Chapter 3
System Analysis

Failures and Failure Classification

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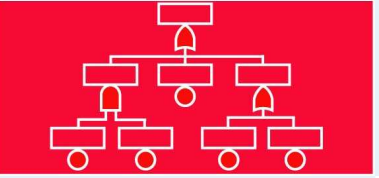


What is a Failure?

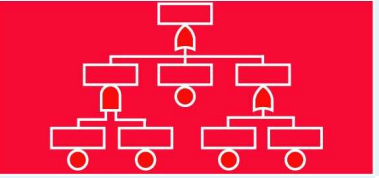
A failure is defined as: “The termination of the ability of an item to perform a required function”

IEC60050(191)

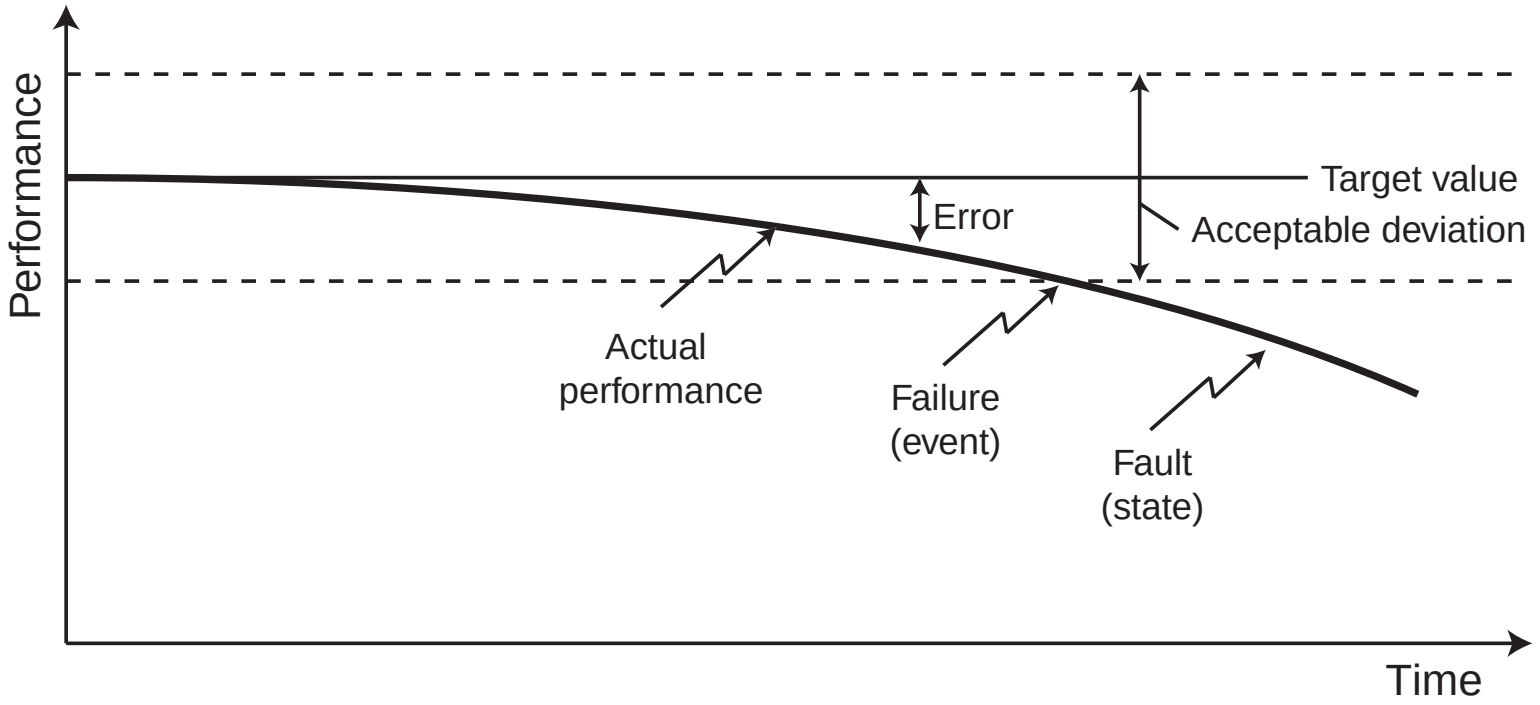
- In other words: A failure is the non-fulfillment of a functional requirement

Example:
Consider a water pump.

- A required function of the pump is to “pump water”
- The functional requirement related to this function is that the output of water should be between 100 and 110 liters of water per minute.
- The pump has a failure if the output of water is outside the interval

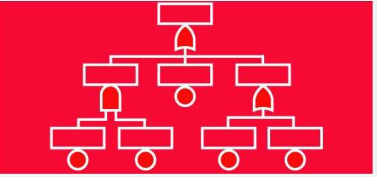


Failure, Fault, and Error



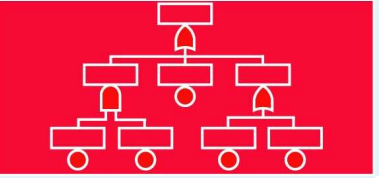
An *error* is a “discrepancy between a computed, observed or measured value or condition and the true, specified or theoretically correct value or condition”

- IEC 60050(191)



Functions

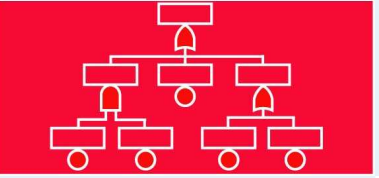
- To identify all potential failure modes of an item, we need to identify all the functions of the item, and the associated functional requirements
- Even “simple” equipment will often have a high number of functions that may be difficult to identify
- Try, for example, to identify all the functions of a mobile phone



Function Categories

It may sometimes be useful to have a list of general function categories (examples for a water pump):

- Essential functions (e.g., pump water)
- Auxiliary functions (e.g., contain water - prevent leakage out)
- Protective functions (e.g., prevent sparks from electro-motor)
- Information functions (e.g., measure internal pressure, temperature)
- Interface functions (e.g., connect to in/out pipes)
- Superfluous functions(e.g., functions remaining after the system has been modified)



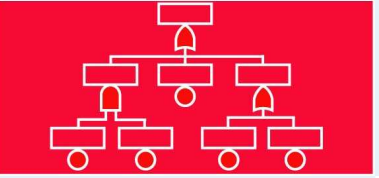
Failure Mode

A failure mode is defined as:

“The effect by which a failure is observed on a failed item”

This definition is not totally clear, but a failure mode should tell us in which way an item is no longer able to fulfill a required function.

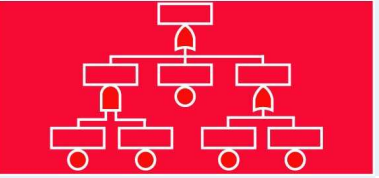
Note that a failure mode is always related to one or more required functions. Sometimes failure mechanisms (e.g., corrosion) are erroneously used as failure modes. Corrosion is not a failure mode, but might be the cause of a failure mode.



General Failure Modes

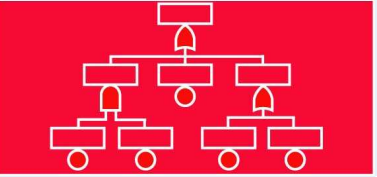
1	Failure during operation
2	Failure to operate at a prescribed time
3	Failure to cease operation at a prescribed time
4	Premature (spurious) operation

- BS 5760-5



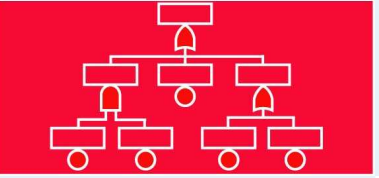
Failure Modes of a Water Pump

- An essential function of a water pump is *"pump water"*. A functional requirement related to this function might be: *"water output must be between 100 and 110 liters per minute"*. Another possible functional requirement could be related to the smoothness of the flow out.
- A failure mode related to the function "pump water" is a specific deviation from the functional requirements. Examples of failure modes are:
  - No output from pump
  - The output is less than 100 liters per minute
  - The output is higher than 110 liters per minute
  - The flow is uneven (not smooth enough)



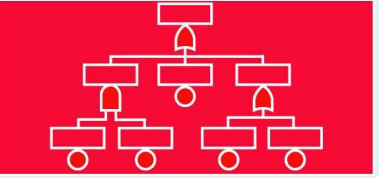
Failure Modes of a Water Tap

- Fail to open (on demand)
- Fail to close (on demand)
- Cannot fully open
- Leakage through (dripping)
- Leakage out (from tap seals)
- Too high temperature
- Too low temperature
- Etc.



Failure Classification

- Failure causes
  - Primary failure (inherent weakness failure)
  - Secondary failure (overstress or misuse failure)
  - Command fault
- Time of failure
  - Sudden failure
  - Gradual failure
- Detectability
  - Evident failure
  - Hidden failure
- Degree of failure
  - Partial failure
  - Complete failure



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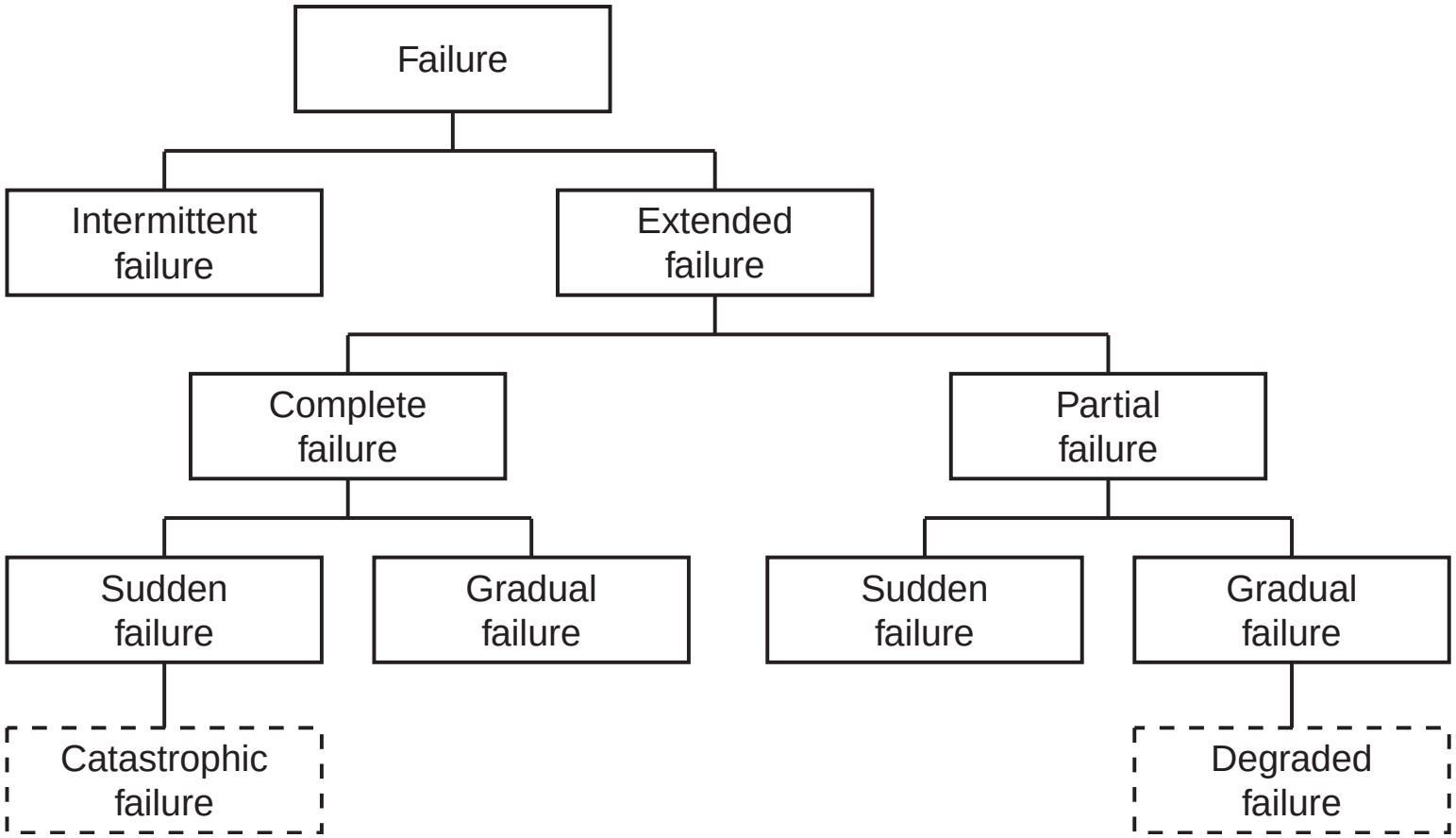
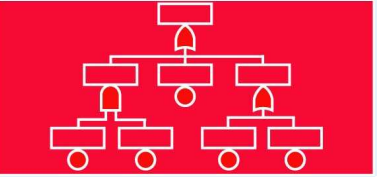
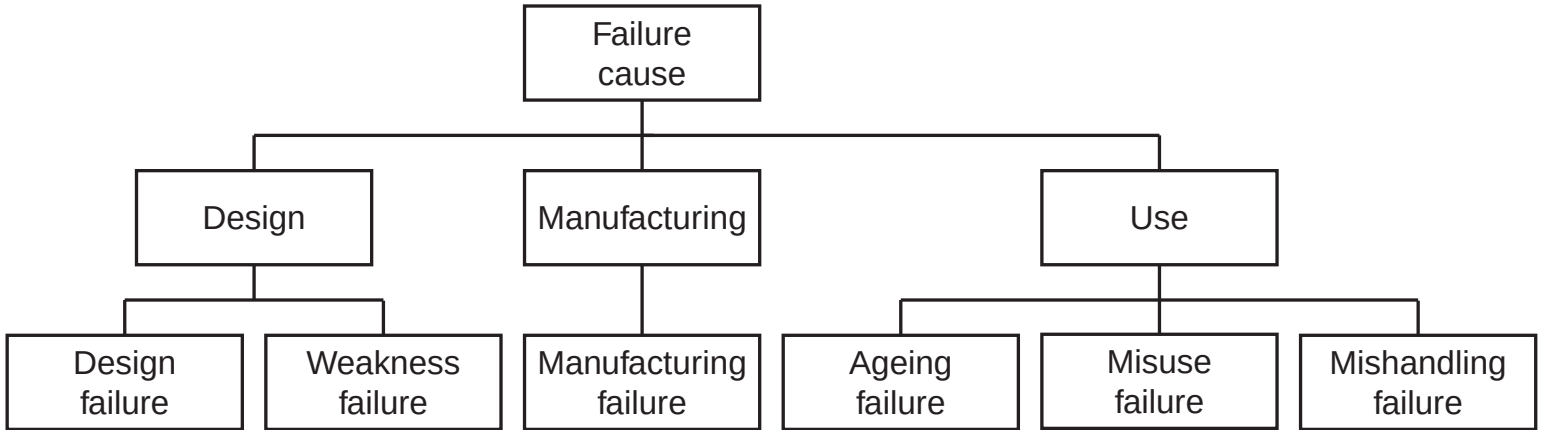
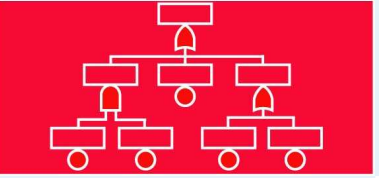




Failure Cause Classification





OREDA Failure Modes

- Critical failure

  Sudden failure that causes termination of one or more fundamental functions

- Degraded failure

  Gradual or partial failure. In time, such a failure may develop into a critical failure

- Incipient failure

  An imperfection in the state or condition of an item so that a degraded or critical failure can be expected to result if corrective action is not taken