Introduction to the New AIAG/VDA DFMEA

Matthew Barsalou

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Learning Objectives

- In this session you will:
  - Learn about changes implemented in the new FMEA Handbook
  - Be able to list the steps for creating a DFMEA
  - Evaluate risks based on Action Priority

Introduction to DFMEAs

- According to a poem by Lowe (1980), a kingdom fell due to a lack of a nail

- Sometimes it's the simple details that matter

- Design Failure Modes & Effects Analysis (DFMEA) helps identify & link "simple" details

Evolution

- Failure Modes & Effects Analysis (FMEA)
  - 1949: Introduced in military standard MIL-P-1629
  - 1960s: Used for NASA's Apollo program
  - 1970s: Used by Ford Motor Company
  - 1980s: Spread across industries

Types of FMEAs

- Design-Failure Modes & Effects Analysis (DFMEA) – for design concepts
- Process-Failure Modes & Effects (PFMEA) – for assembly processes

DFMEAs

- Performed as early as possible in the design process
  - Identifies risks of failure
  - Prioritizes risks
  - Develops & implements improvement actions

DFMEA Documentation

Company Name		Design Failure Modes and Effects Analysis														
Part:	FMEA Type:	Customer:		Part Number:		DFMEA Team:		FMEA Nr.:		Version Date:						
Function	Requirement	Failure Mode	Failure Effect	Severity	Failure Cause	Prevention Actions	Occurrence	Detection Actions	Detection	RPN	Improvement Actions	Severity	Prevention	Detection	RPN	

DFMEA Documentation

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Function	Requirement	Failure Mode	Failure Effect	Severity	Failure Cause	Prevention Actions	Occurrence	Detection Actions	Detection	RPN	Improvement Actions	Severity	Prevention	Detection	RPN

- **Function:** What the component must do
- **Failure mode:** The failure
- **Failure effect:** Effect of the failure
- **Severity:** Consequences of failure (1-10 scale)
- **Failure cause:** Caused the failure
- **Prevention controls:** Actions to prevent failure from occurring
- **Occurrence:** How likely the failure is (1-10 scale)
- **Detection controls:** Actions taken to detect failure if it occurs
- **Detection:** How well failure can be detected if it occurs (1-10 scale)

Risk Priority Number (RPN) = Severity x Occurrence x Detection

Rating Scales

Rating	Criteria		
	Severity	Occurrence	Detection
1	Not noticeable to customer.	Highly unlikely. < 1 in 1.5 million opportunities	Almost certain to detect failure.
2	Some customers will notice. Very minor effect on product or system.	Extremely rare. 1 in 150,000 opportunities.	Excellent chance of detecting failure: 99.99%
3	Most customers notice. Minor effect on product or system.	Rare. 1 in 15,000 opportunities.	High chance of detecting failure: 99.9%
4	Customer slightly annoyed. Product or system slightly impaired.	Few. 1 out of 2,000 opportunities.	Good chance of detecting failure: 95%
5	Customer annoyed. Noncritical aspects of product or system impaired.	Occasional. 1 out of 500 opportunities.	Fair chance of detecting failure: 80%
6	Customer experiences discomfort or inconvenience,. Noncritical elements of product or system inoperable.	Often. 1 out of 100 opportunities.	Might detect failure: 50%
7	Customer very dissatisfied. Partial failure of critical system elements of product or system. Other	Frequent. 1 out of 20 opportunities.	Unlikely to detect failure: 20%
8	Customer highly dissatisfied. Product or system inoperable, but safe.	Repeated. 1 out of 10 opportunities.	Very unlikely to detect failure: 10%
9	Customer safety or regulatory compliance endangered, with warning.	Common. 1 out of 3 opportunities.	Highly unlikely to detect failure: 5%
10	Catastrophic. Customer safety or regulatory compliance endangered, without warning.	Almost certain. > 1 out of 2 opportunities.	Nearly certain not to detect failure, or no controls in place.

DFMEA Documentation

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Function	Requirement	Failure Mode	Failure Effect	Severity	Failure Cause	Prevention Actions	Occurrence	Detection Actions	Detection	RPN	Improvement Actions	Severity	Prevention	Detection	RPN

- **Recommended actions:** Actions to improve prevention and/or detection
- **Responsible & target date:** Who will perform the actions & when they will be completed
- **Actions taken & completion date:** What was done & when finished
- **Re-evaluate Severity, Occurrence & Detection**
- **Re-calculate Risk Priority Number** (RPN) = Severity x Occurrence x Detection

DFMEA Example – Retaining Clip

Function	Failure Mode	Failure Effect	S	Failure Cause	Prevention Controls	O	Detection Controls	D	RPN
Retaining clip spring must have sufficient tension to hold clip to assembly	Unintended release of spring	Retaining clip falls off	8	Incorrect tension specified on drawing	Use of carryover design	5	Test in spring tension tester	6	240

- Severity: 8 due to total product failure
- Occurrence: 5 due to previous use of similar design
- Detection: 6 due to use of a proven test method with test to failure

S – Severity; O – Occurrence; D – Detection; RPN – Risk Priority Number = S x O x D

DFMEA Example – Retaining Clip

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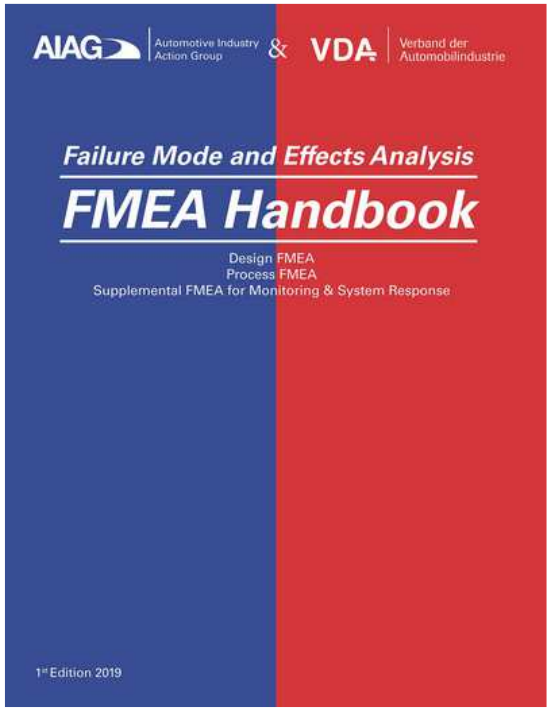
- Recommended actions: Implement degradation testing (detection)
- Responsible & target date: Jane S. / 22 July
- Actions taken & completion date: Degradation testing performed on 22 July
- Re-evaluate detection: Degradation testing implemented so rating is now 5
- Re-calculate RPN: 8 x 5 x 5 = 200 (additional actions?)

S – Severity; O – Occurrence; D – Detection; RPN – Risk Priority Number = S x O x D

AIAG/VDA FMEA Handbook

- Two FMEA standards are now combined
  - AIAG's (Automotive Industry Action Group)
  - VDA's (Verband der Automobilindustrie) – German Association of the Automotive Industry

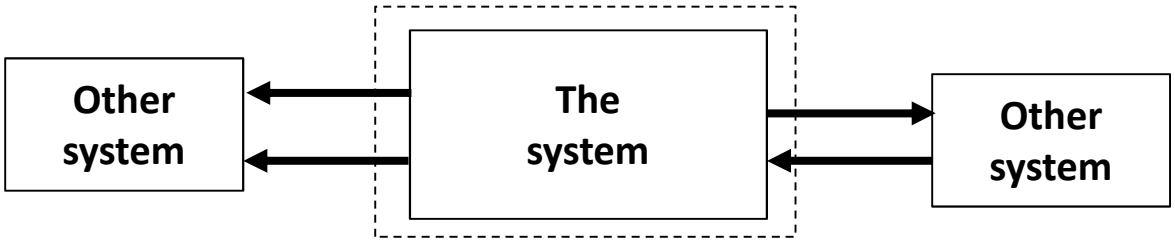


AIAG/VDA FMEA Handbook

- Required use of the new standard:
  - Fiat Chrysler Automobiles (FCA)
    - Can be used immediately, but an agreement between supplier and FCA is required
  - Ford
    - Can be used immediately
  - General Motors
    - Implementation anticipated in 2023
  - Honda North America
    - Can be used immediately
    - Anticipated to be in use in 2022 for new parts

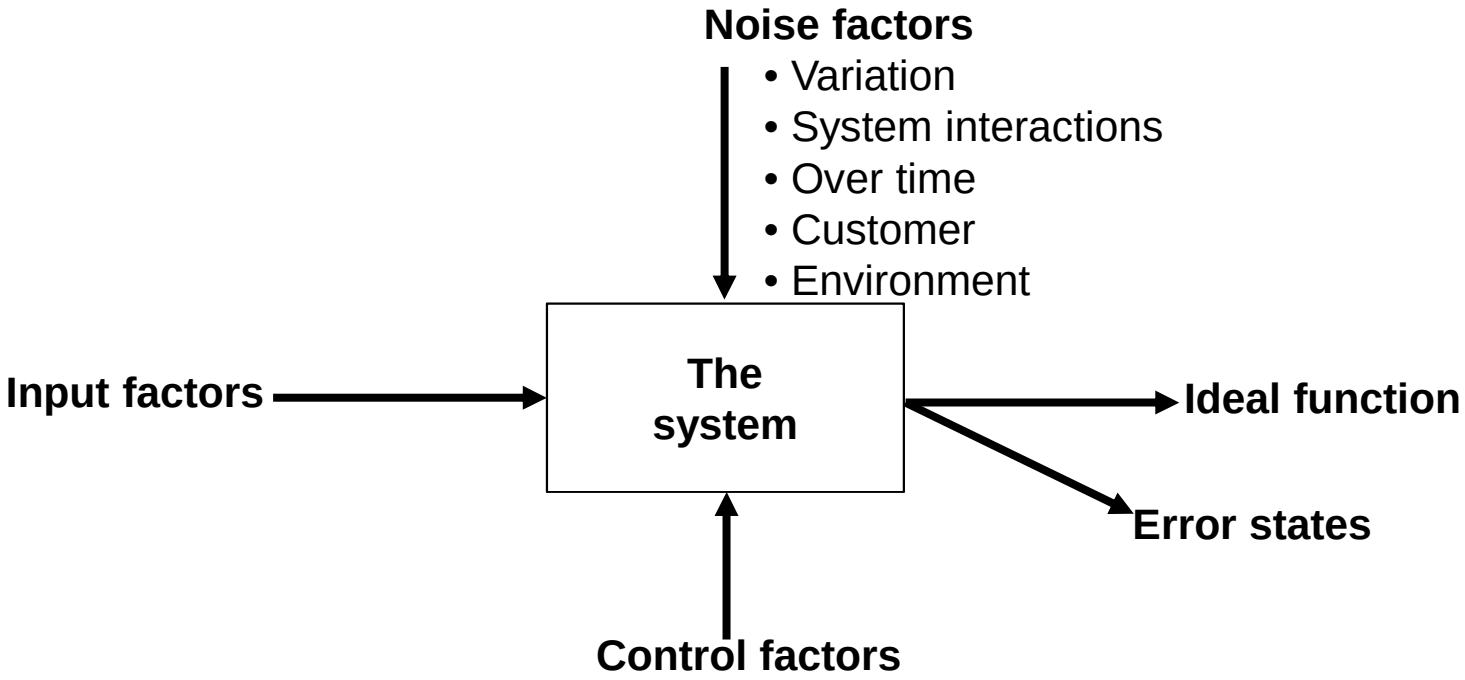
AIAG FMEA Handbook

- Required boundary diagrams to identify the limits & interfaces of the system



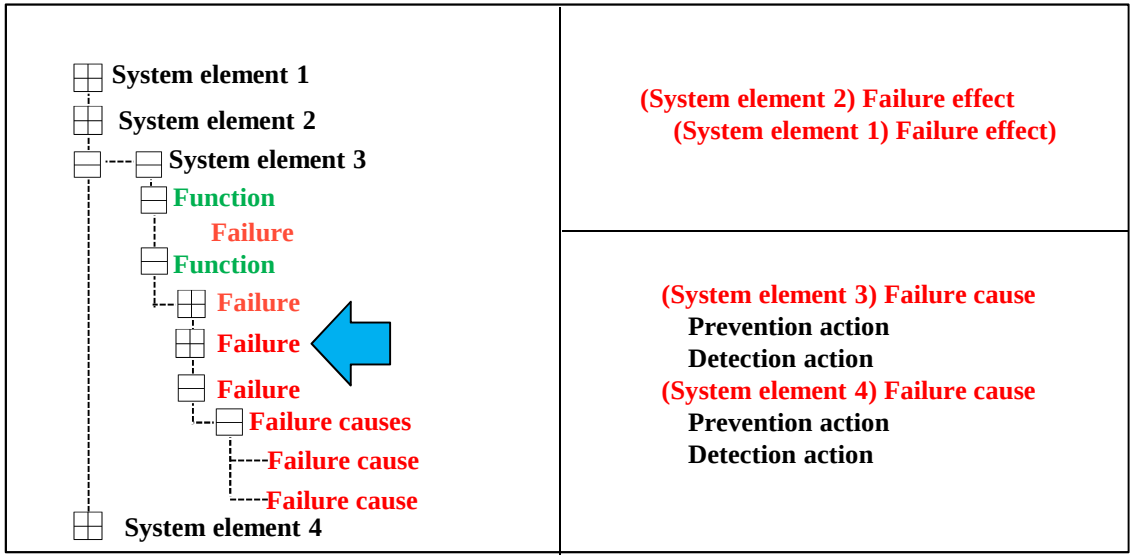
AIAG FMEA Handbook

- Required p-diagrams (parameter diagrams)



VDA FMEA Handbook

- Required use of a structure tree
  - Software is used to create the structure tree



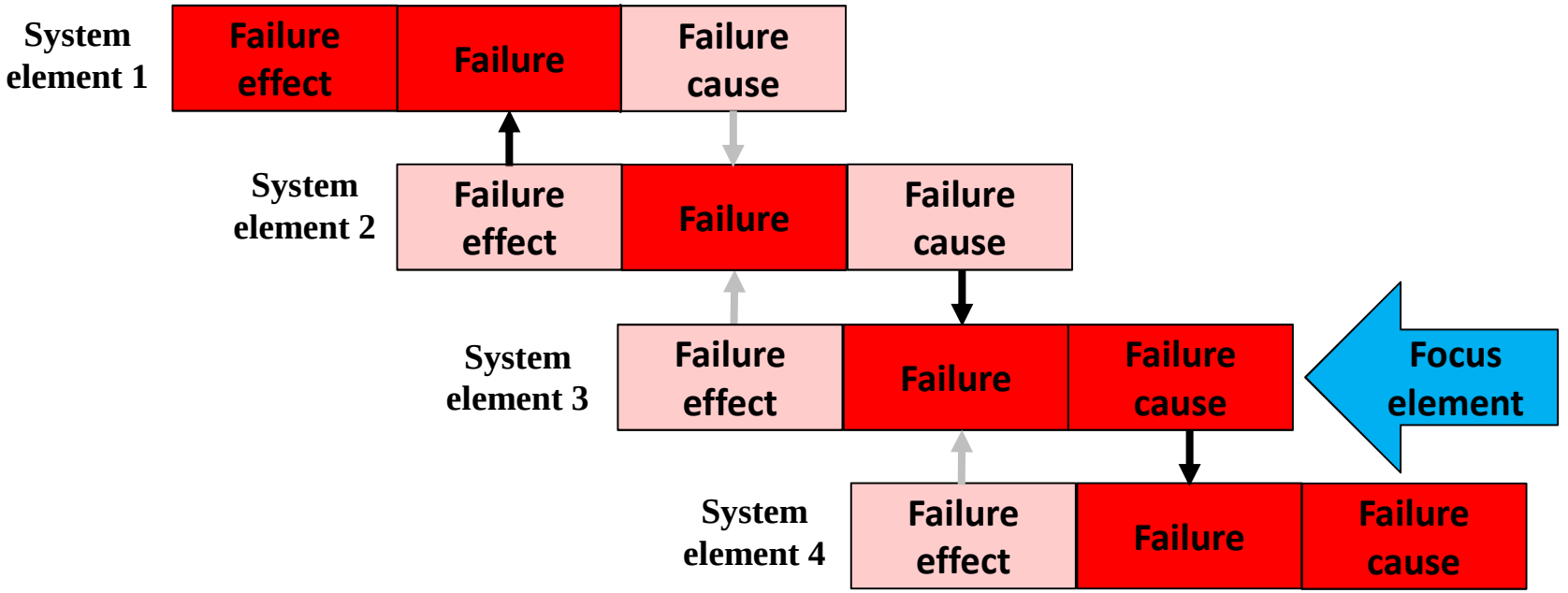
- DFMEAs can be difficult to create

AIAG/VDA FMEA Handbook

- Failures causes, failure modes, and failure effects are linked between system elements
  - A failure mode at one system element is an effect for a lower system element and the cause of failure for a higher system element

AIAG/VDA FMEA Handbook

- Failure effect, modes & causes are linked between system elements
  - A failure in one element is an effect for a lower element & the cause for a higher element



AIAG/VDA FMEA Handbook

- Replaces RPN by an Action Priority (AP)
  - Tables are used to identify the AP on a scale of High (H), Medium (M) & Low (L)
    - Emphasis is given to high severity ratings together with a high occurrence rating
    - Ex.: A severity of 9 and occurrence of 8 is always High regardless of detection
  - Tables are available in the handbook

AIAG/VDA FMEA Handbook

- New DFMEA form lists the focus system element & the next higher & lower system element, as well as their functions

Higher level system element	System element in focus	Lower level system element	Higher level function and requirement	Function and requirement in focus	Lower level function and requirement	Potential failure effect(s)	Sev.	Potential failure mode(s)	Potential failure cause(s)
System element 1	System element 2	System element 3	SE 1's function	SE 2's function	SE 3's function	Failure at SE 1 is the effect		Failure at SE 2 is the failure mode	Failure at SE 3 is the failure cause

AIAG/VDA FMEA Handbook

- Two possible approaches – component or function
  - Lowest level uses a function in place of a component when the focus is a component

Assembly as Focus Element	Component as Focus Element
System Element 1: Final product Failure effect: Water leak in vehicle	**System Element 1: Final product** Failure effect: Water leak in vehicle
System Element 2: Assembly Failure mode: Water pump seal not tight	**System Element 2: Component** Failure mode: Coupling not tightly sealed
System Element 3: Component Failure cause: Coupling with wrong tolerance	**System Element 3: Component Function** Failure cause: Wrong tolerance

AIAG/VDA FMEA Handbook

- Step 1: Planning & Preparation
- Step 2: Structure Analysis
- Step 3: Functional Analysis
- Step 4: Failure Analysis
- Step 5: Risk Analysis
- Step 6: Optimization
- Step 7: Results Documentation

Step 1: Planning & Preparation

- Form a DFMEA team (cross-functional)
- Review relevant documents
  - Drawings and specifications
  - Requirements (legal, customer, etc.)
  - Previous, comparable DFMEAs
  - Lessons learned
- Establish project plan & timing
  - Schedule reviews
  - Recommendation: Multiple 2-hour DFMEA sessions

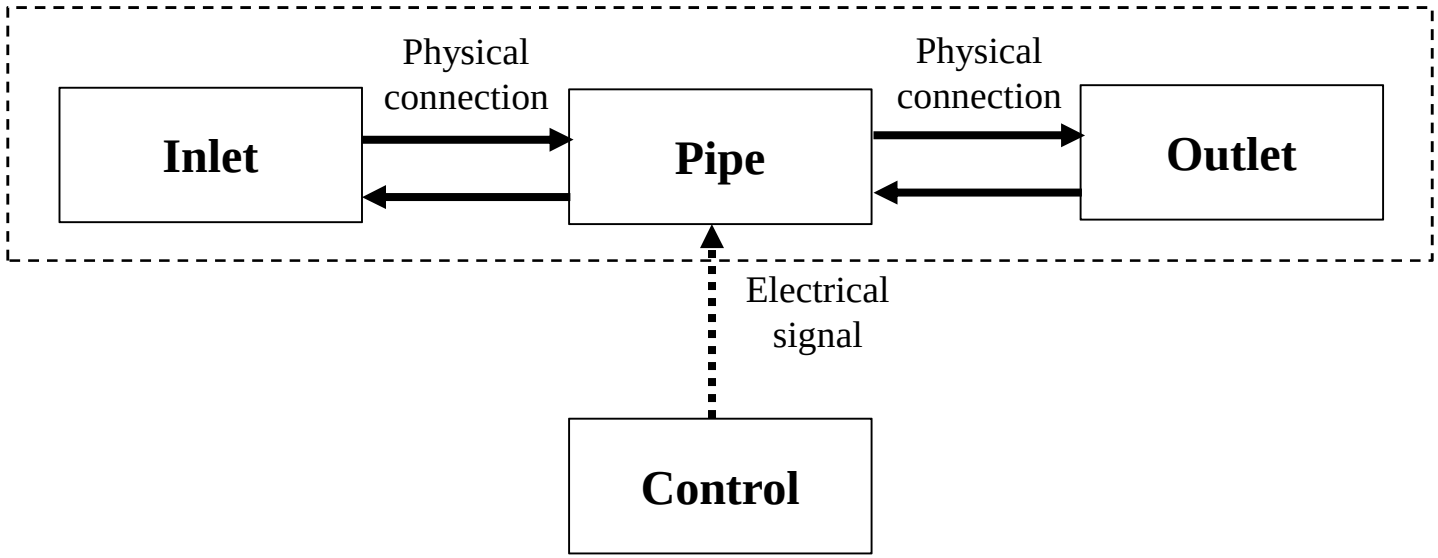
Step 1: Planning & Preparation

- Fill out DFMEA header
  - Recommendation: Customize to the organization's needs

DFMEA	Organization: Quick Molding Inc.	Project: Delux heat transfer manifold	Project owner: Ware	DFMEA number: 46484154581	QMI
	Location: Small Town	Product: Heat transfer manifold pipe	Project leader: Duran	Revision date: 1 April 2021	
	Product line: Manifolds	System element: Pipe	Team: Holland, Martinez, Spence	Revision number: 4	

Step 2: Structure Analysis

- Create a structure tree or equivalent (boundary diagram, model, parts)
  - Identify interfaces & interactions



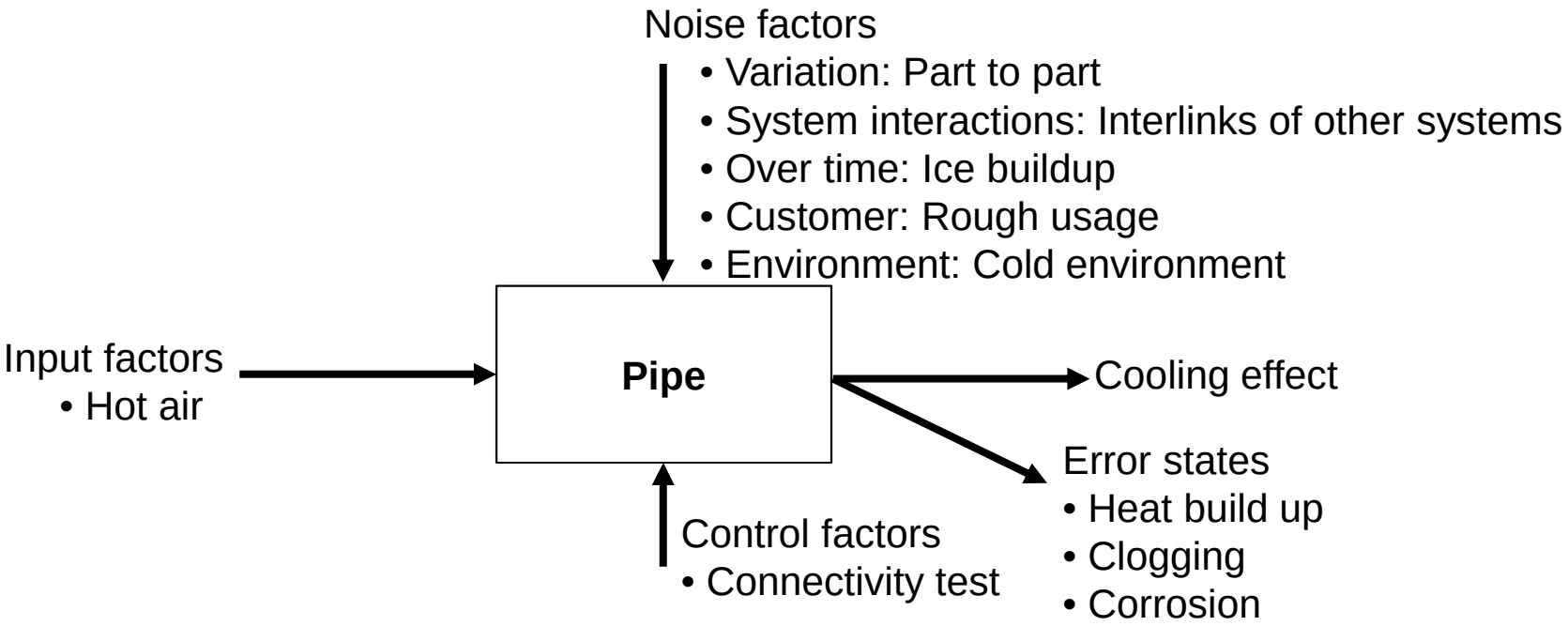
Step 2: Structure Analysis

- List the focus element & the next higher & lower elements

Step 2: Structure analysis		
Higher level system element	**System element in focus**	**Lower level system element**
Manifold assembly	Pipe	Inlet

Step 3: Functional Analysis

- Use a function tree or function analysis in DFMEA form together with p-diagram
  - Identify requirements of each function



Step 3: Functional Analysis

- Identify the functions of the three system elements

Step 3: Function analysis		
Higher level function and requirement	**Function and requirement in focus**	**Lower level function and requirement**
Heat removal	Hot air transfer	Solid seal

Step 3: Functional Analysis

- Alternatively, functions can be used if no system elements are available

	Step 2: Structure analysis			
	Higher level system element	System element in focus	Lower level system element	
Focus is on the inlet with no lower level system element	Manifold assembly	Inlet	Smooth air flow	Function “smooth air flow” used as a lower level system element
No higher level system element so a function is used	Producibility	Manifold assembly	Inlet cover	Lower level system element is used

Step 4: Failure Analysis

- Identify failure effects, modes & causes
  - Effect relates to the system function
  - Mode pertains to hot air transfer
  - Cause relates to sealing

Step 4: Failure analysis			
Potential failure effect(s)	**Sev.**	**Potential failure mode(s)**	**Potential failure cause(s)**
Heat buildup -> partial loss of functionality	7	Reduced heat transfer	Inlet diameter too small

Step 5: Risk Analysis

- Identify & evaluate current prevention & detection actions

Step 5: Risk Analysis				
Current prevention actions	**Ocur.**	**Current detection actions**	**Det.**	**AP**
Use inlet diameter from previous design for new application	6	Heat transfer test Nr. 4896	6	H

Step 6: Optimization

- Identify improvements & assign responsibility for improvement actions

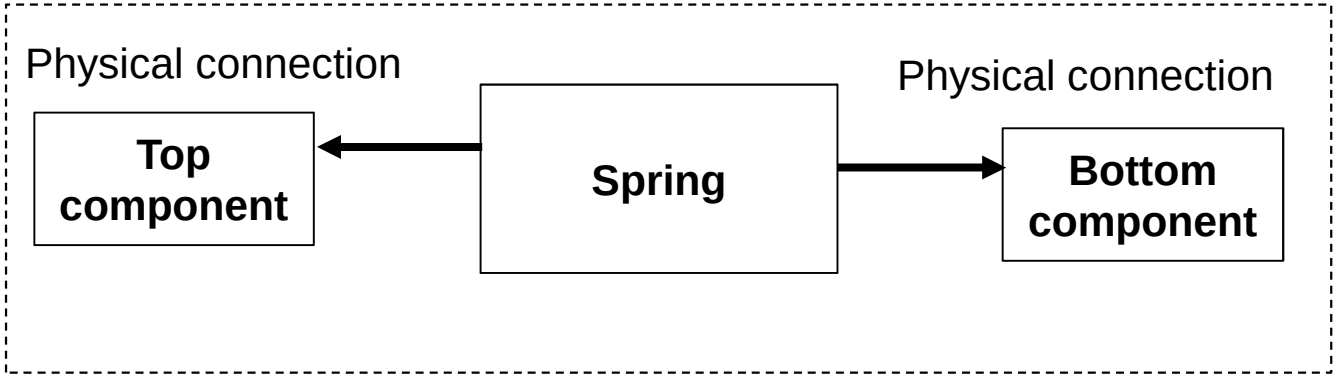
Step 6: Optimization									
Planned improvement actions	**Responsible**	**Due date**	**Status**	**Implemented improvement actions**	**Completion date**	**Sev.**	**Occur.**	**Det.**	**AP**
P: Check heat transfer rates per supplier's documents	C. Spence	6 Jan. 20	Done	P: Supplier documents checked	5 Jan. 20	7	3	6	M

Step 7: Results Documentation

- A company specific document should be created to communicate risk:
  - Purpose & scope of the DFMEA
  - Timing & team members
  - An explanation of how functions were identified
  - A summary of high-risk failures together with actions taken to address them
  - Timing for continuing actions
  - Commitment to review & update the DFMEA during mass production & when failures occur

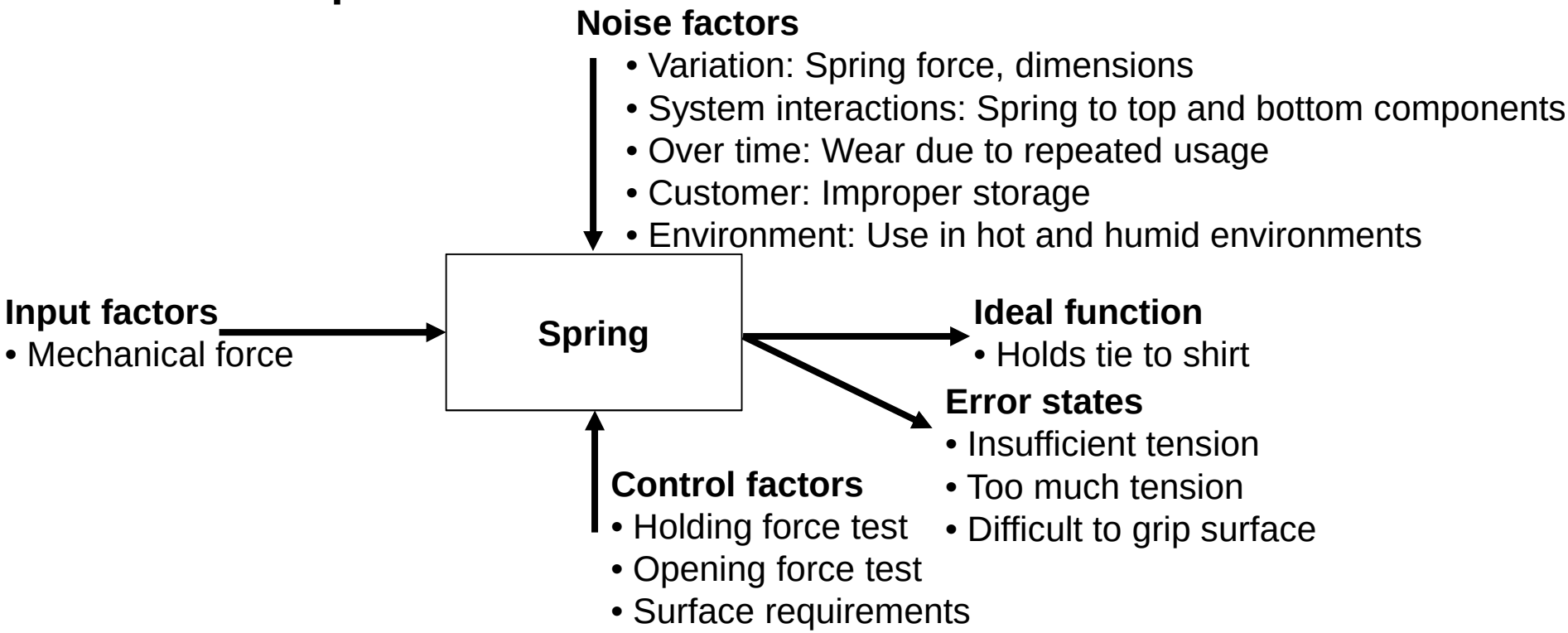
Example: New Tie Clip Design

- All three components of the assembly are shown in a boundary diagram



Example: New Tie Clip Design

- p-diagram shows possible influences on tie clip



Example: New Tie Clip Design

- Structure analysis:

Step 2: Structure analysis		
Higher level system element	**System element in focus**	**Lower level system element**
Top component	Spring	Bottom component

Example: New Tie Clip Design

- Functional analysis:

Step 3: Function analysis		
Higher level function and requirement	**Function and requirement in focus**	**Lower level function and requirement**
Grip tie	Hold tie to shirt	Grip shirt

Example: New Tie Clip Design

- Failure analysis:

Step 4: Failure analysis			
Potential failure effect(s)	**Sev.**	**Potential failure mode(s)**	**Potential failure cause(s)**
Tie falls off	8	Clip not tight enough	Insiffcent spring tension
Difficult to remove	7	Clip too tight	Too much spring tension
Difficult to remove	7	Slippery surface	Insufficient surface roughness

Example: New Tie Clip Design

- Risk analysis:

Step 5: Risk Analysis				
Current prevention actions	**Ocur.**	**Current detection actions**	**Det.**	**AP**
Use spring per company spring standard	4	Spring tension test	3	M
Use spring per company spring standard	4	Spring tension test	3	M
Use hammered surface	2	Operation trials	2	L

Key Take-aways

- New AIAG/VDA FMEA Handbook helps identify potential failures early in the design process
  - Boundary diagrams help identify system interactions with other components
  - P-diagrams help identify influences, functions & failures
  - Tree structure links causes, failures & effects though the assembly or system

Summary

- In this session you should have learned about:
  - Changes implemented in the new FMEA Handbook
  - How to list the steps for creating a DFMEA
  - How to evaluate risks based on Action Priority

References

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