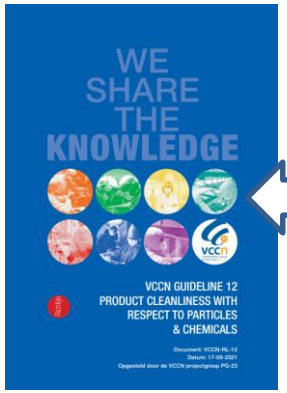
Product cleanliness (VCCN Guideline 12)

Msc. Olof Teulings

WE SHARE THE KNOWLEDGE

Contents



After this presentation, you will know

- Who I am and where I work
- What the VCCN is

- Contents of the guideline 12
- Practical interpretation by NTS

- Impact on design of the cleanroom

MSc. Olof Teulings

Process & Cleanroom engineer @ NTS

Over 10 years of experience in:

- Continuous improvement of
  - **clean assembly**
  - **clean room**
- Layout and expansion of the cleanroom

Co-author of the VCCN guideline 12.

NTS

<u>First-Tier Contract Manufacturer of (opto-) mechatronic systems and mechanical modules</u>

- Semicon & Analytical markets
- High complexity products, Low Volume
- Complete chain
  - Development,
  - Precision components and frames
  - System integration

- Global presence (Europe, Asia, USA)
- Over 1700 employees
- Turnover of €350+ million

NTS

Facilities

- **Cleanroom**
  - over 5500 m^2 (ISO 5-8, AMC)
- **Cleaning processes**, a.o.
  - Alkaline cleaning
  - Vapour degreasing (in 2023)
  - Bake-out
  - Sensitive snowcleaning
- **Laboratory**, a.o.
  - Fast Micro + PMC
  - Sem-EDX
  - Sensitive RGA

VCCN – What is the VCCN?

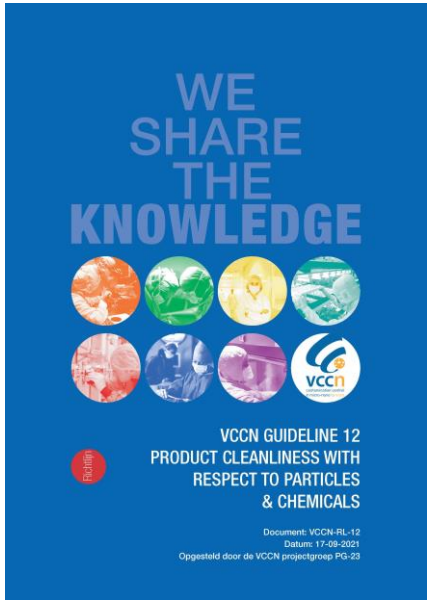
- **Dutch society for Contamination Control**
- **Founded in 1988**
- **Over 500 members**
- **Active in different markets:**
  - Micro-Nano
  - Health care
  - Pharma
  - Food
  - Space

Developing knowledge

Developing knowledge

ISO classification number (*N*)	Maximum concentration limits (particles/m³ of air) for particles equal to and larger than the considered sizes shown below					
	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1 000	237	102	35	8	
ISO Class 4	10 000	2 370	1 020	352	83	
ISO Class 5	100 000	23 700	10 200	3 520	832	29
ISO Class 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class 7				352 000	83 200	2 930
ISO Class 8				3 520 000	832 000	29 300
ISO Class 9				35 200 000	8 320 000	293 000
NOTE Uncertainties related to the measurement process require that concentration data with no more than three significant figures be used in determining the classification level						

ISO standards



Guidelines

Projects

Transferring knowledge

Transfering knowledge

Courses, Trainings and Workshops

Technical

Behaviour

Cleaning

Product cleanliness

Sharing knowledge

Sharing knowledge

Excursions & Business fairs

Conferences & Symposia

C² MGZN - Magazine

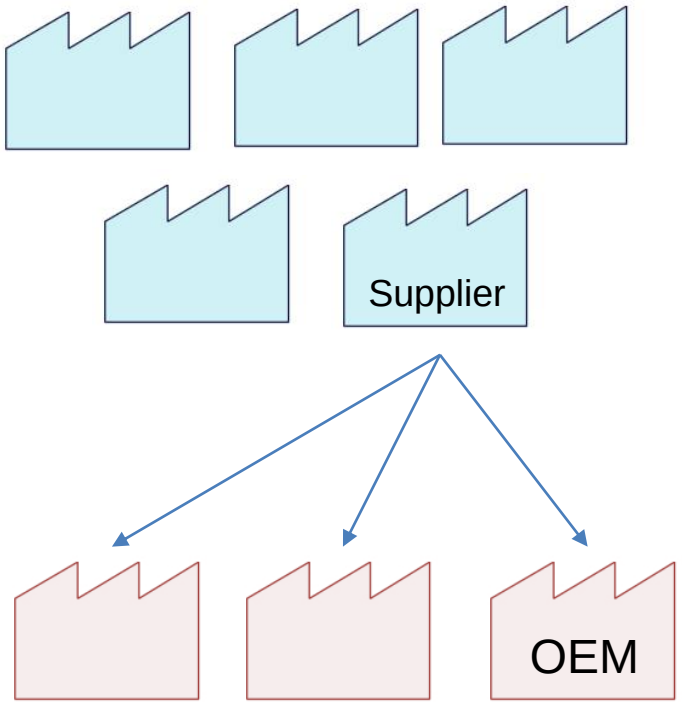
Guideline 12

Product cleanliness

with respect to Particles & Chemicals

WE SHARE THE KNOWLEDGE

Guideline 12 – Why?



Surface cleanliness for particles and chemicals

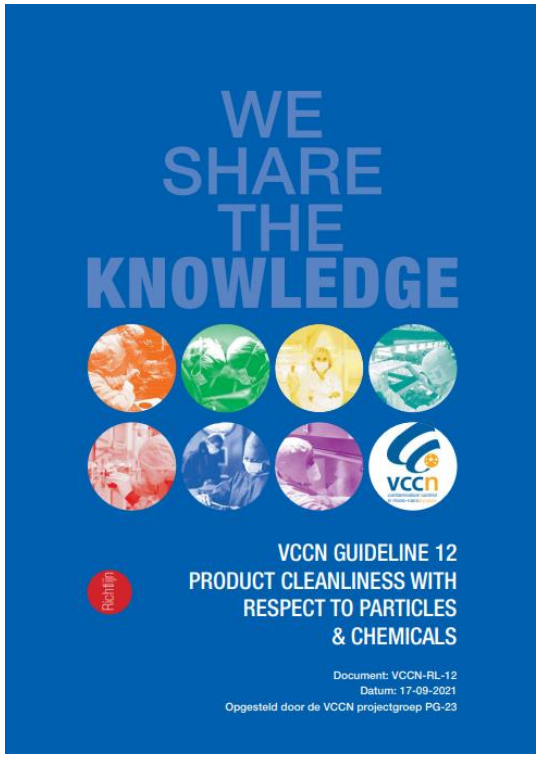
A lot of different suppliers deliver parts/modules to the same set of OEM's:

- Every OEM specifies cleanliness **in its own way**
- Every supplier produces and cleans **in its own way**

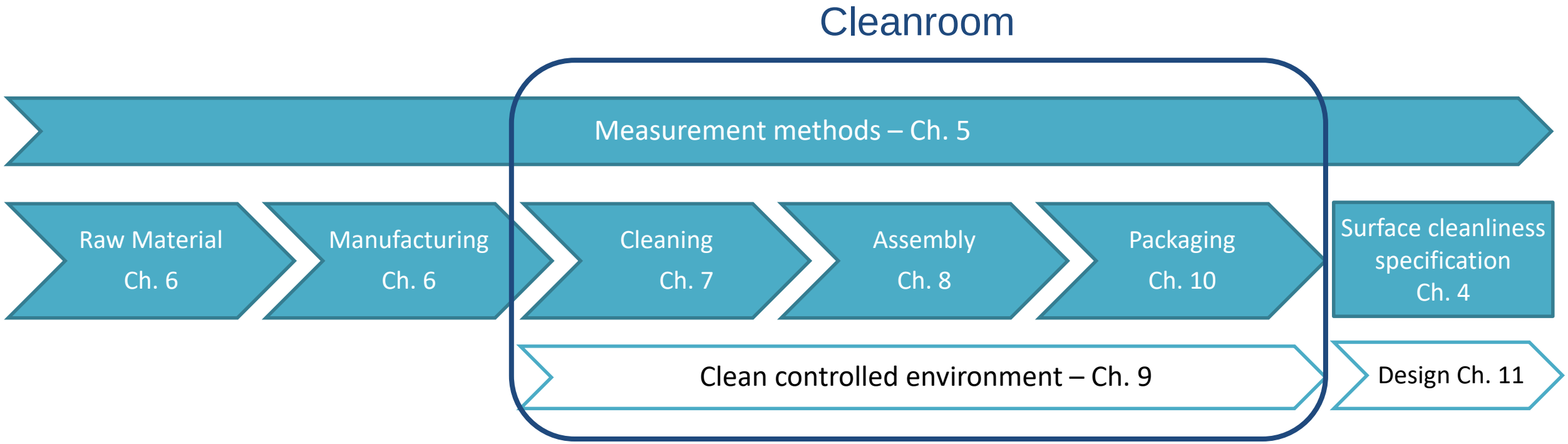
Is there not a common ground?

Guideline 12: Product cleanliness

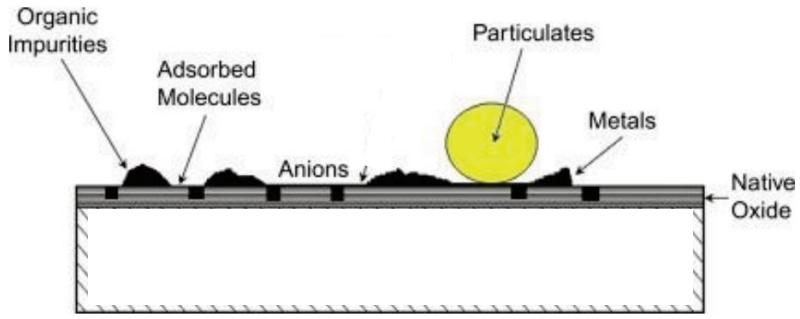
Group organised by VCCN with **OEM, Suppliers & Consultants**



Complete supply chain (Contents)



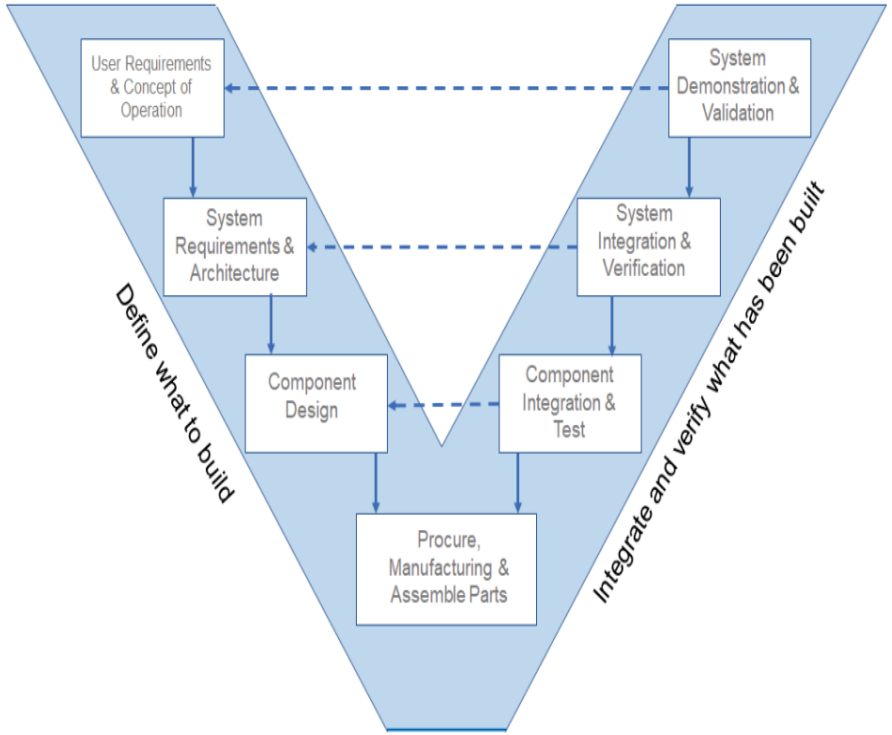
Surface cleanliness specification (Chapter 4)



ISO SCC	Extremely clean		Very Clean		Clean		Dirty		
-1							■	■	Dirty
-2							■	■	
-3							■	■	
-4			■	■	■	■			Clean
-5			■	■	■	■			
-6			■	■	■	■			
-7	■	■	■	■					Very clean
-8	■	■	■	■					
-9	■	■	■	■					
-10	■	■	■	■					Extremely clean
-11	■	■	■	■					
-12	■	■	■	■					
	1	2	3	4	5	6	7	8	ISO SCP

- **Use ISO14644 standards**
  - other standards in Annex
- **Specification for:**
  - Particles → SCP
  - Chemicals → SCC
  - Trace elements
- **Relation between Particles and Chemicals**

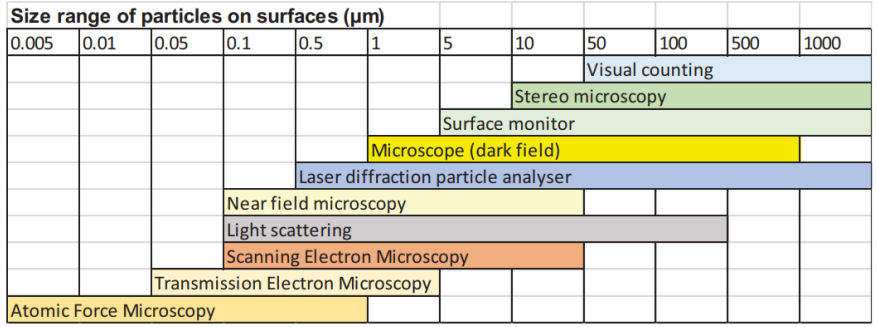
Surface cleanliness specification (Chapter 4)



- **Design using the 'V-model'**
  - Define and validate each phase
- **Make cleanliness budgets**
- **Don't over or under specify**
  - Use a risk assessment
- **Specify with measurement method!**

Measurement methods (Chapter 5)

Particle measurement techniques



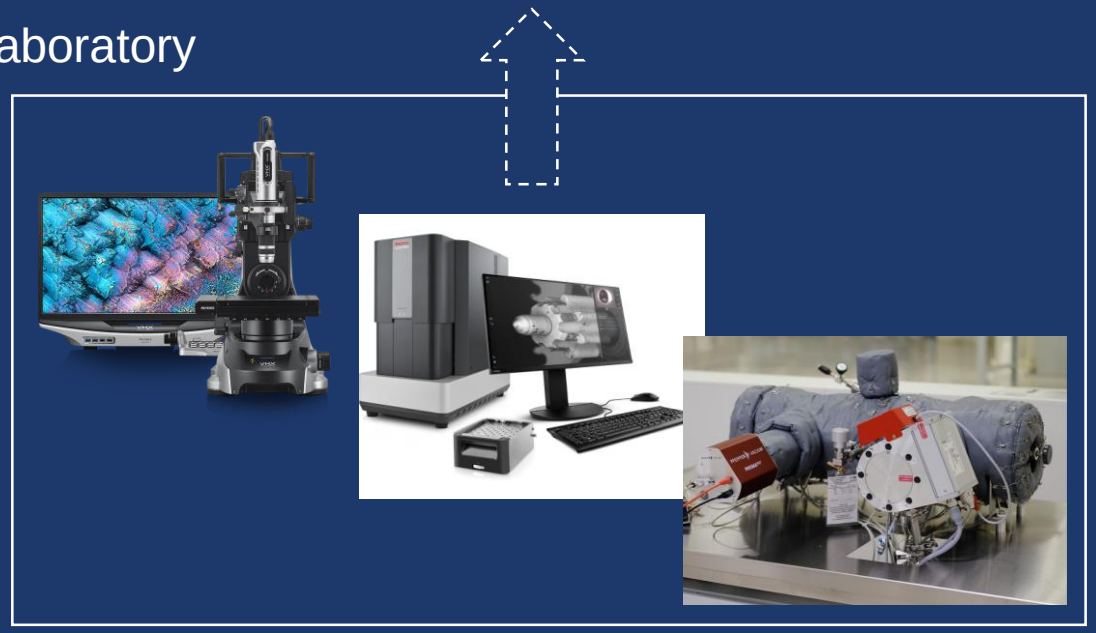
Chemical sampling techniques

Sampling procedure	Measured contaminant	Measurement technique	Industry/Laboratory
Gas purge	Organics,	Tenax-TD-GC, RGA	Industry
Gas Purge	Acids, bases	Ion chromatography, Ion Mobility Spectrometry, specific monitoring	Laboratory
Leaching	Inorganics, organics	Ion chromatography, ICP-MS, Gas Chromatography	Laboratory
Leaching	Inorganics, organics	Weighing	Industry
Witness plate	Inorganics, Organics	ICP-MS, FTIR, XPS, AAS	Laboratory
C-tabs	Inorganics, organics	SEM-EDX,	Industry/Laboratory
Moisture	Water	CRDS	Laboratory
Vacuum extraction	Organics	RGA	Industry/Laboratory

- **Direct or indirect measurements**
  - Indirect is removing with air, liquid or solid
- **Industrial or laboratory methods**
- **Total overview in:**
  - ISO 14644-9 (particles)
  - ISO 14644-10 (chemical)

Routine measurement

Laboratory



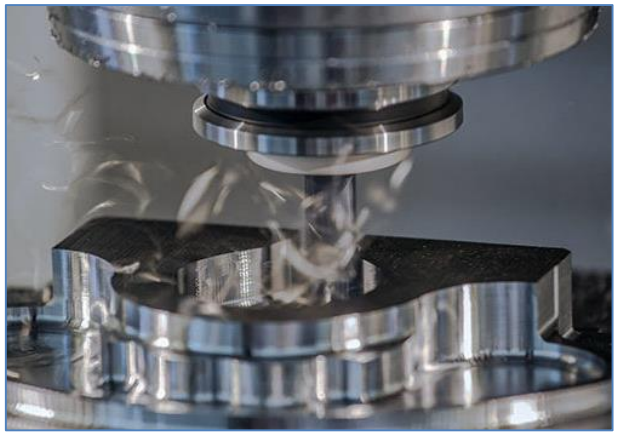
MEASUREMENT METHODS

- Have a laboratory!
  - Be able to measure (more than) the OEM's demand
- Laboratory techniques are transferring (temporary) to Routine measurements

Raw material & Manufacturing (Chapter 6)

- **Raw material**
  - Uniform
  - Properties change for larger blocks…
- **Environment of manufacturing**
  - Separate materials for cross-contamination
  - Air
- **Handling, packaging & transport**
  - Gloves,
  - Covered,
  - markings

Raw material & Manufacturing (Chapter 6)



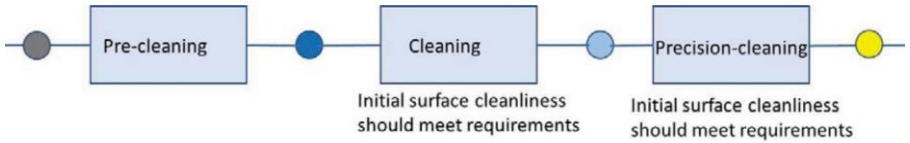
- **Machining**
  - Fluids quality
  - Cross contamination previous products
  - Fluids must be matched to cleaning process
- **Intermediate cleaning**
  - Prevents drying in of fluids
- **Surface treatment**
  - Contamination can diffuse through the surface
  - Cleanliness of treatment fluids

MACHINING

- Fluid control
- Environmental control
- Intermediate cleaning
- Everything with gloves, no exception

→ **1 FTE**

Cleaning (Chapter 7)



Guide to choosing cleaning method:

1. Object description
2. Cleanliness specification
3. Initial contamination level
4. other requirements
   - a.o. capacity, environment
5. Select cleaning methodology
6. Check material compatibility
7. Cleanliness validation
8. Validate cleaning methodology

Cleaning (Chapter 7)

Particle removal	dirty		very clean			extremely clean		
Technique	**SCP 8**	**SCP 7**	**SCP 6**	**SCP 5**	**SCP 4**	**SCP 3**	**SCP 2**	**SCP 1**
Mechanical cleaning								
Wiping	x	x	x	x				
Brushing/Sweeping	x	x	x					
Scraping/Abrading		x	x					
Grinding		x	x					
Fluidic cleaning								
Washing/Rinsing		x	x					
Compressed gas cleaning/rinsing		x	x					
Vacuum cleaning		x	x					
Acoustic cleaning			x	x				
1 Ultrasonic cleaning			x	x				
2 Megasonic cleaning			x	x				
Spray cleaning		x	x	x				
Vacuum cyclic nucleation				x	x			

Chemical removal	dirty		very clean			extremely clean		
Technique	**SCC -1**	**SCC -2**	**SCC -3**	**SCC -4**	**SCC -5**	**SCC -6**	**SCC -7**	**SCC -8**
Fluidic cleaning								
Washing/Rinsing	x	x	x	x				
Compressed gas cleaning/rinsing	x	x	x	x				
Acoustic cleaning	x	x	x	x	x			
1 Ultrasonic cleaning	x	x	x	x	x			
2 Megasonic cleaning	x	x	x	x	x			
Spray cleaning	x	x	x	x	x			
Vacuum cyclic nucleation		x	x	x	x			

- **Overview of cleaning methods and their achievable cleanliness level**
  - Particles (SCP)
  - Chemicals (SCC)

CLEANING

- Keep improving cleaning Process
- Introduction of Sensitive snow cleaning (SCP 4, SCC -6)
- Validation of cleaning
- More processes

→ **1 FTE!**

Assembly (Chapter 8)

- **Deposition contamination**
  - Particle Deposition Rate (ISO 14644-17)
- **Assembly contamination**
  - Handling
  - Assembly action (screw, glue, etc.)
- **Assy cleaning**
  - Less cleaning methods available
- **Product risk assessment**

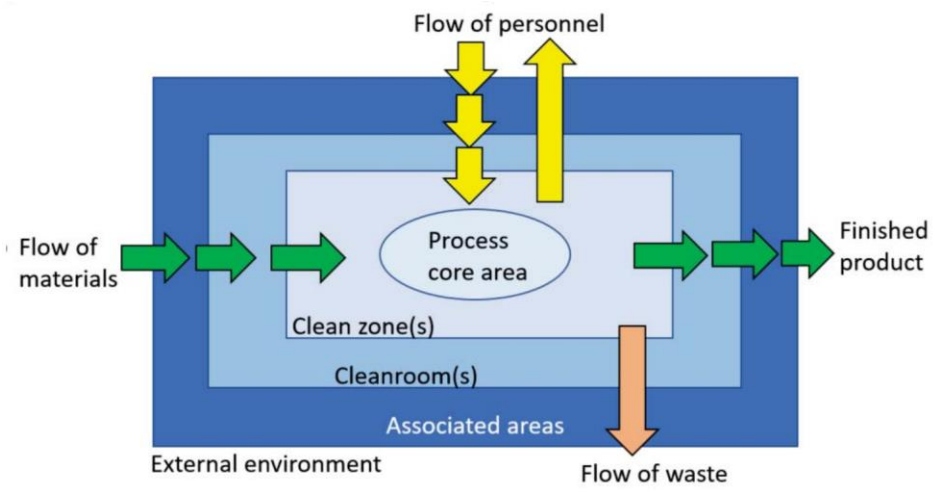
Product Risk Evaluation

Product demand(s)	Zero 10 mu particles								
		Part cleanliness		Processtep 1		Cleanstep 1			Assy cleanliness
		Start	→	Subassembly mirrors	→	Cleaning Subassy	→ ... →		Stop
Location name		n.a.		CLR Hal2 (ISO7/8)		CLR Hal 2 - Darkroom			
		"mirrors"							
Deposition [#/m2]									
Environment [ISO] * Exposure time [h]				6,5	0,25				
Size [um]	Speed [m/h]			#/m3	#/m2 in T				
10	10,8	0		219	591				
Handling									
WOW - Mirror assembly					5%				
WOW - Standard Cleanroom Assembly									
Cleaning									
Cleaning efficiency (in location)						90%			
Accessability surfaces						100%			
Assy cleanliness								[#/m2]	
Size [um]					#/m2	#/m2		per Size	Cumulative
10		0			620	-558		2642	2642

ASSEMBLY

- Measure deposition (ACP, PDR)
- Train & audit for Assembly
- Dark rooms for assy cleaning
- Do the product risk assessment!

Contamination control (Chapter 9)



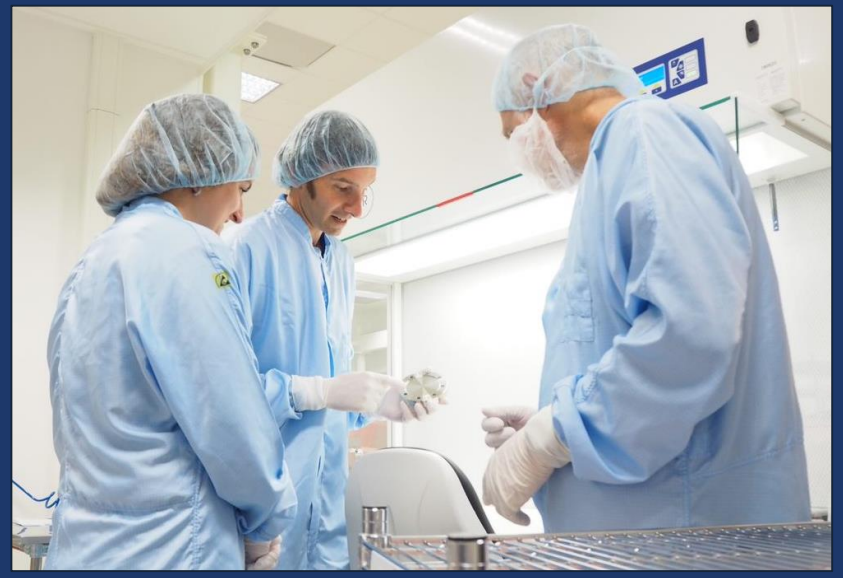
- **Air cleanliness**
  - Particle/Chemical Deposition Rate calculations

$$PDRL = \frac{\mathrm{PDR(D)} \cdot \mathrm{D}}{10}$$

$$\mathrm{Cs(D)} = \mathrm{PDR(D)} \cdot \mathrm{T}$$

$$\mathrm{N(D)} = \mathrm{PDR(D)} \cdot \mathrm{A} \cdot \mathrm{T}$$

- **Particle control solutions**
  - Installation
  - Layout personnel & goods Locks
  - Equipment
  - Cleaning
  - Way-of-Working

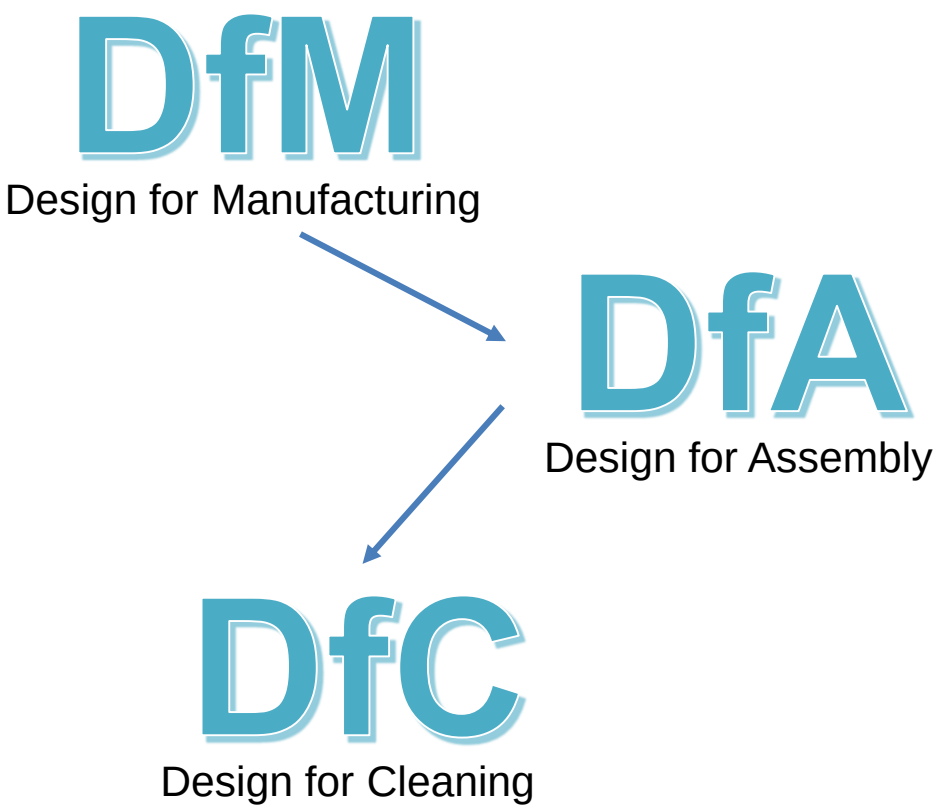


CONTAMINATION CONTROL

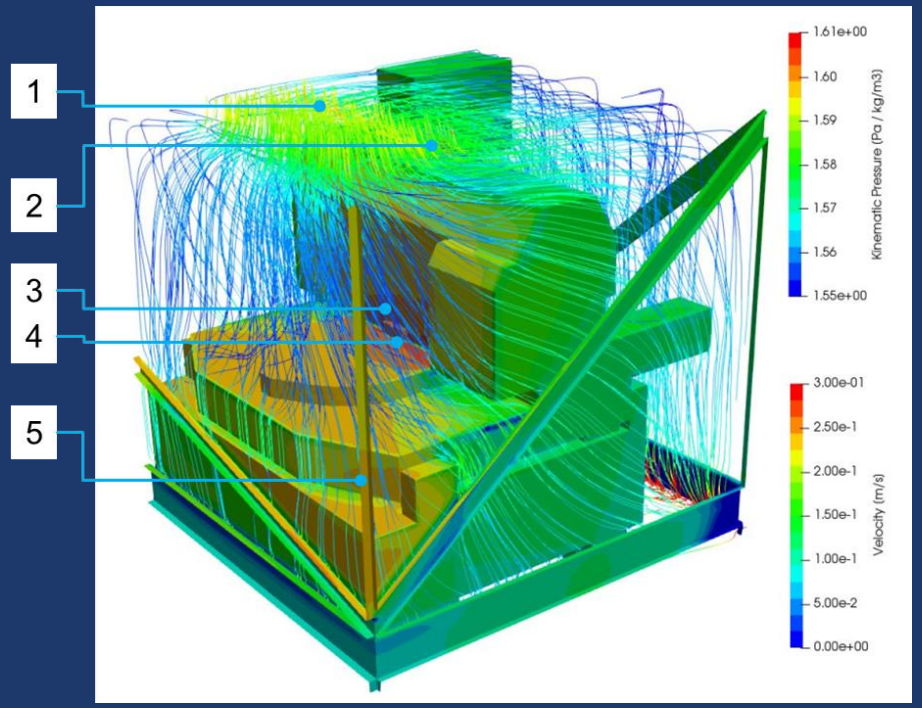
- Keep measuring
- Organise responsibility
- Layout challenge:
  - Flexible (m^2) vs Separation
- Continuous improvement

  → **1 FTE!**

Design for Cleanliness (Chapter 10)



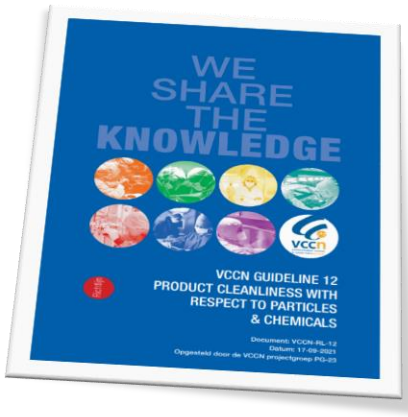
- **Design considerations for Particles**
  - Low particle generation material
  - Small surfaces
  - Short exposure
- **Design considerations for Chemicals**
  - Rules for UHV design
  - Low outgassing materials
  - Surface roughness
- **Design for cleaning**



DESIGN FOR CLEANLINESS

- DfC training
- Outgassing calculations
- CFD simulations for particles

Closure



Process is the most important!

- Guideline 12 describes the process for the **complete supply chain!**

Cleanroom

- Cleaning processes will grow
- Labo is Needed
- Flexibility

Product cleanliness

- Is a lot of work!
- **Work together**
  - Cleanliness Competence Team!

Thank you for your attention,

Any questions?

WE SHARE THE KNOWLEDGE