Cleanliness an underestimated area when solving problems on Safety Critical Aerospace parts

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European Network for Business and Industrial Statistics

21th Annual Conference 13-15 September 2021

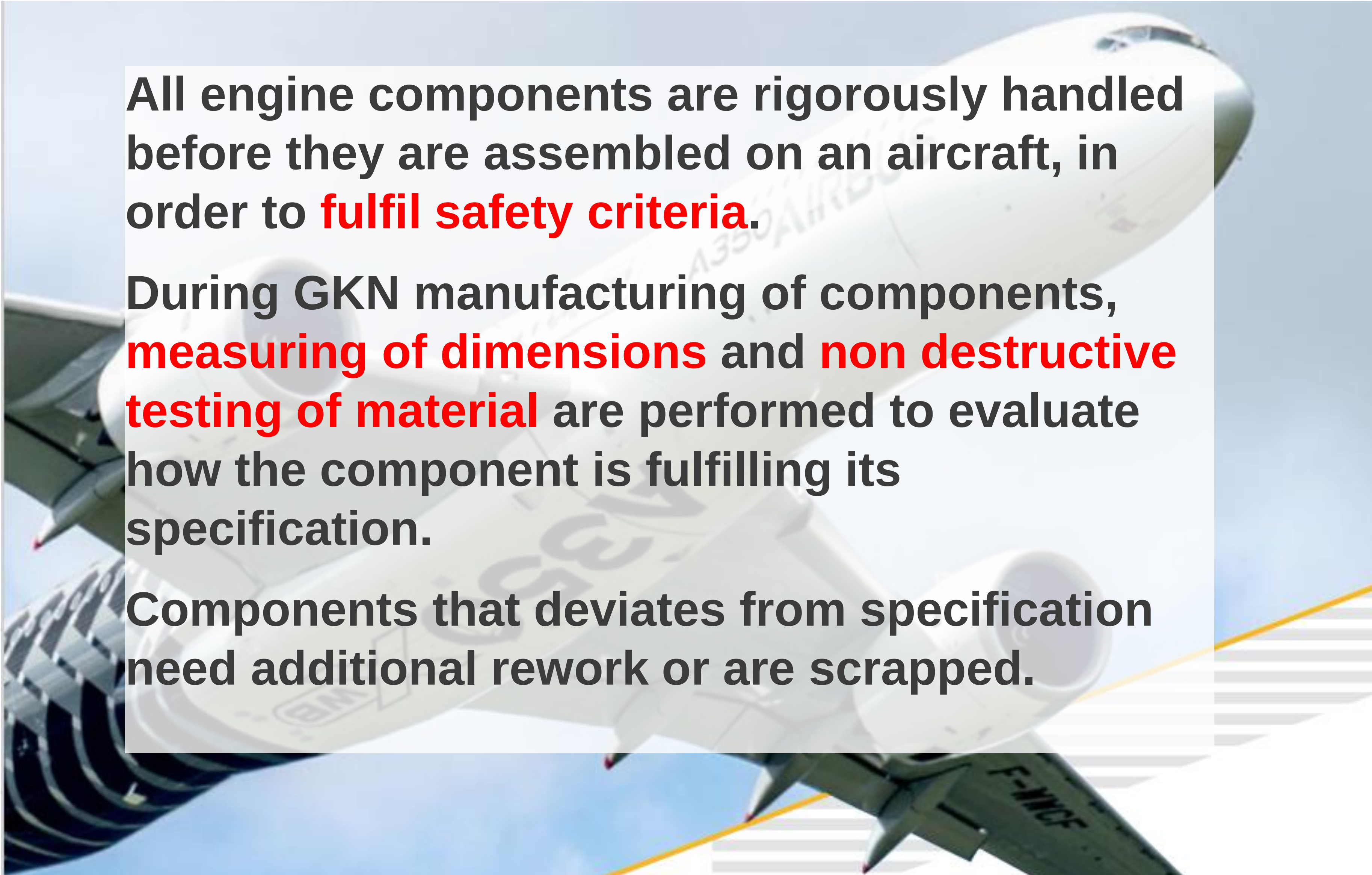
10110 Rev. 23

Agenda

- Prologue-Safety first
- Prologue-Manufacturing process
- The Cleanliness Problem
- General idea on improving a cleaning process
- How to solve a problem?
- Structure of a problem- A Special Cause.
- Back to the Background flourescence problem solving
- The new approach in 2019/2020 problem solving
- Conclusion and Problem resolution
- Future improvements

Prologue-Safety first

thinkSAFE!



All engine components are rigorously handled before they are assembled on an aircraft, in order to fulfil safety criteria.

During GKN manufacturing of components, measuring of dimensions and non destructive testing of material are performed to evaluate how the component is fulfilling its specification.

Components that deviates from specification need additional rework or are scrapped.

Prologue-Manufacturing process

In this example a component is manufactured in following sequence:

OP-1-8
Different Cutting operations

OP-9
Washing machine

OP-10-12
Deburring and checking operations

OP-13
Etching to approve casting process of material

OP-14
Flourescence Penetrant inspection(FPI) of surface defects

OP-15
Final Measuring of dimensions (Measuring machine)

OP-16
Final check

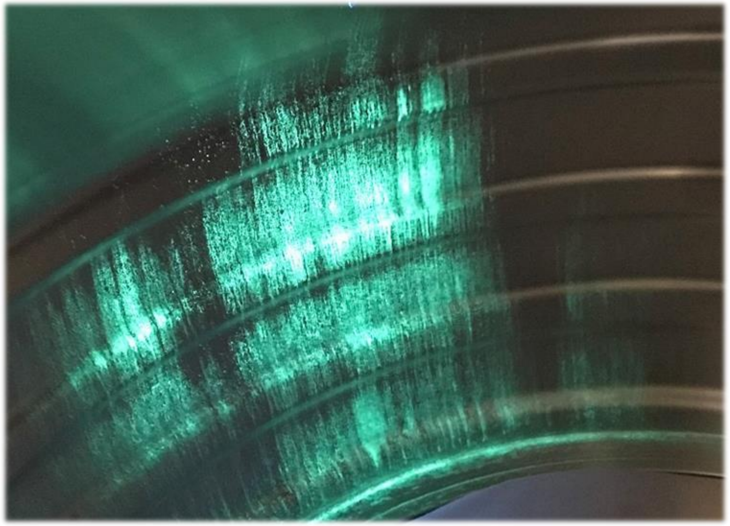
In the **grey boxes** all operations that adds value in terms of features.
In **blue box** the operation with measuring of all dimensions/features are done.
In **green boxes** are the operations with non destructive testing of material
In **yellow box** the first cleaning operation is performed.
However also in **green boxes** cleaning operations are done, as part of the chemical processes.

The Cleanliness Problem, an intermittent problem

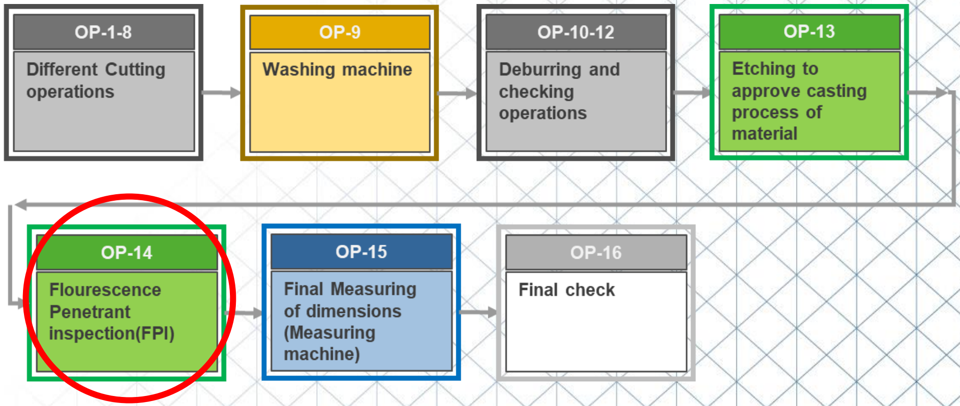
The **etching process** is implemented by a **customer standard.** However to control the etching process is not completely defined by the standard. Only very limited data exists in SPC system from the process. The **existing data is followed up in certain intervals and is limited to chemical concentrations on acids and detergent**.

When the **problem is detected, it is reported manually** by the operators working in the Non Destructive Testing area. When the part is not clean they can not complete their work. They have to clean the part in order to complete the inspection.

When the **problem is frequent and parts are queing** a **TASK FORCE** is started!



Not possible to find cracks in an area of Background flourescence



General idea on improving a cleaning process

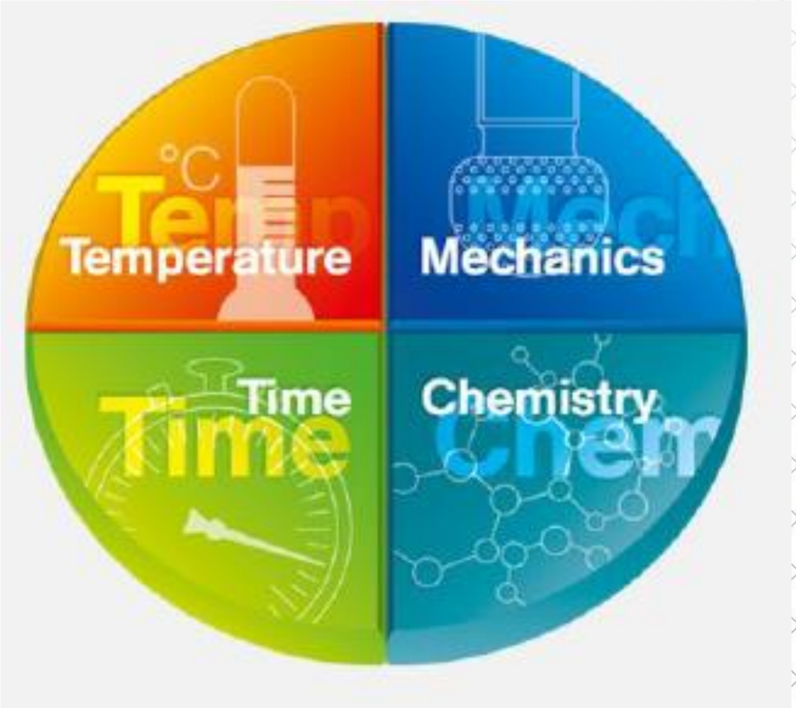
Following the idea´s of Sinner´s circle:

-one factor can be compensated by any of the three other factors.

Cleaning is mainly controlled by:

- **Number of cleaning steps.**
- **Detergent/dish soap (surfactants)**
- **Temperature**
- **De-ionized water**
- **Time**
- **Mechnical/manual cleaning**

  (big components)



How to solve a problem?

- Gather a task force group- a **multi disciplinary team with operators and method experts** **(important)**
- **Gather data** from all observations that can be done. **(challenging)**
- **Map process** and its possible variations.
- **Express hypothesis** and check with data which hypothesis that need to be further worked on, and which can be deleted. **(difficult)**
- This is to find a reasonable **root cause that can be attacked**.
- In parallel find **containment actions** that acts **on the problem**. **(big focus)**

AESQ - 8D REPORT   Example of work process

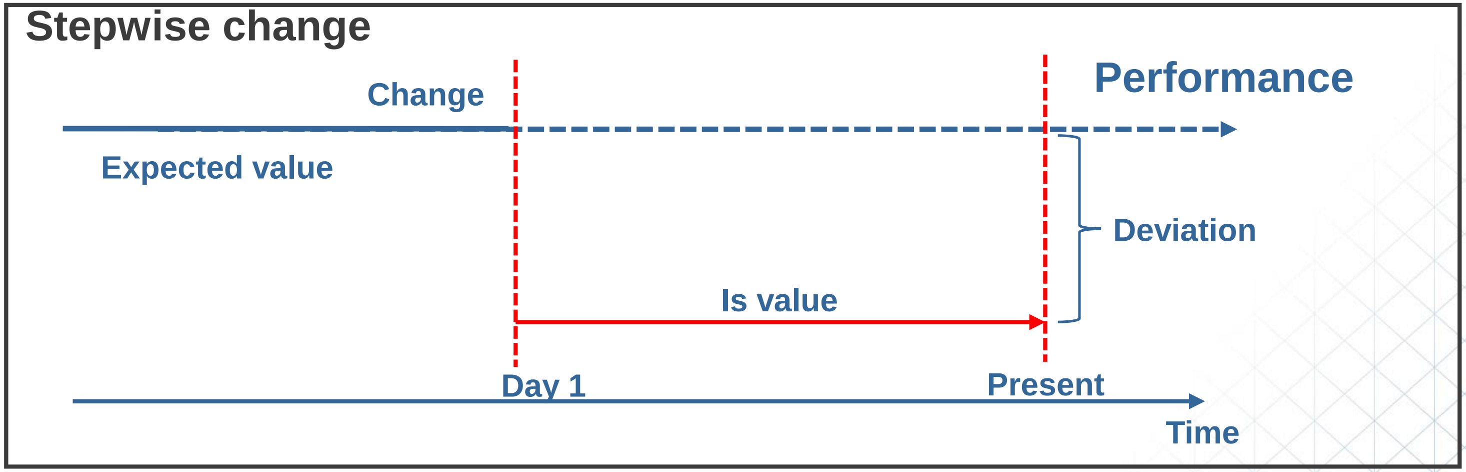
	Supplier Name	Supplier Code	Date Opened	Targeted Closure	Date Closed
	GKN aerospace				

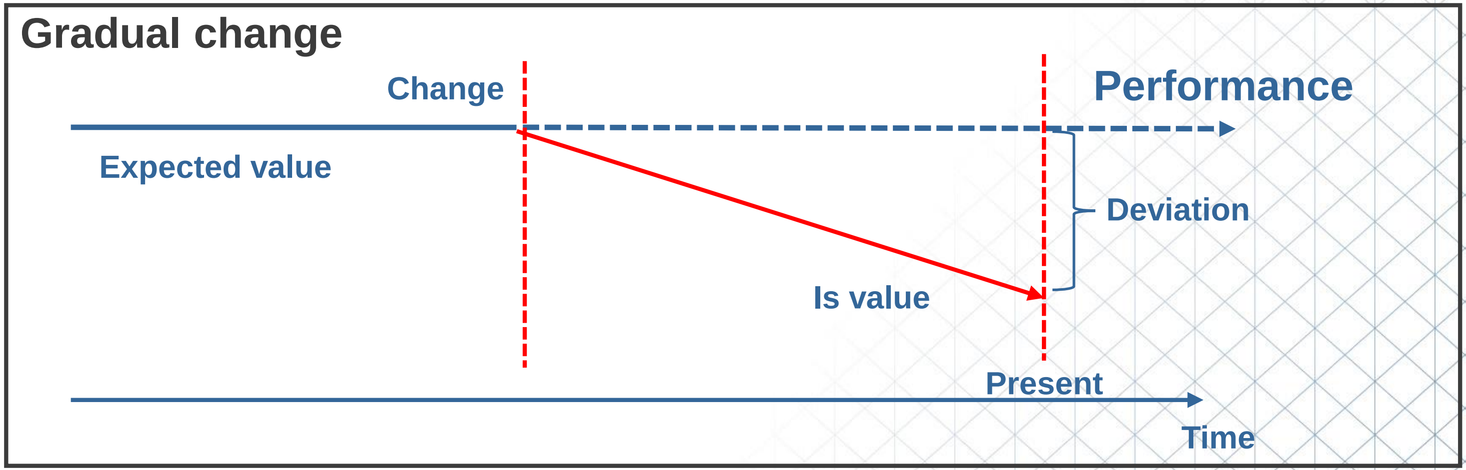
Progress Tracker	Discipline	0	1	2	3	4	5	6	7	8
		Implement Immediate containment and prep.	Form the team	Define the Problem	Develop Containment Actions	Identify and verify Root Cause	Identify Corrective Action	Implement Corrective Action	Define and plan Preventive action	Recognise the team
Closure Date										
Effectiveness check Date										

Structure of a problem- A Special Cause.

When everything works as intended, it works at its **nominal performance**.

But if something is **changing the result** will also possibly change. **That is a Special Cause.**





Back to the Background flourescence problem solving

There is a **"lack of data"** that actually is pointing out what has happened.

What is the nominal performance? How can we see that the process is deviating?

Subjective ideas are limiting how the team can find the real solution to the problem.

First Task Force was run 2006.

Extensive DoE 40 different experiments were run with different settings. 5 parameters where varied, in a full factorial way.

Hard to evaluate the result.

Mainly due to lack of physical understanding and relevant factors to measure and vary.

Test chart according to DOE

(Design Of Experiment)

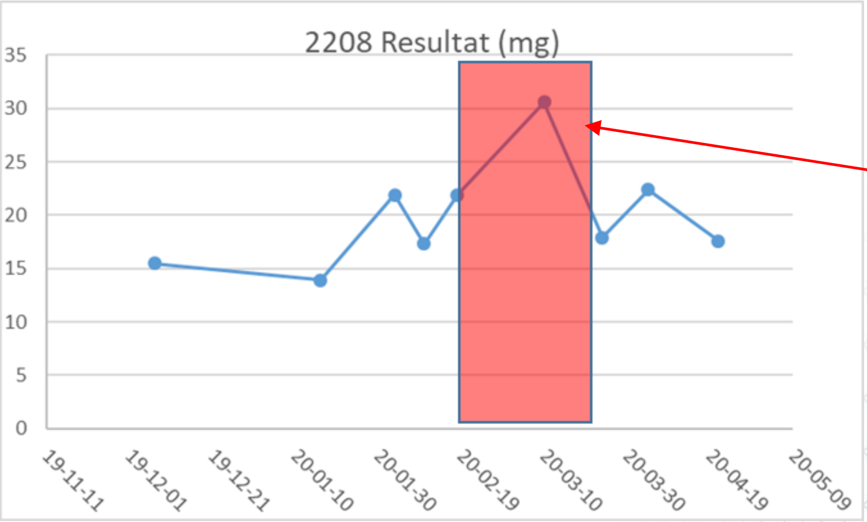
KAR nr.	4398	7804	7805	2262	7806	1868	7805	2263	7807	7806	7808	7602	2263	7807	7806	7808	7602
StdOrd	Alk. Clea	Rin	Rin	Activatin	Rin	Anodizin	Rin	Etc	Rin	Rin	Rin	Hot Rin	Remove Blu	Rin	Rin	Rin	Hot Rin
1	300	30	10	210	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	600
2	900	30	10	50	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	120
3	900	30	10	50	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	600
4	300	30	10	210	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	600
5	600	30	10	130	10	<1 amp.	10	75	10	10	10	60	75	10	10	10	360
6	600	30	10	130	10	<1 amp.	10	75	10	10	10	60	75	10	10	10	360
7	300	30	10	50	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	600
8	900	30	10	210	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	120
9	300	30	10	210	10	<1 amp.	10	120	10	10	10	60	120	10	10	10	600
10	900	30	10	210	10	<1 amp.	10	120	10	10	10	60	120	10	10	10	120
11	900	30	10	210	10	<1 amp.	10	120	10	10	10	60	120	10	10	10	600
12	900	30	10	50	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	120
13	300	30	10	210	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	120
14	900	30	10	210	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	600
15	600	30	10	130	10	<1 amp.	10	75	10	10	10	60	75	10	10	10	360
16	300	30	10	50	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	120
17	900	30	10	50	10	<1 amp.	10	120	10	10	10	60	120	10	10	10	600
18	300	30	10	210	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	120
19	300	30	10	50	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	120
20	300	30	10	210	10	<1 amp.	10	120	10	10	10	60	120	10	10	10	120
21	900	30	10	210	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	120
22	900	30	10	210	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	600
23	900	30	10	50	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	120
24	300	30	10	50	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	600
25	900	30	10	50	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	600
26	900	30	10	50	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	600
27	300	30	10	210	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	120
28	900	30	10	50	10	<1 amp.	10	120	10	10	10	60	120	10	10	10	120
29	300	30	10	50	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	600
30	900	30	10	210	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	600
31	300	30	10	210	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	600
32	900	30	10	210	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	120
33	300	30	10	50	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	120
34	300	30	10	50	10	<1 amp.	10	120	10	10	10	60	120	10	10	10	600
35	600	30	10	130	10	<1 amp.	10	75	10	10	10	60	75	10	10	10	360
36	300	30	10	50	10	<1 amp.	10	120	10	10	10	60	120	10	10	10	120
37	600	30	10	130	10	<1 amp.	10	75	10	10	10	60	75	10	10	10	360
38	900	30	10	210	10	<1 amp.	10	30	10	10	10	60	30	10	10	10	120
39	300	30	10	50	10	<1 amp.	10	30	10	10	10	60	120	10	10	10	600
40	900	30	10	210	10	<1 amp.	10	120	10	10	10	60	30	10	10	10	120

The new approach in 2019/2020 problem solving

More detailed understanding in physical process that affects the cleaning problem.

- Measurements on new parameters like **amount of particles** in bath

Problem was detected end of Oct 2019 first measurement in Dec 2019



Problem Background flourescence

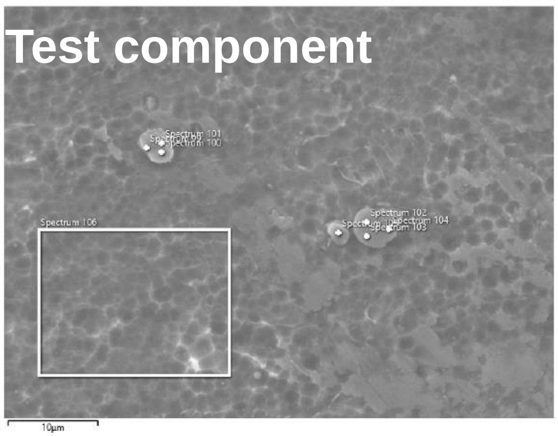
Figure shows enhanced particle level in a certain bath in etching process at the time period of the problem.

However there is still a measurement challenge connected to small amount of particles.

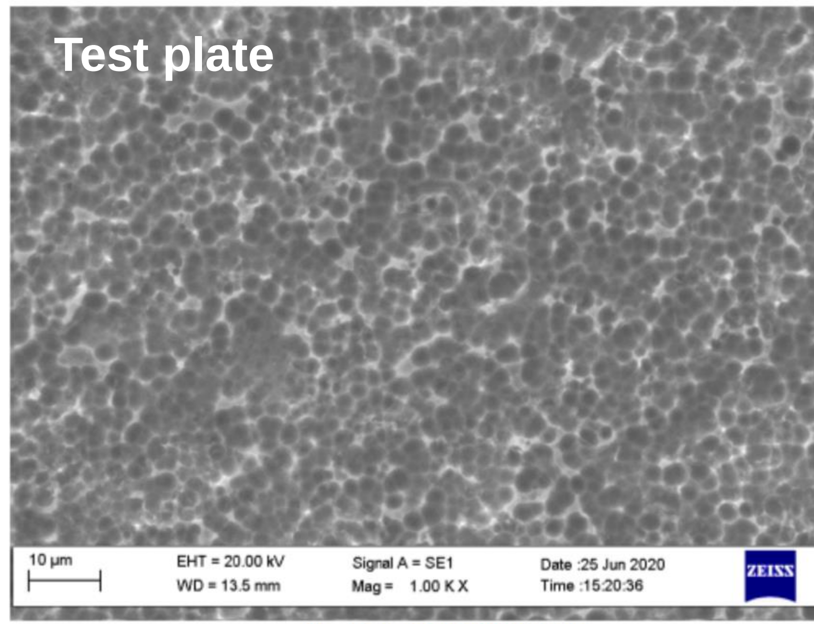
The approach in 2019/2020 problem solving

More detailed understanding in the physical process **etching** that affects the cleaning problem.

- Measurements by scanning electron microscope to detect surface roughness structure from etching.



(SEM-SE)



i) D-1, SEM-SE (1000x)

Figures show particles that are fixed on a test component surface from the time of the problem. The surface roughness and size of pits are similar to the particle size.

Still problem due to cleaning of material sample before entering electron microscope.

Conclusion and Problem resolution

At present:

Due to pandemic the **volume today** of the components are **significantly lower** of what we had during the period of problems. The problem of background flourescence has also not been seen as before the pandemic.

- One interpretation is that there is a correlation to the number of parts run in the process. **Decreased volume of components decreased problem.**
- The **measurements systems has been improved** in such away that it is **possible to read out** in the SPC system **whether a problem with background flourescence has appeared** or not.
- **Manual measurements on amount of particles in critical bath**, is done on a **regular basis.**

Conclusion and Problem resolution

> New **SPC-reporting**
  – Tendency of cleanliness data
  – Combination of subjective and objective data

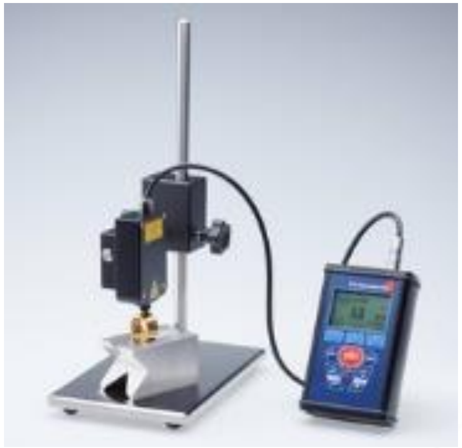
Etching (OP 13)		FPI (OP 14)		Final check (OP 16)	
Requirement no.	**Estimate**	**Requirement no.**	**Estimate**	**Requirement no.**	**Estimate**
Cleanliness before etching	*0 = Clean cloth *1 = Grey cloth	Hard to clean	*0 = Easy to clean *1 = Hard to clean	Cleanliness at final check	*0 = Clean part *1 = Runnings with particles *2 = Runnings with etching *3 = Other type of uncleanliness *4 = Uncleanliness that affects the delivery (Q4)
Cleanliness after etching	*0 = Clean cloth *1 = Grey cloth	Sufectant rests(Blue)	*0 = No rests *1 = Rests of surfectant		
		Background flourescence (Green)	*0 = No rests *1 = Rests of BF *3 = Not possible to inspect(Q3)		

***Error codes and data that is gererated as a one sided distribution. (only values > 0, 0 = Nominal value)**

Future improvements to be explored

Particle measurements

- SITA CleanoSpector
  - Organic pollution
  - UV-light
  - SPC-program



Concentration measurements

- SITA
  - Measurement of **active** surfactant content
  - SPC-program
- Choices
  1. Stationary – Pro Line T15
  2. Mobile – DynoTester


1.


2.

THANKS FOR LISTENING

QUESTIONS?