TPK4120 - Lecture summary

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Chapter 3 - Failures and Faults

States and transitions

Some items only operate in one state, e.g., a cooling pump may always be pumping. Other components operate in two or more states, e.g., a safety valve may be in an open position, or a closed position. For each state the item might have different functions. For example a valve in an open position have two main functions, i.e., keep open and close upon demand. Failing to perform a function is denoted a failure, and more precisely:

Failure

Definition: The termination of the ability of an item to perform as required

A failure is then an event that occurs in time, whereas a fault is a *state* where the item is not able to perform as required. An error is a "discrepancy between a computed, observed or measured value or condition and the true, specified or theoretically correct value or condition". See Figure 1 for an illustration.

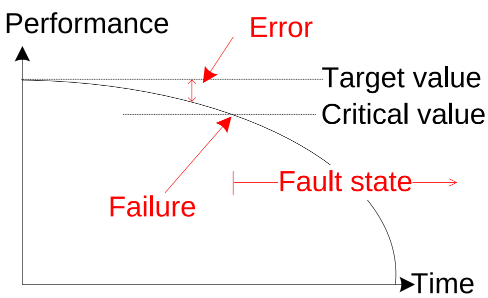

Figure 1: Failure and fault

Fault of an item

Definition: A state of an item, where the item is not able to perform as required.

Failure mode

Definition: The manner in which a failure occurs, independent of the cause of the failure.

To understand the failure mode concept it is important to have focus on how the failure manifest it self, and not on the cause of the failure.

Failure causes and Effects

Failure cause

Definition: Set of circumstances that leads to failure.

The term 'cause' is a difficult term and in our context we distinguish between the "direct" or "proximate" cause and the "root cause", i.e.,:

Proximate cause

Definition: An event that occurred, or a condition that existed immediately before the failure occurred, and, if eliminated or modified, would have prevented the failure

Root cause

Definition: One of multiple factors (events, conditions, or organizational factors) that contributed to or created the proximate cause and subsequent failure and, if eliminated, or modified would have prevented the failure.

Note that the direct or proximate cause on one level in a system hierarchy may be the effect of a failure mode on a lower level. For example the failure proximate failure cause of a pump might be a "bearing failure", where again the failure mode of the bearing is to provide "friction less" rotation of the impeller.

"Behind" the bearing failure we may find the root cause, e.g., lack of lubrication (grease). To trace root causes we may even go further behind, e.g., lack of maintenance and even deficiency in the maintenance management.

Root Cause Analysis

A systematic root cause analysis is usually a brainstorming process with the following steps:

1. Clearly define the failure or fault

2. Gather data/evidence in terms of:
    - When and where did the failure occur?
    - What conditions were present prior to the occurrence?
    - What controls or barriers could have prevented the occurrence?
    - What are the potential causes?
    - Which actions can prevent recurrence?
3. Ask why and identify the true root cause associated with the failure
4. Check the logic and eliminate items that are not causes
5. Identify corrective action(s) addressing both proximate and root causes
6. Implement the action(s)
7. Observe the effectiveness of the action(s)
8. If necessary, reexamine the root cause analysis

To find root causes it is recommended to ask "why?" at least five times for each main cause identified, e.g.;

1. Why did the pump fail? -> Cause: Bearing failure
2. Why did the bearing fail? -> Cause: Lack of lubrication
3. Why was the bearing not lubricated? -> Cause: Inadequate maintenance procedures
4. Why was maintenance procedures inadequate? -> Bad maintenance management
5. Why was maintenance management bad? -> To much focus on production rather than a holistic perspective on all support processes, thus failing to recruit RAMS students from NTNU!