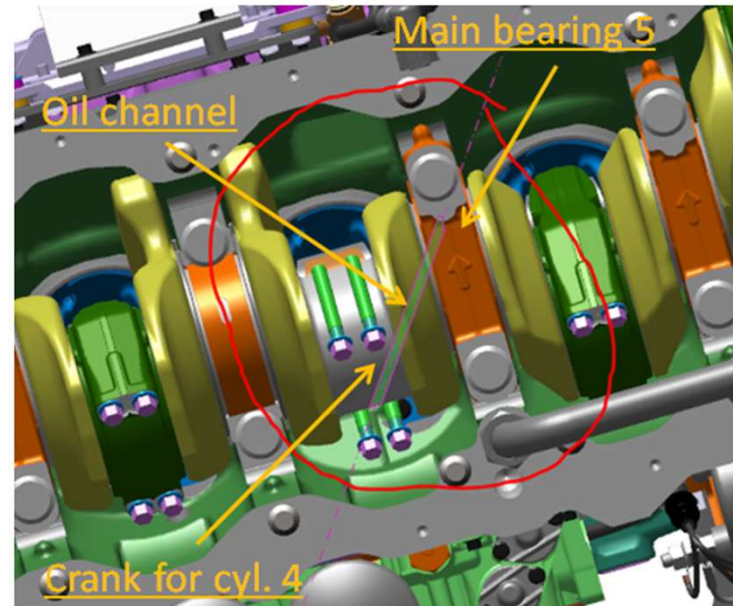
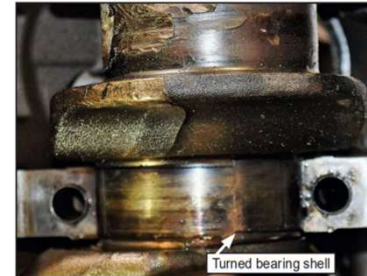


3c - hole in engine crankcase



3b - Bearing pin of cylinder unit 4





2018/120 Consider offering wear particle detection technology for engines that cannot be easily serviced on board.



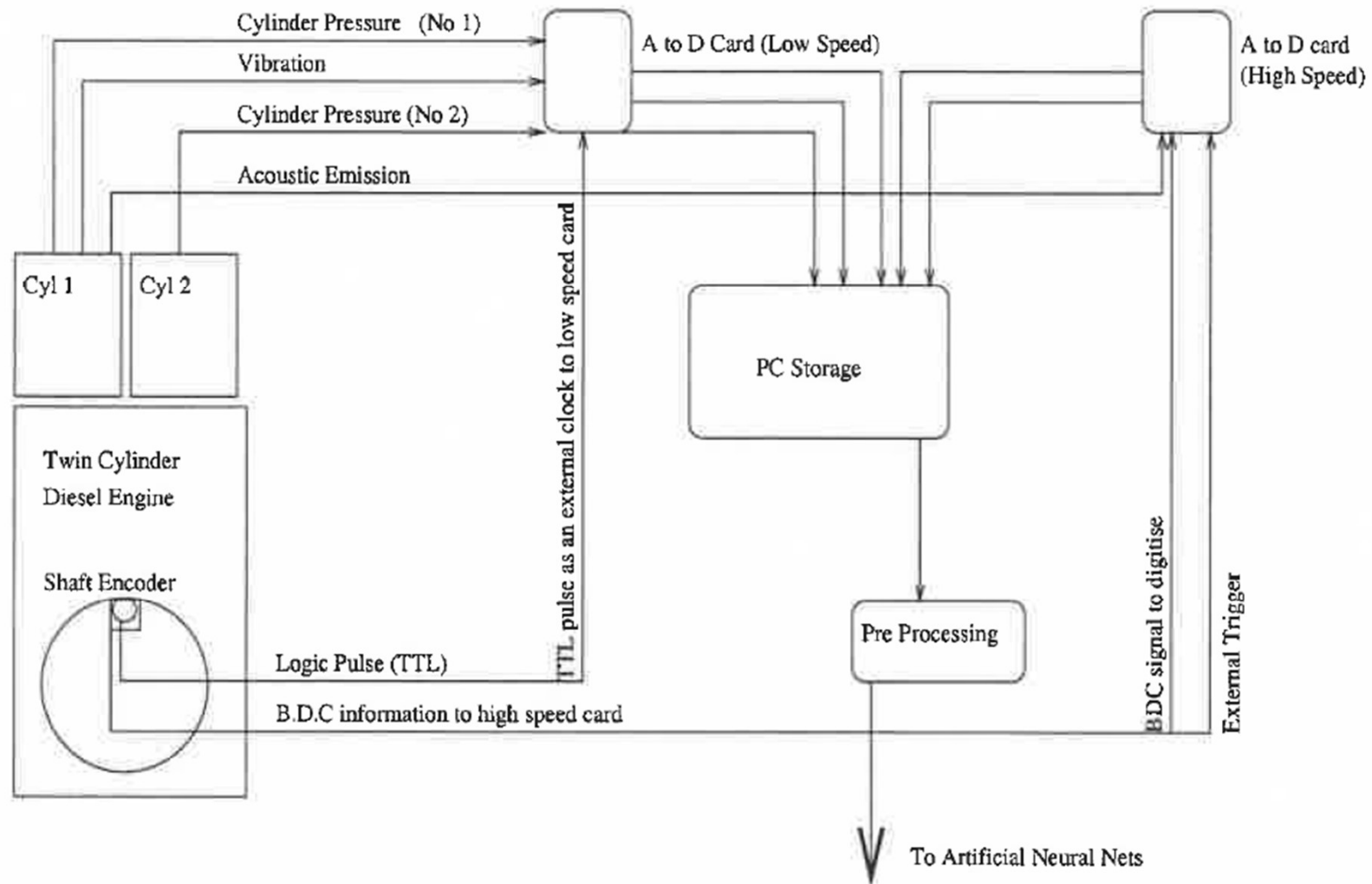
Human error is erroneous thinking

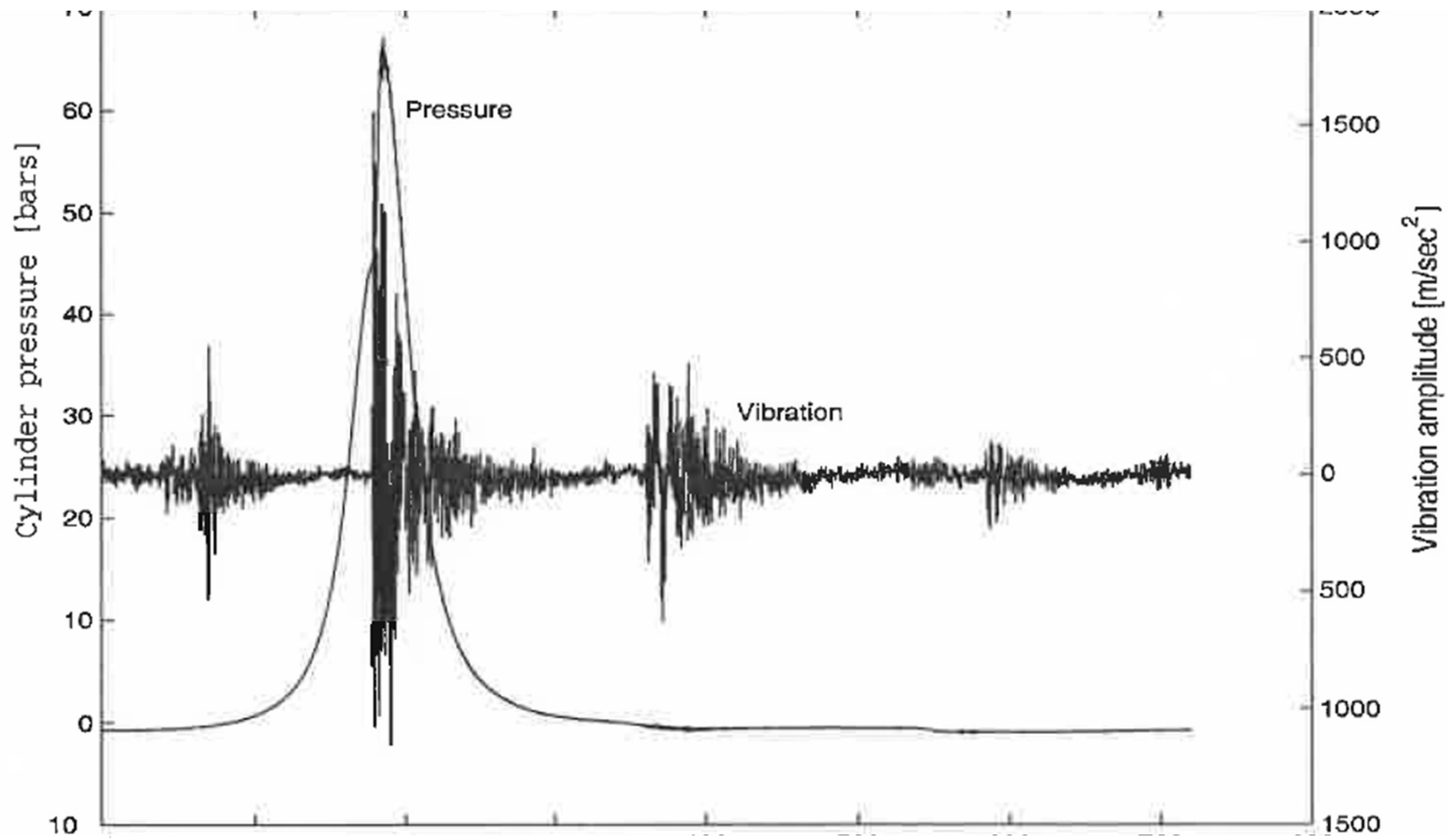
Human Model 2 not yet born

Design human error out

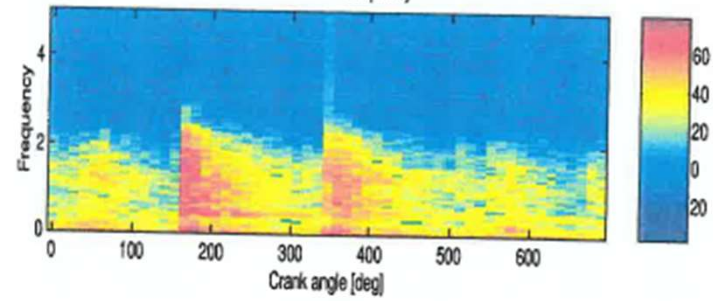
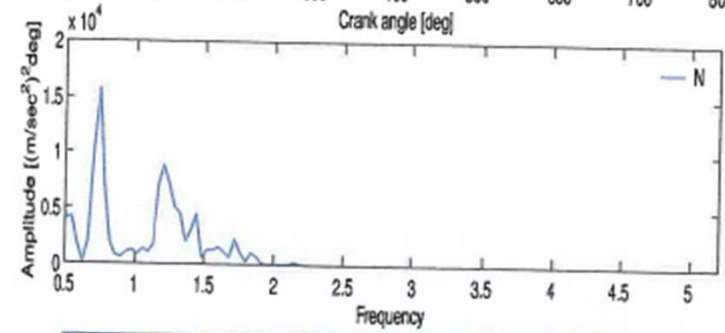
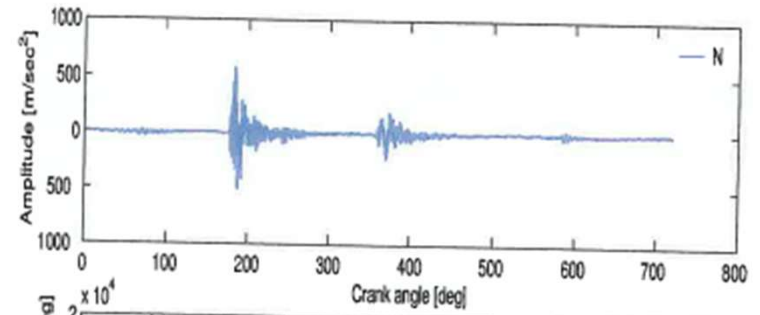
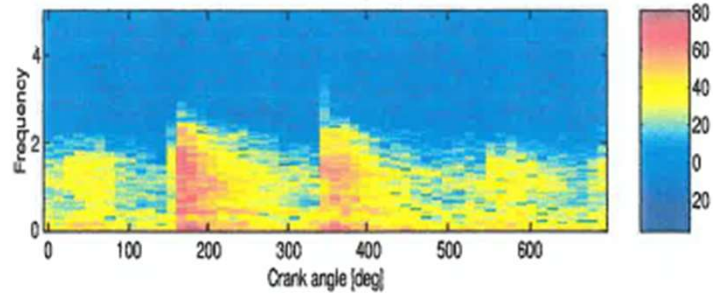
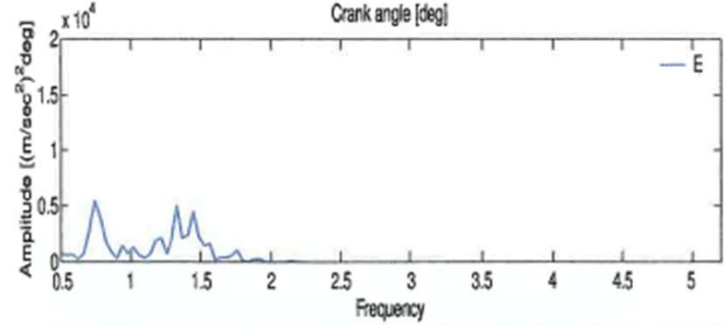
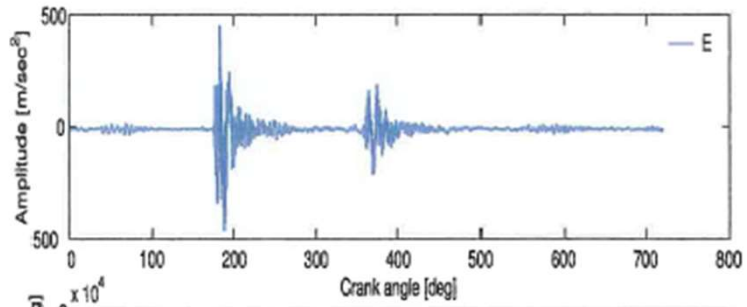


Artificial Intelligence in fault prediction





||



Method	Correct	Ambiguous	Misclassif.
Wavelet	7085 (94.46%)	397(5.30%)	18 (0.24%)
PCA	7099 (94.65%)	335 (4.47%)	66 (0.88%)
Domex(vib)	6785 (90.47%)	698 (9.30%)	17 (0.23%)
Domex(pr)	6646 (88.61%)	618 (8.24%)	236 (3.15%)



Combination	R.Impr ψ	Triple failure	Performance
Single (Wavelet)	38.74	7.20	97.88
Single (Pca)	30.55	15.2	96.76
Single (Domex)	21.90	35.8	93.15
Single (Pressure)	9.06	59.7	90.54
Unique	34.98	5.86	96.78
Exhaustive	25.76	8.82	96.06

1. **Pc4-Wv4-Wv5 system:** In the confusion matrix of the ensemble, it can be seen that there was just one input which was misclassified. Out of 3000 test cases, 2958 (98.6%) were correctly classified, 41 were rejected as ambiguous and 1 test case was misclassified.

$$\begin{matrix} & N & I & B & L & E \\ \begin{matrix} N \\ I \\ B \\ L \\ E \end{matrix} & \begin{pmatrix} 596 & 0 & 0 & 0 & 0 \\ 0 & 582 & 0 & 0 & 0 \\ 0 & 0 & 595 & 0 & 0 \\ 0 & 0 & 0 & 594 & 0 \\ 0 & 1 & 0 & 0 & 591 \end{pmatrix} \end{matrix}$$

2. **Pc5-Pr1-Wv5 system:** In the confusion matrix of this ensemble, it can be seen that not a single input was misclassified. Out of 3000 test cases, 2938 (97.93%), were correctly classified and 62 were rejected as ambiguous.

$$\begin{matrix} & N & I & B & L & E \\ \begin{matrix} N \\ I \\ B \\ L \\ E \end{matrix} & \begin{pmatrix} 592 & 0 & 0 & 0 & 0 \\ 0 & 583 & 0 & 0 & 0 \\ 0 & 0 & 595 & 0 & 0 \\ 0 & 0 & 0 & 583 & 0 \\ 0 & 0 & 0 & 0 & 585 \end{pmatrix} \end{matrix}$$



Predictive maintenance

Vibration monitoring



Vibration: Alternator misalignment

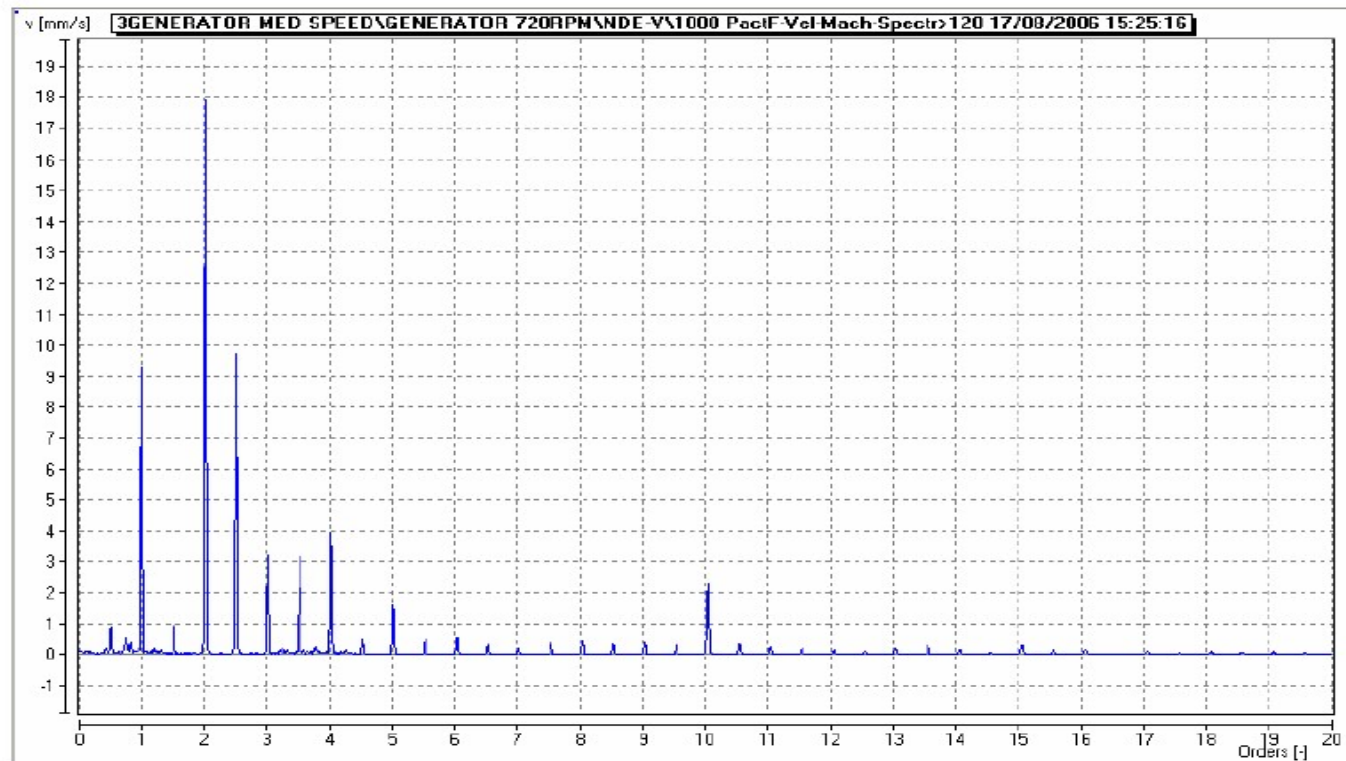
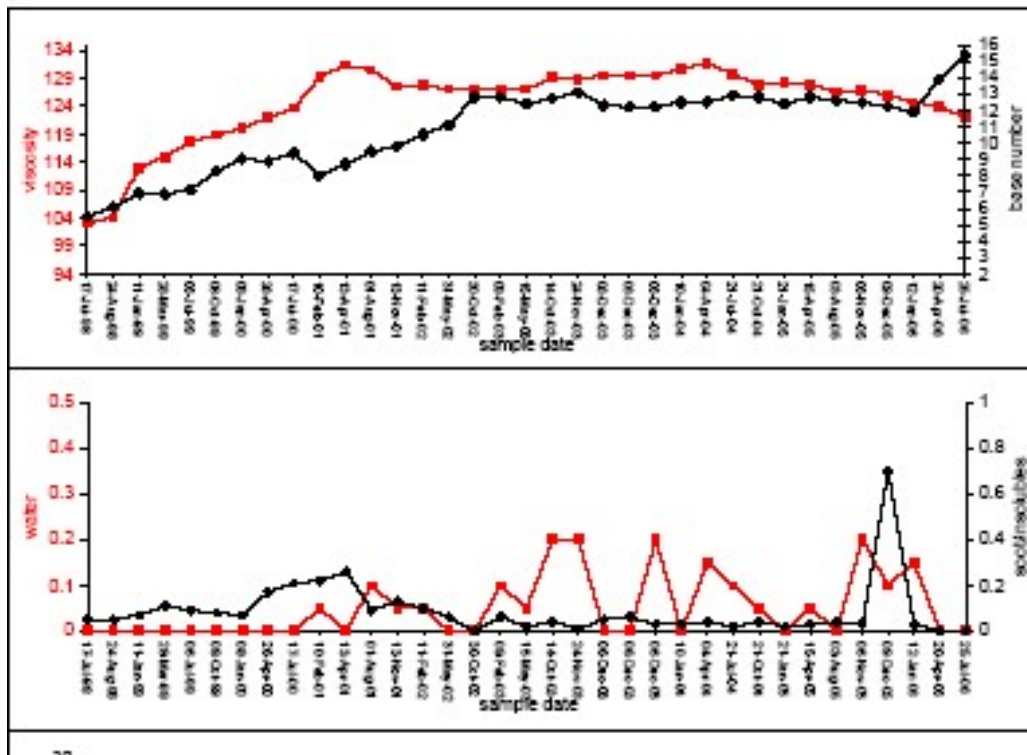


Figure 13: Frequency spectrum of vibration data at alternator non drive end (vertical) indicating parallel misalignment.

Lube oil analysis



Elemental analysis

Additive analysis

Viscosity, water
content

Cleanliness



Alternator exciter stator coil

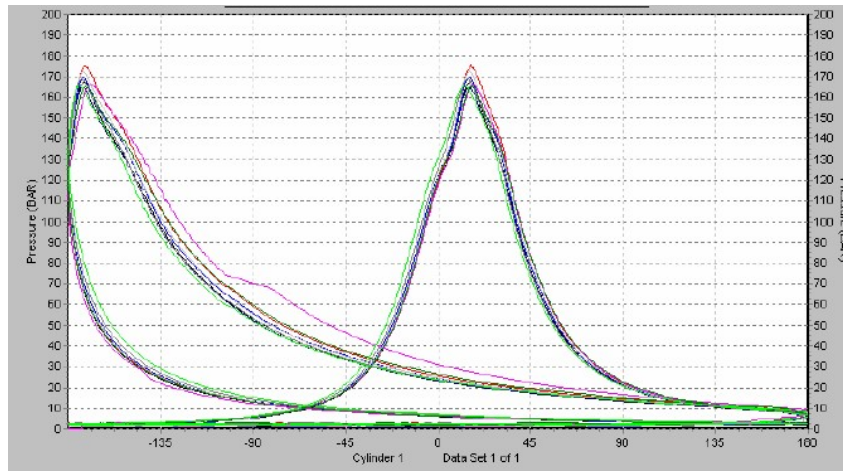


Air compressor valve



Engine performance

Bore 220mm Stroke 260mm Boost 1.1Bar		Conrod 483mm Load 71.0%		Mean Indicated Power 104.0kW Indicated Power 624.1 kW		Trevs 1 29000						
CYL	Pmax	Pcomp	Pdiff	Power	%MCR	Speed	APmax	IMEP	Pign	Aign	IDEL	RPR
1	109.0	60.3	48.8	101	4.5%	719.9	13.2a	17.0	60.3	0.0a	11.0	4.7
2	118.3	63.1	55.2	110	81.7%	719.6	12.5a	18.6	60.9	0.5b	10.5	5.5
3	108.3	61.5	46.7	94	69.9%	720.2	12.0a	15.9	61.5	0.0a	11.0	4.8
4	117.4	65.9	51.5	108	79.6%	720.2	11.7a	18.1	62.6	0.5b	10.5	5.2
5	110.0	59.3	50.6	102	75.7%	719.6	13.8a	17.2	59.3	0.0a	11.0	5.3
6 AE1	117.1	70.4	46.7	109	80.9%	720.2	11.3a	18.4	59.2	2.0b	9.0	5.5
MEAN	113.3	63.4	49.9	104	77.0%	719.9	12.4a	17.5	60.6	0.5b	10.5	5.2

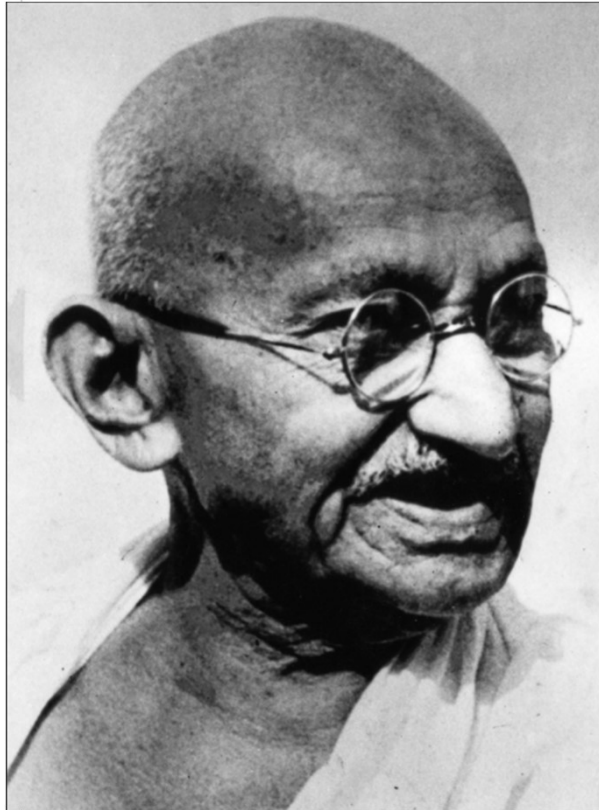


Accidents

Lesson

- Accidents can be predicted and prevented





*The truth must
manifest
in one's thoughts,
words and actions*