FMEA

- Basic principles-

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FMEA allows to identify and rank failures or failure risks of an equipment or a process in order of importance

- Failure Mode and Effects Analysis (FMEA) is a rigorous method that is used in the form of a working group.
- This analysis has various application domains:
  - during the design of equipment where anticipated reliability is a significant concern,
  - on an existing machine where reliability needs to be improved,
  - on an existing process that experiences frequent failures and requires reliability correction,
  - during the industrialization of a new product where anticipated reliability is a significant concern in terms of cost and criticality.
- The FMEA has three main objectives:
  - improve reliability by preventing existing or potential defects or malfunctions,
  - consider all requirements to challenge specifications and control plans,
  - Set quantified reliability objectives.

The use of FMEA (Failure Mode and Effects Analysis) on equipment or processes enables significant gains in various components of industrial performance

- An increase in production volume:
  - by reducing downtime
  - by limiting slowdowns.
- Optimization in stocks:
  - finished products: Reduction of safety stocks implemented due to fear of breakdowns and/or rejects
  - spare parts: Prioritization and knowledge of failures.
- Indirect gains:
  - formalization of know-how/information
  - improvement of communication between departments (Production/Maintenance)
  - improvement of safety
  - improvement of service quality (reliability of delivery times).

The FMEA is a tool for analyzing and addressing malfunctions, consisting of seven steps.

	Steps	Content	Tools
1	Preparation and Information	Machine selection Method training	
2	Equipment breakdown into functional units	Functional description	
3	Analysis and evaluation of failures		Rating grids O, G, D FMEA grids
4	Prioritization of failures		PARETO diagram
5	Analysis of critical failure causes		5M Diagram Cause-and-Effect Tree
6	Definition and implementation of improvement actions	Development of the implementation schedule	
7	Monitoring and implementation of corrective actions		

The entire process requires between five and eight working meetings.

Step 1: Preparation and Information

- Objectives:
  - choose the machine to be studied.
  - form the working group.
  - plan the work meetings.
  - introduce the general principles of the method.
  - collect data related to the equipment: process description, plans, functional diagrams, specifications, maintenance and failure history, process-related issues, quality data, etc…
- The working group should include representatives from all functions involved with the machine:
  - production department (operators, supervisors, etc.).
  - maintenance department (specialists, methods experts, etc.).
  - methods department…
- The working group is led by a facilitator who ensures adherence to the method.
- Experts may be invited on an as-needed basis.

Step 2: Equipment breakdown into functional units

- Objectives:
  - decompose the process into elementary operations,
  - describe the elementary functions that contribute to the realization of each operation.

- A function is a set of elementary tasks performed by equipment to provide a necessary and essential result for the next function.
- The decomposition is carried out by the working group, and the session is led by the facilitator.

Example: A table describing the cutting operations and their functions

Operations	Elementary functions
Supply of sheets	▪ Bring the sheet pallet ▪ Insert the pallet into the margin ▪ Center the stack of sheets
Margin	▪ Vacuuming with a suction group ▪ Bring the tablecloth ▪ Position the sheet ▪ Correct the sheet
Cut	▪ Pinch the sheet ▪ Bring the sheet onto the platen ▪ Cut
Peeling	▪ Bring the sheet onto the tool ▪ Pinch the waste ▪ Eject the waste

Step 3: Analysis and evaluation of failures

- Objectives:
  - to identify all failure modes (existing and potential) for each functional unit,
  - define the criticality of failure modes.
- The criticality depends on three parameters:
  - severity, it allows assessing the importance of the consequences of a failure:
    - there can be multiple severity criteria, such as productivity, non-quality, safety, and environment.
    - when multiple severity criteria are considered, the overall severity is determined by selecting the maximum value or the average value,
  - occurrence, it corresponds to the frequency of failure occurrence,
  - detectability, which indicates the ease of detecting the failure. The detection objectives include :
    - preventing the occurrence of the failure (e.g., indicators, patrols)
    - and reducing the time required to search for the cause (e.g., diagnostic aid guides…).
- The criticality is calculated as **Severity x Occurrence x Detectability**.
- Each parameter is evaluated on a scale from 1 (“low evaluation”) to 5 (“high evaluation”).

Step 4: Prioritization of failures

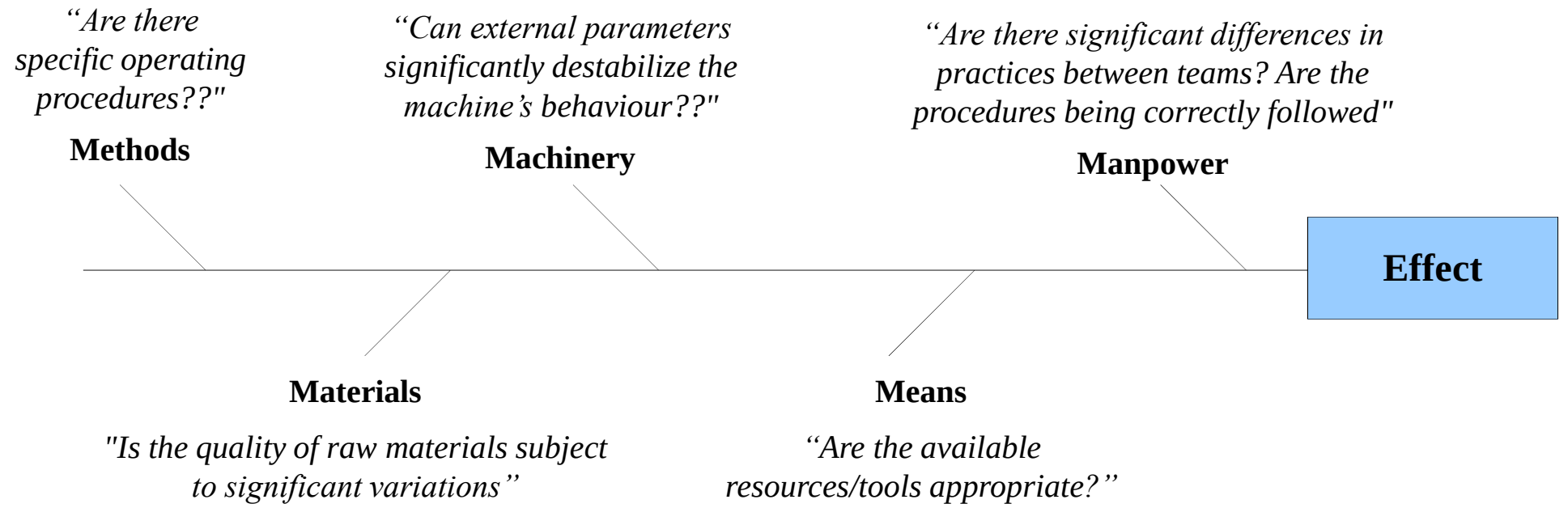
- Objectives:
  - to prioritize failure modes
  - select the most critical ones that need to be addressed,.
- Failure modes are hierarchically prioritized through the:

OPERATIONS	ELEMENTARY FONCTIONS	FAILURE MODES	CONSEQUENCES				PRINCIPAL CAUSES	G_{max}	O	D	C
			Type 1	G1	Type 2	G2					

- The working group sets threshold limits above which a failure is considered critical:
  - either based on parameters (e.g., severity must be less than 4)
  - or based on criticality (e.g., failure mode criticality must be less than 15)
- The group then selects the failure modes that they will subsequently work to resolve

Step 5 : Analysis of critical failure causes

- Objectives:
  - rechercher les causes des défaillances dont la criticité et supérieure au seuil de criticité retenu,
  - rechercher la ou les causes premières pour chaque cause,
  - hiérarchiser les causes identifiées (de la plus probable à la moins probable) pour rendre plus efficace la recherche de solutions.
- Analyse des causes des défaillance les plus critiques : le diagramme 5M



Step 6 :Definition and implementation of improvement actions

- Objectives:
  - define one improvement action for each critical failure cause.
  - evaluate the residual criticality.
  - choose the actions to be implemented.
  - establish the implementation schedule for the actions.
- The proposed actions can reduce one of the three components of criticality:
  - reduction of detectability through:
    - Improved diagnostic assistance (diagnostic guides).
    - Enhanced preventive maintenance (rounds, 5S methodology).
    - Implementation of anomaly detectors,
  - reduction of occurrence through improved component reliability,
  - reduction of severity through improved maintainability or faster repair capability (redundancies, backup systems, SMED…).

Step 7: Monitoring and implementation of corrective actions

- Objectives:
  - continuously monitor the progress of action implementation.
  - perform periodic updates of criticalities.
  - define corrective actions

ACTION SHEET

N°	Title								
Description									
Chart									
Estimates	Criticality before				Critically after (estimate)				Cost =
	G	O	D	C	G	O	D	C	

SUMMARY OF ACTIONS ON A MACHIN

PRINCIPAL CAUSES	N°	ACTIONS	RESPONSIBLE	DEADLINE	COST	CRITICALLY BEFORE	CRITICALLY AFTER

The limitations of FMEA

- FMEA does not allow for a cross-sectional view of possible failures and their consequences:
  - If two failures occur simultaneously in two subsystems, what is the impact on the overall system?
  - For example, in the aviation industry, airplane accidents are rarely caused by a single failure; they are generally linked to multiple incidents that occur simultaneously.
- It is common for fanciful risks to be unnecessarily associated with FMEA:
  - For example, “Someone may break their leg while skiing».