Collaborative Engineering

Product Reliability and Safety

- Product Reliability
- Failure Modes & Effects
- Fault Tree Analysis
- Product Safety

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Reliability of Product

Probability that a product will perform its required function under stated conditions for a specific period of time

$R(t) = e^{-t/MTBF}$ MTBF = Mean Time Before Failure

$MTBF = T / R$ t= time, T = Total time

R = Number of failures

Ex. 10 devices are tested for 500 hours, 2 failures occur during testing

*MTBF = 10*500/2 = 2,500 hours*

Reliability of the system till MTBF:

$R(t) = e^{-1} = 0.37$

Failure Analysis

Systematic methods of identifying and preventing failures before they occur

- **Bottom Up Approach:** ***Failure Mode Effect analysis (FMEA)***
  - Branch up paths from component failure to effect
  - Identify potential failure of system and its effects
  - Identify system failure in early stage
- **Top Down Approach:** ***Fault Tree analysis (FTA)***
  - Branch down *logical* paths from effects to the cause
  - Series or parallel combinations of faults/causes
  - Uses Boolean operators - Probability of the event ?

FMEA – Failure mode effect analysis

Identify product components
↓
List the functions of components
↓
Failure Modes for function
↓
Describe *Effects* of the failures
↓
Determine failure Severity
↓
Determine Occurrence of failure
↓
Determine failure Detection rate
↓
Analysis: RPN = S x P x D
↓
Take action: Reduce highest risk

Light Source for flashlight

Switch Flashlight On/Off

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Low output	No output	Always output	No output

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6	4	2	4
2	8	4	4
5	5	8	8

FTA – Fault Tree Analysis

Postulate Top Event
↓
Branch down listing *Faults*
↓
Consider Parallel and Serial combinations of faults
↓
Boolean algebra to quantify fault *Tree* with event probabilities
↓
Analysis: determine probability of top event

Fire Protection system Fails

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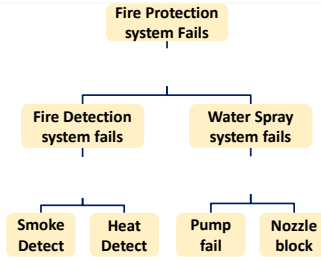

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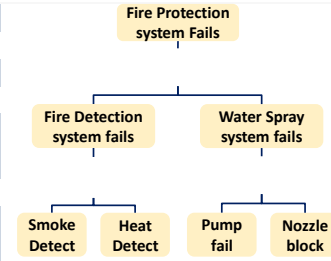

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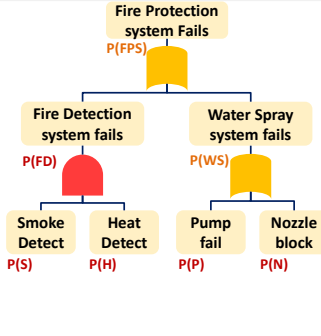

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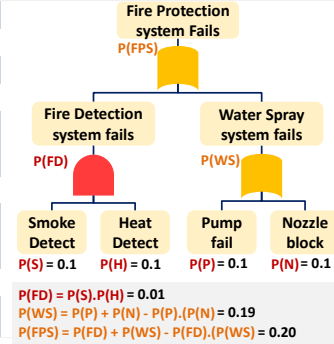

P(FD) = P(S).P(H) = 0.01
P(WS) = P(P) + P(N) - P(P).(P(N) = 0.19
P(FPS) = P(FD) + P(WS) - P(FD).(P(WS) = 0.20

Product Safety

- **Design for Compliance:** ***"Design process incorporates product safety design principles at all stages of development"***

➢ **Identify Requirements:**

Market for distribution, Environment: temperature, humidity etc.
Design to Standards, Certifications (ex. FDA, CE)

➢ **Construction Requirements:**

Material: Strength, rigidity, resistance to electrical shock and fire etc.
Safety mechanism: Grounding, insulation, fire detection

➢ **Product Testing:**

Life tests (reliability)
Functional tests (Static or Dynamic testing)

SUMMARY

- **Reliability analysis helps predict potential failures, enabling better product quality, safety, service, customer satisfaction**
- **FMEA:**
  - **inductive: effects of single component failure on system**
  - **cannot detect an effect of multiple failures**
- **FTA:**
  - **deductive: effects of initiating faults on a complex system**
  - **can take external effects into account**
- **Safety:**
  - **Design for compliance with standards**
  - **Certification for different markets**