

B.E. Mechanical Engineering 4th Year 2nd Semester Examination, 2022

Maintenance and Safety Engineering

Time: Four hours

Full marks: 70

Question 1 is compulsory. Answer any five from the rest.

1. It is observed that a particular type of fan is going out of order on regular interval based on customer's feedback. In this context, the design department wants to find out relevant failure modes and prioritize them so that the department may improve the design. Apply Failure Mode and Effect analysis (FMEA) in relation to following requirements:
- List down different failure modes
 - Assign different scale values to each failure mode based on following tables 1 and 2. Assume suitable values of occurrences based on failure modes and table 3.
 - Find out RPN. Explain and justify any two RPN and its corresponding table values.
 - Comment on results. [20]

Table 1: Severity on a Ten-grade Scale

Effect	Rating	Criteria
Hazardous	10	Safety related failure modes causing non-compliance with government regulations without warning
Serious	9	Safety related failure modes causing non-compliance with government regulations with warning
Very high	8	Failure modes resulting in loss of primary system/component function
High	7	Failure modes resulting in a reduced level of system/component performance and customer dissatisfaction
Moderate	6	Failure modes resulting in a loss of function by comfort/convenience system/component
Low	5	Failure modes resulting in a reduced level of performance of comfort/convenience system/component
Very low	4	Failure modes resulting in a loss of fit and finish, squeak and rattle functions
Minor	3	Failure modes resulting in partial loss of fit and finish, squeak and rattle functions
Very minor	2	Failure modes resulting in minor loss of fit and finish, squeak and rattle functions
None	1	No effect

[Turn over

Table 2: Detection of Design Control of Failure Cause/mechanism

Detection	Rating	Criteria
Uncertain	10	Design control will not and/or can not detect a potential cause/mechanism and subsequent failure mode.
Very remote	9	Very remote chance the design control will detect a potential cause/mechanism and subsequent failure mode.
Remote	8	Remote chance the design control will detect a potential cause/mechanism and subsequent failure mode.
Very low	7	Very low chance the design control will detect a potential cause/mechanism and subsequent failure mode.
Low	6	Low chance the design control will detect a potential cause/mechanism and subsequent failure mode.
Moderate	5	Moderate chance the design control will detect a potential cause/mechanism and subsequent failure mode.
Moderately high	4	Moderately high chance the design control will detect a potential cause/mechanism and subsequent failure mode.
High	3	High chance the design control will detect a potential cause/mechanism and subsequent failure mode.
Very high	2	Very high chance the design control will detect a potential cause/mechanism and subsequent failure mode.
Almost certain	1	The design control will almost certainly detect a potential cause/mechanism and subsequent failure mode.

Table 3: Occurrence of Failure Cause/mechanism

Likelihood of Failure	Estimated or expected failure frequency	Rating
Very high (failure is almost inevitable)	>1 in 2	10
	1 in 3	9
	1 in 8	8
High (frequently repeated failures)	1 in 20	7
	1 in 80	6
Moderate (occasional failures)	1 in 400	5
	1 in 2000	4
Low (rare failures)	1 in 15,000	3
	1 in 150,000	2
Remote (failures are unlikely)	<1 in 150,000	1

2. Write short notes on **any two** of the following: [5+5]
- (i) Engineering maintenance in 21st Century
 - (ii) Overhaul, Rebuild, Servicing
 - (iii) Hierarchy of consequences in safety
 - (iv) Unsafe act and conditions
3. Define and explain five indices that can be used to evaluate overall performance of a maintenance organization. [10]
4. Discuss seven elements of preventive maintenance. [10]
5. (i) Assume $\lambda = 0.005$ failures per hour, $\lambda_p = 0.008$ per hour, $\mu = 0.009$ repairs per hour, and $\mu_p = 0.009$ per hour. Calculate the system steady state availability.
- (ii) What are the benefits and drawbacks of performing PM? [5+5]
6. Discuss the following: [3+3+4]
- (i) Mean PM time
 - (ii) Maximum PM time
 - (iii) Median PM time
7. Assume, $\lambda_1 = 0.002$ failures per hour, $\lambda_2 = 0.003$ failures per hour, $\lambda_3 = 0.001$ failures per hour, $\mu_{C1} = 0.006$ repairs per hour, $\mu_{C2} = 0.004$ repairs per hour, and $\mu_{C3} = 0.008$ repairs per hour. Calculate the value of the system full steady-state availability. [10]
8. (i) Explain steps towards hazard identification.
- (ii) Define incident, accident and near miss. [4+(2+2+2)]