

Durability of Thermal Energy Meters

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EN 1434-1:2022

3.24

durability

characteristic of a measuring instrument to keep the metrological characteristics over time (e.g. to fulfil the double of MPE), provided that it is properly installed, maintained and used within the permissible environmental conditions



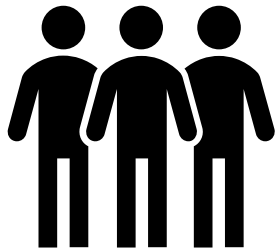
**Waste of Resources
Waste of Labour
Waste of Money**

Every year more than 10 million meters are being replaced in Germany

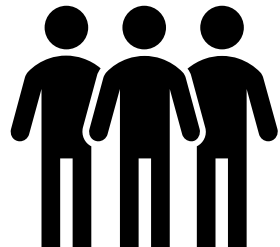
Ca. 90% are being disposed

**15 years of guaranteed operation!
15 years of correct measurement!
No recalibration necessary!
No replacement necessary!**

Is that possible?



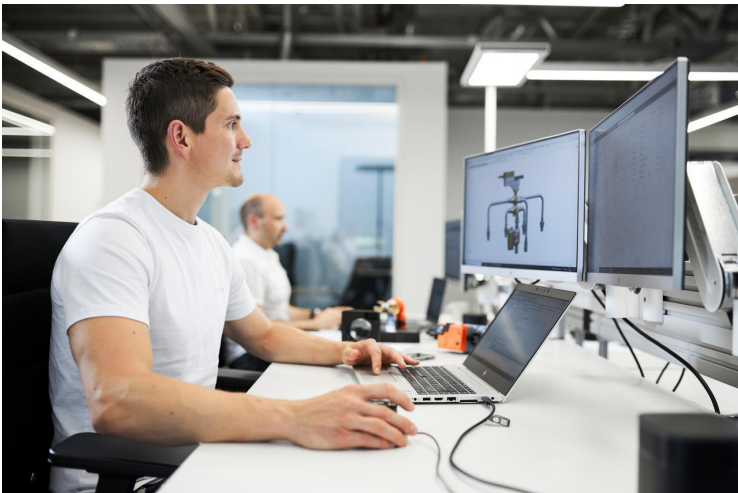
Long Durability is Possible



Of course!

Influencing Factors on the Durability of a Meter

Design



Production



Operation



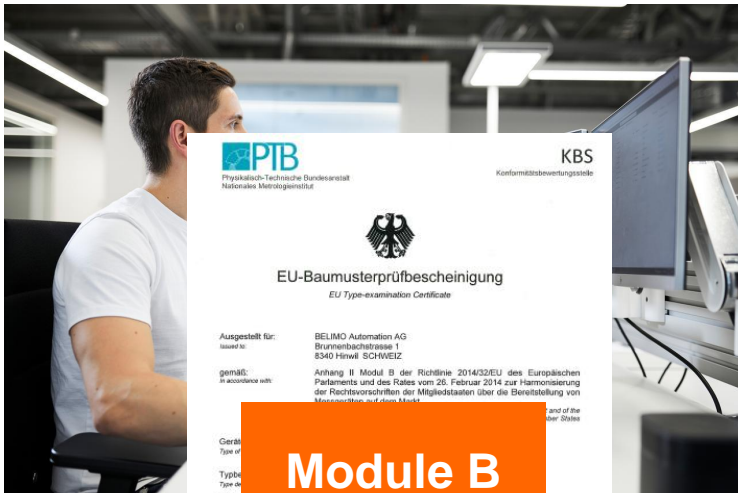
Today's Method



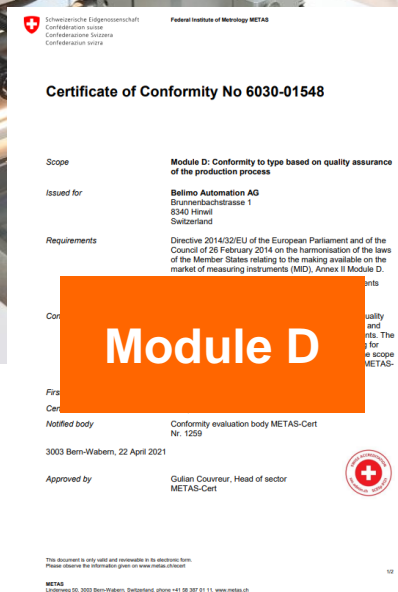
Design

Production

Operation



Module B



Module D



Recalibration periods

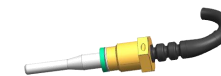
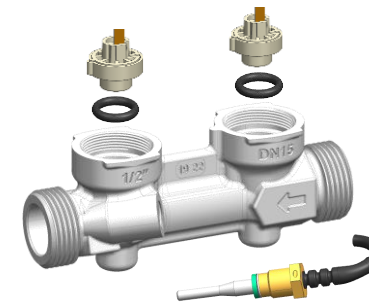
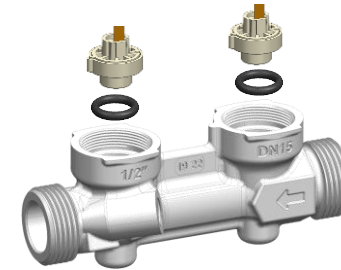
Today's Type Approval Durability Test (EN1434-4)



- Basic test
 - 100 days
 - Varying flows
 - At maximum specified temperature (e.g. 120°C)

- Accelerated test
 - 4000 temperature cycles = 5 years
 - 8000 temperature cycles = 10 years
 - 15...20°C / 80...85°C

- High temperature test
 - 10 cycles à 24h
 - 22h at max. temperature (e.g. 120°C) / 2h at ambient temperature

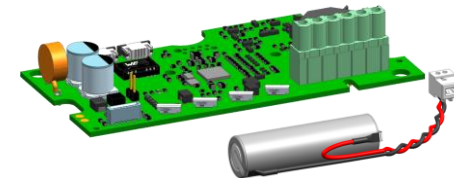
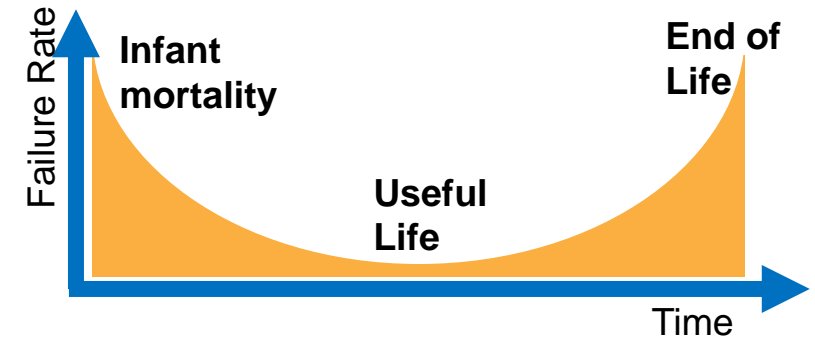


Drawbacks in Today's Approvals

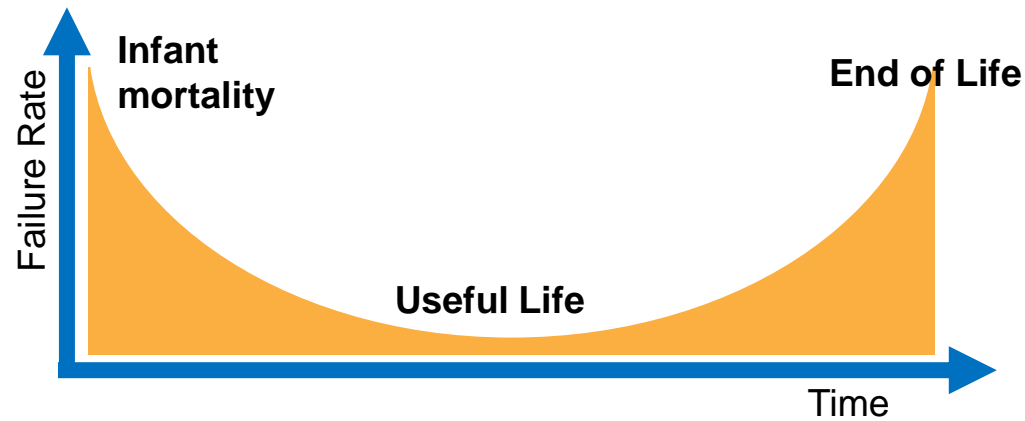
- Application requirements are not reflected
- Approval tests with only 5 samples
 - No statistical data to predict durability
- Just increasing the number of cycles or samples is not enough
 - Only parts in contact with the liquid are tested on durability
 - Other failures could occur, if the weak components are improved
→ e.g. electronics and battery are not covered in durability tests



Source: ecohausshop.ch



Legal Recalibration Periods without Foundation



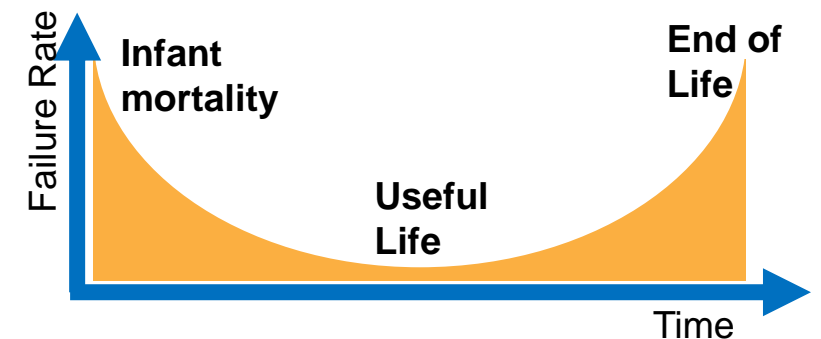
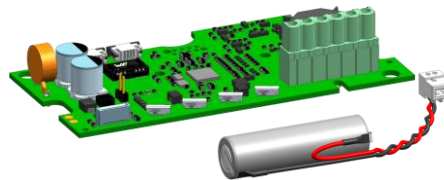
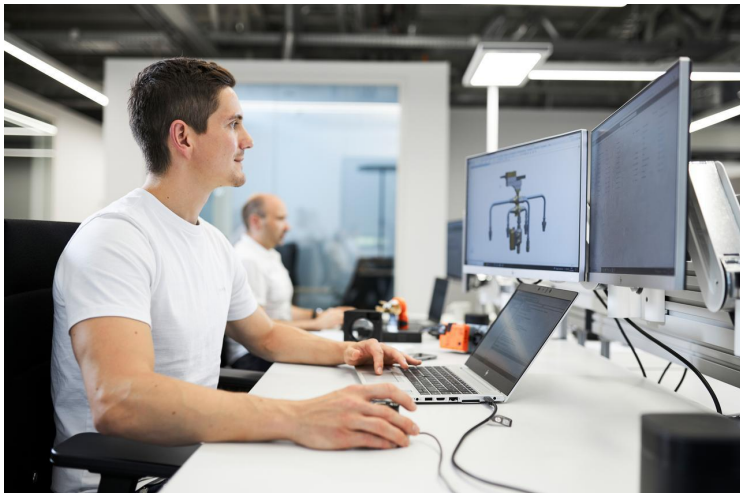
Durability can be designed and predicted

Country	Recalibration period heat meters	Recalibration period district heat meters
Austria	-	5 years
Belgium	8 years	-
Bulgaria	2/5 years	2 years
Croatia	-	3 years
Czech Republic	-	4 years
Denmark	-	6 years
Estonia	-	2 years
Germany	8 years	6 years
Hungary	-	6 years
Poland	5/10 years	4 years
Romania	4 years	4 years
Sweden	-	5/10 years
France, BH, Cyprus, Greece, Ireland, Italy, Malta, Montenegro, Portugal, Spain, Turkey, UK	-	-

Where do we need to improve? → Analysis and Prediction

Design

- Take a look at all components
- Risk based approach to improve quality and durability on component level
- Create statistical data to predict durability



Where do we need to improve? → Recalibration Periods

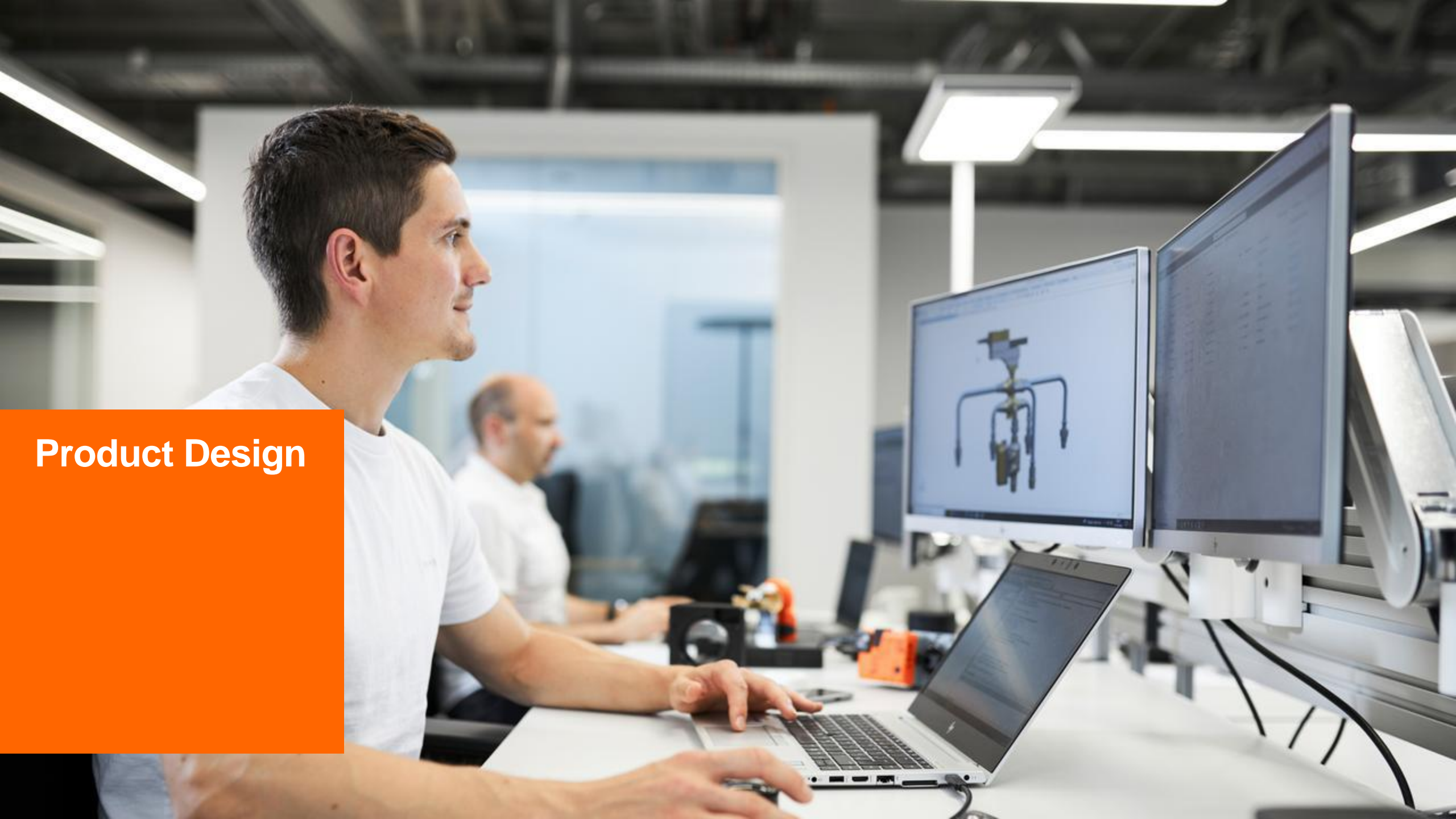
Recalibration periods should be founded on

- **designed and statistically proven durability**
- **health state of the meter**
- **stress level of the meter**

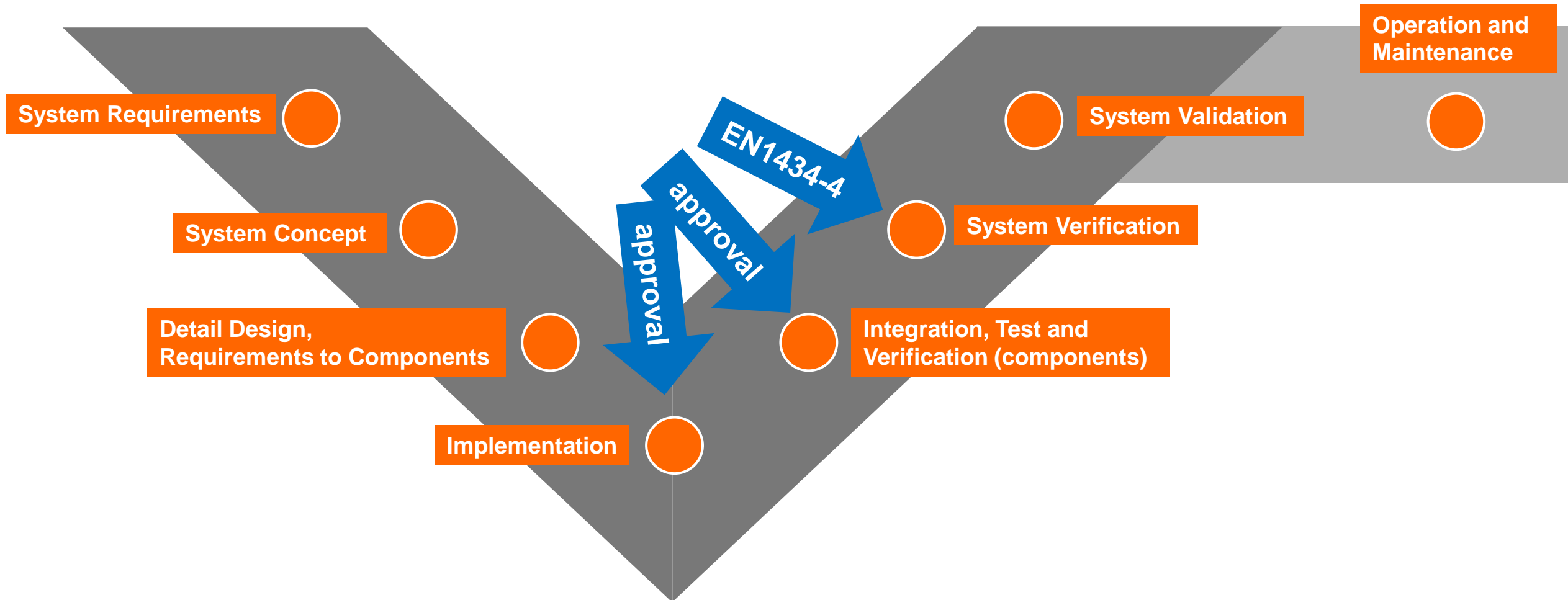
Operation



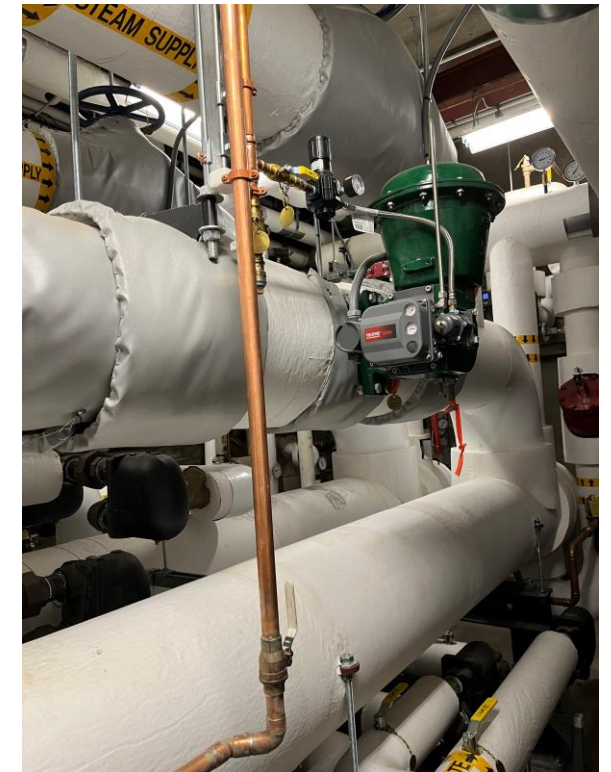
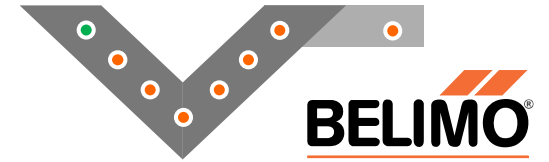
Product Design



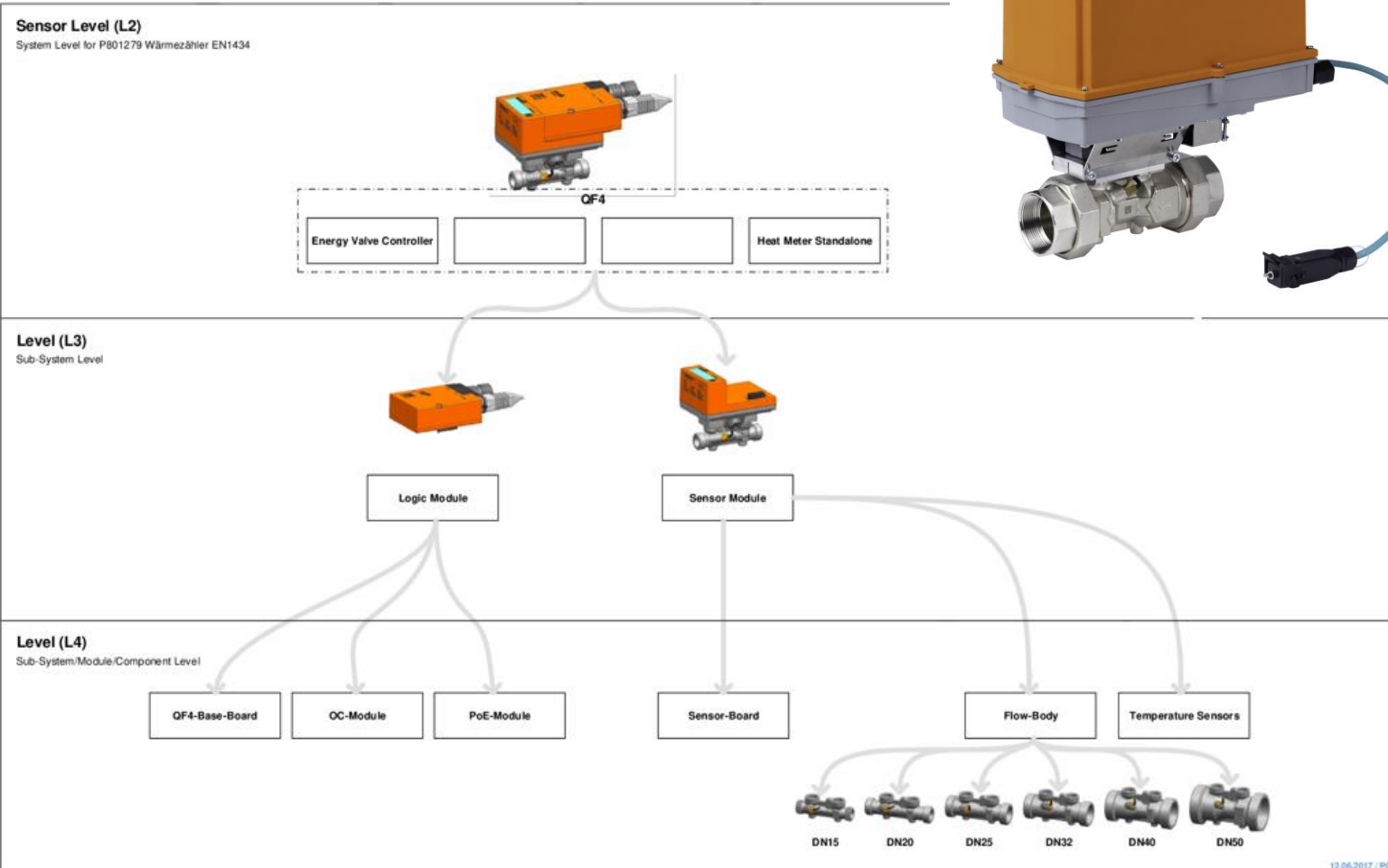
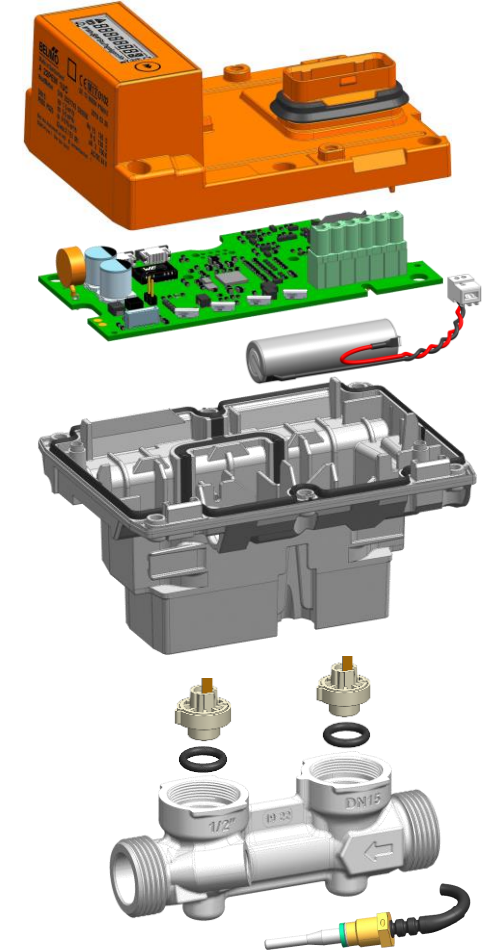
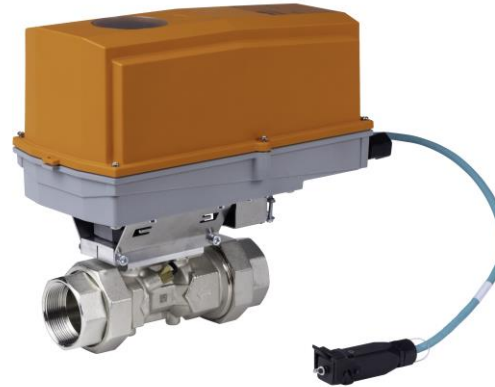
Product Design



Requirements

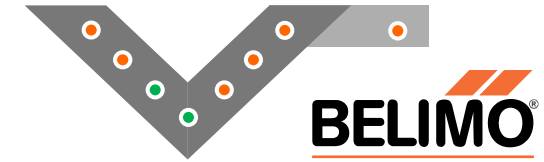
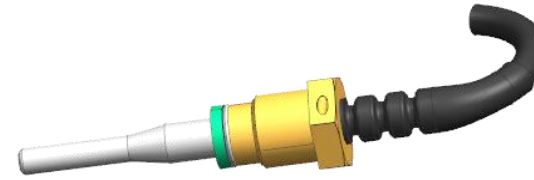


System Concept → Split into Components

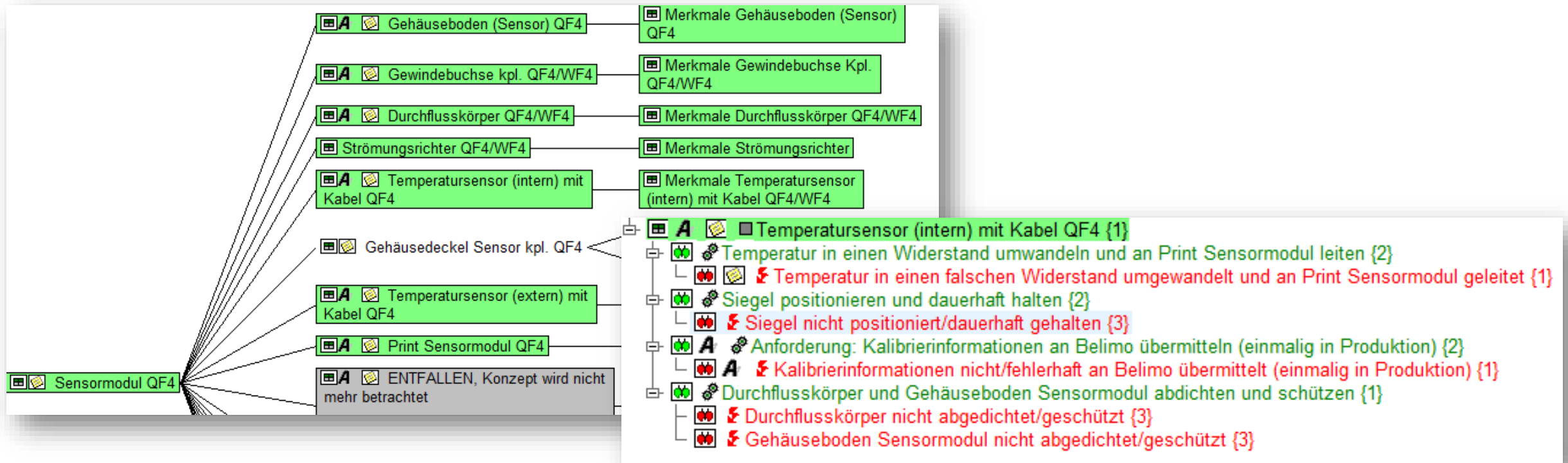


12.06.2017 / POT

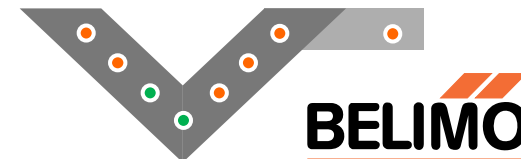
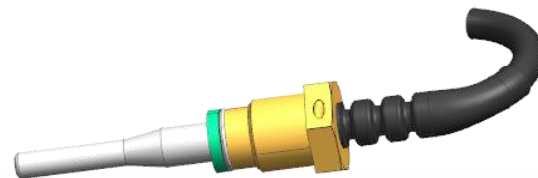
Requirements to components



- Define functionalities of components
- Do a risk assesment (e.g. FMEA = Failure Mode and Effects Analysis)
 - Identify failure modes



Detail design Implementation



- Implement measures against risks
 - Detect weak spots
 - Avoid failures

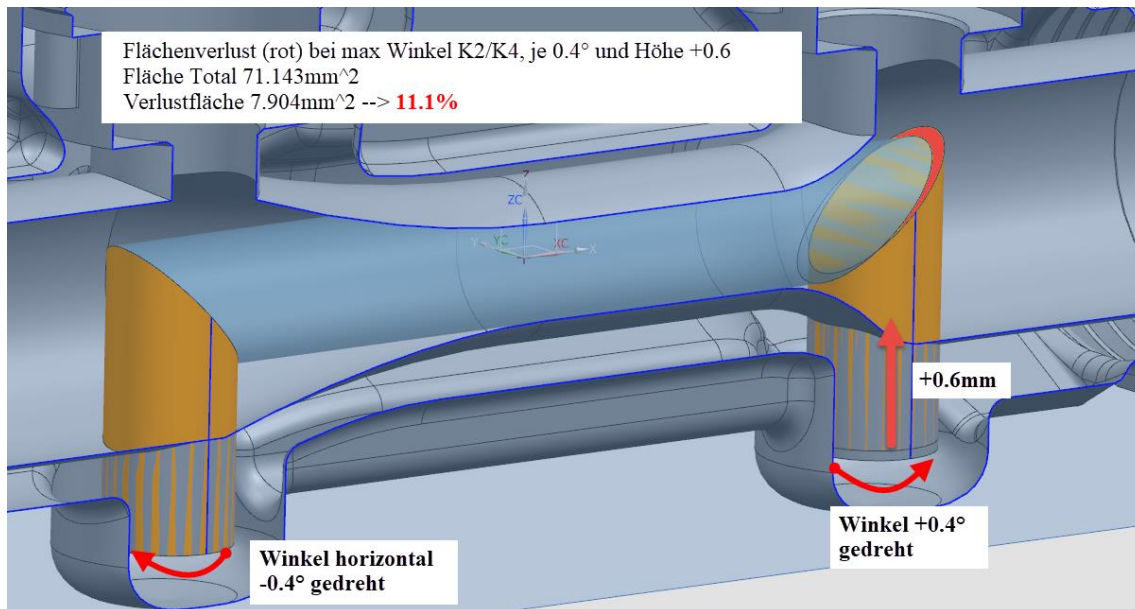
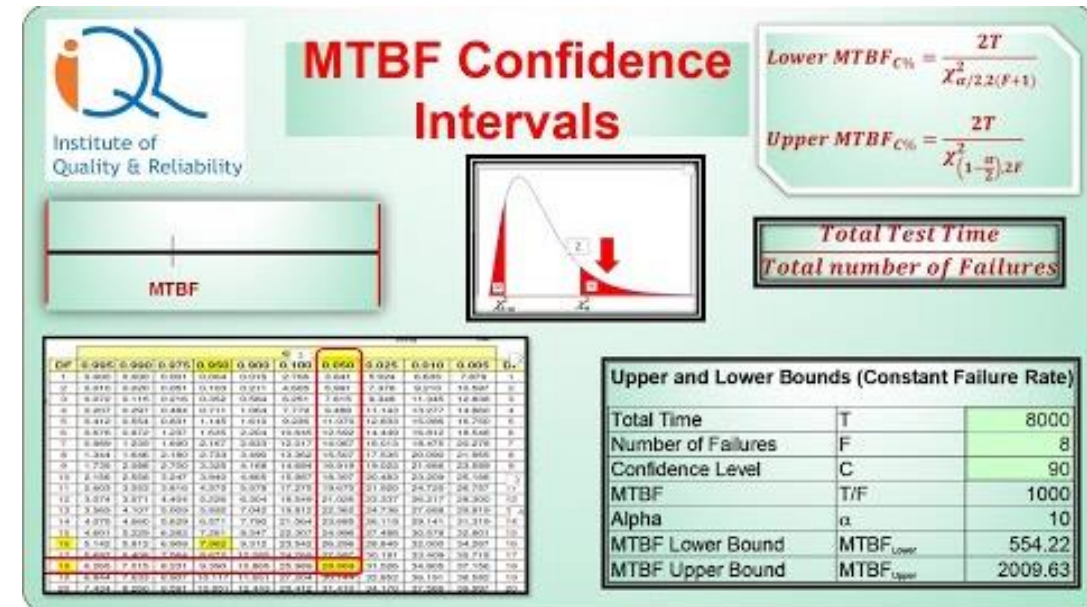
■ Merkmale Temperatursensor (intern) mit Kabel QF4/WF4 {1}

- ☑ Geometrie, Material und Toleranzen des Temperatursensors abgestimmt zu Schnittstellen {2}
- ☒ **Geometrie, Material oder Toleranzen des Temperatursensors erfüllt nicht die Anforderungen zur Klemme Print {1}**
 - A=4 E=10 RPZ=360 ☑ Maßnahmenstand - Anfang 24.05.2018
 - ☑ Maßnahmenstand 24.05.2018
 - A=4 E=3 RPZ=108 ☑ Maßnahmenengruppe [Designphase] [📅 20.12.2019 (abgeschlossen)] 👤 Hauser, Daniel, IEX
 - A=4 E=3 RPZ=(108) ☑ Maßnahmenengruppe [Designphase]
 - A=2 E=3 RPZ=54 ☑ Maßnahmenengruppe [Realisierungsphase]
- ☒ **Geometrie, Material oder Toleranzen des Temperatursensors erfüllt nicht die Anforderungen zur Kabeltülle Umspritzung {1}**
 - A=6 E=10 RPZ=540 ☑ Maßnahmenstand - Anfang 24.05.2018
 - ☑ Maßnahmenstand 24.05.2018
 - A=2 E=1 RPZ=18 ☑ Maßnahmenstand [Serienphase] 05.12.2019 [📅 03.07.2020 (abgeschlossen)] 👤 Weber, Beat
 - A=2 E=2 RPZ=(36) ☑ Maßnahmenstand [Realisierungsphase] 17.12.2019 [📅 23.12.2020 (in Umsetzung)] 👤 Dreher, Peter, IEM, Entwicklungsingenieur
 - A=2 E=2 RPZ=(36) ☑ Maßnahmenstand [Serienphase] 16.12.2020 [📅 25.06.2021 (in Umsetzung)]
 - A ☑ Feldtest -> Belimo Dachttest [👤 Weber, Beat] {37}
 - A ☑ Feldtest -> Verwendung im typischen Einsatzszenario (Outdoor) [👤 Gresch, Valentin, IPVB, Projektleiter] {37}
- ☒ **Geometrie, Material oder Toleranzen des Temperatursensors erfüllt nicht die Anforderungen zum O-Ring, Durchflusskörper {1}**
 - A=2 E=10 RPZ=180 ☑ Maßnahmenstand - Anfang 24.05.2018
 - ☑ Maßnahmenstand 24.05.2018
 - A=2 E=1 RPZ=18 ☑ Maßnahmenengruppe [Designphase] [📅 20.12.2019 (abgeschlossen)] 👤 Hauser, Daniel, IEX
 - ☑ Prototypentest -> Dichtheittest, Hochtemperaturtest, Temperaturwechseltest und Hochdrucktest {81}
 - A=1 E=1 RPZ=9 ☑ Maßnahmenengruppe [Designphase]
 - A ☑ Nach den Tests/Prüfungen ggf. Anpassung der Geometrie/Material/Toleranzen [📅 20.12.2019 (abgeschlossen)] 👤 Hauser, Daniel, IEX {4}
 - A ☑ Spezifikation -> Eventuell Schraubensicherung vorsehen? [📅 01.10.2019 Start Alpha-Serie (verworfen)] 👤 Weber, Beat {50}
 - A=1 E=1 RPZ=9 ☑ Maßnahmenengruppe [Realisierungsphase] [📅 31.05.2020 0-Serie Qualifikation (abgeschlossen)] 👤 Hauser, Daniel, IEX
 - ☑ 0-Serietest -> Dichtheittest, Hochtemperaturtest, Temperaturwechseltest und Hochdrucktest {190}
- ☒ **Geometrie, Material und Toleranzen des Temperatursensors abgestimmt zu Gehäusedeckel {1}**
- ☑ Geometrie, Material und Toleranzen des Temperatursensors gemäß Spezifikation und Normen {2}
- ☒ **Geometrie, Material und Toleranzen des Temperatursensors erfüllt nicht die Anforderungen gemäß Spezifikation und Normen {1}**
 - A=2 E=10 RPZ=180 ☑ Maßnahmenstand - Anfang 24.05.2018
 - ☑ Maßnahmenstand 24.05.2018
 - A ☒ **Label erfüllt nicht die Anforderungen gemäß Spezifikation {1}**
 - A=2 E=10 RPZ=180 ☑ Maßnahmenstand - Anfang 24.05.2018
 - A=2 E=3 RPZ=54 ☑ Maßnahmenstand [Realisierungsphase] 24.05.2018 [📅 20.12.2019 (abgeschlossen)] 👤 Hauser, Daniel, IEX
 - A ☑ Prototypentest -> Datenübermittlung {81}
- ☒ **Materialbeständigkeit vom T-Sensor Kabel erfüllt nicht die Anforderungen bzgl. Nema 4 {1}**
 - A=10 E=10 RPZ=900 ☑ Maßnahmenstand - Anfang [Designphase] 17.12.2019
 - A=3 E=2 RPZ=(54) ☑ Maßnahmenstand [Realisierungsphase] 17.12.2019

☒ A ☑ Feldtest -> Verwendung im typischen Einsatzszenario (Outdoor) [👤 Gresch, Valentin, IPVB, Projektleiter] {37}

Integration, Test and Verification (Component Level)

- Calculations (e.g. tolerances)
- Simulations
- MTTF investigations

MTBF Confidence Intervals

Institute of Quality & Reliability

Lower $MTBF_{C\%} = \frac{2T}{\chi^2_{\alpha/2, 2(F+1)}}$

Upper $MTBF_{C\%} = \frac{2T}{\chi^2_{(1-\alpha/2), 2F}}$

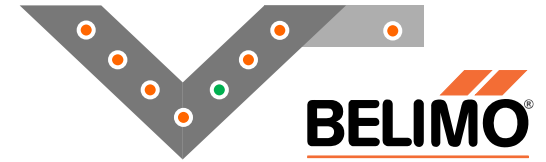
Total Test Time
Total number of Failures

Upper and Lower Bounds (Constant Failure Rate)

Total Time	T	8000
Number of Failures	F	8
Confidence Level	C	90
MTBF	T/F	1000
Alpha	α	10
MTBF Lower Bound	$MTBF_{Lower}$	554.22
MTBF Upper Bound	$MTBF_{Upper}$	2009.63

Source: Institute of Quality and Reliability

Integration, Test and Verification (Component Level)

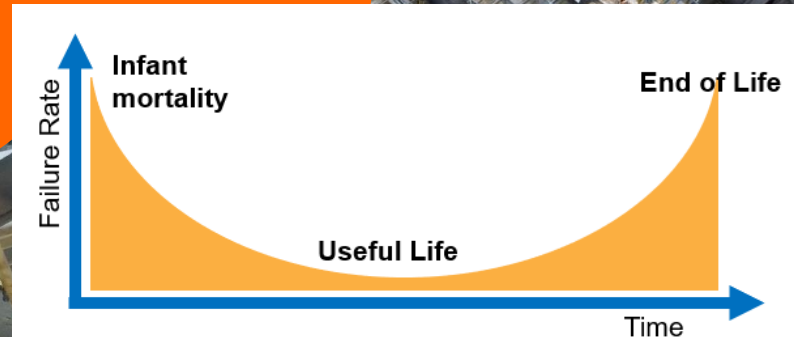


- Tests

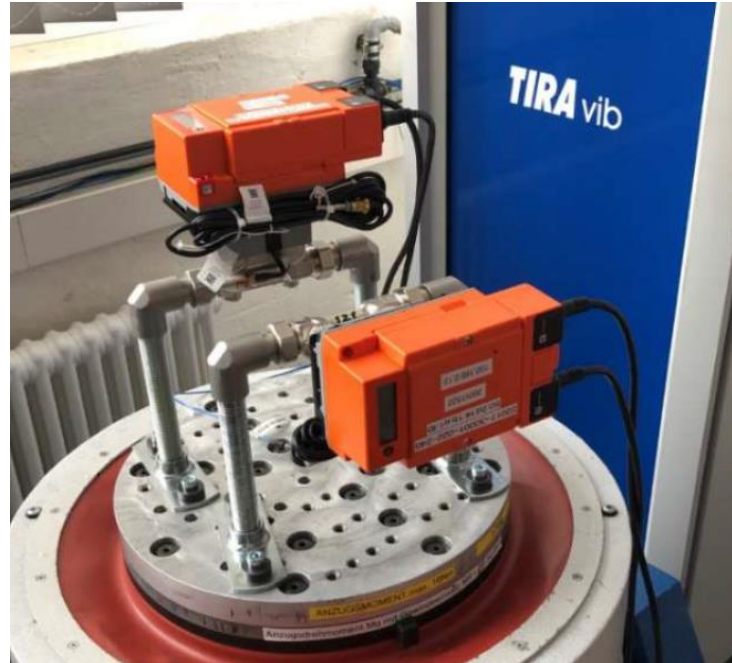
- Sealing tests
- Environmental tests (climate ...)
- Aging tests
- Contamination tests
- EMC tests
- ...

verify on component level !

- Tests are easier and faster
- Tests are more focused to the failure mode
- Tests can be done in higher numbers to gain statistical information



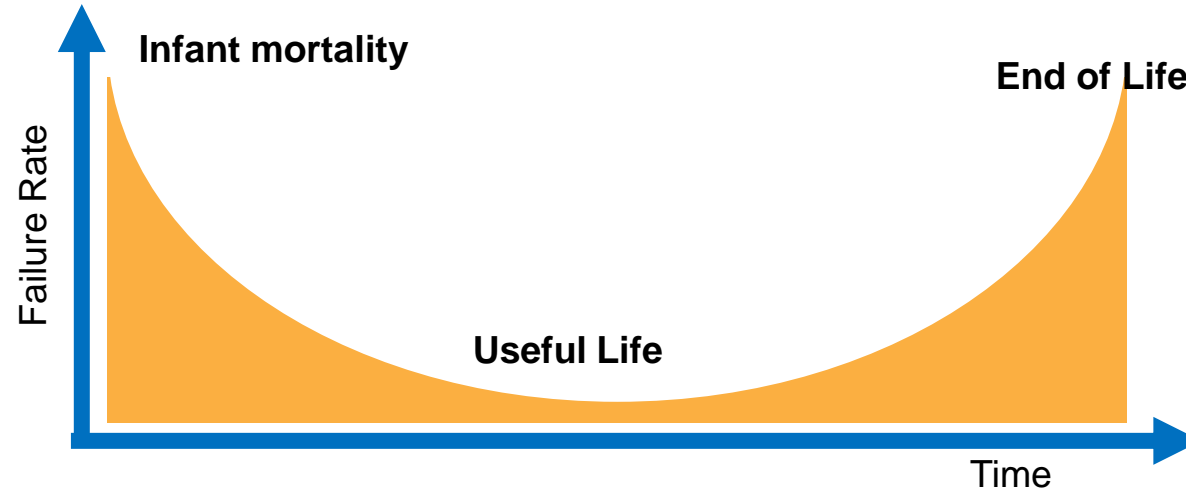
System verification → Tests on System Level





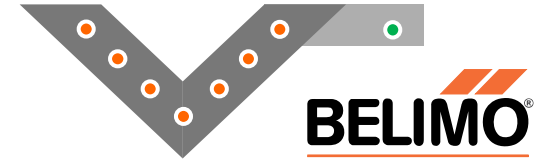
Operation & Recalibration

Recalibration period based on predicted durability

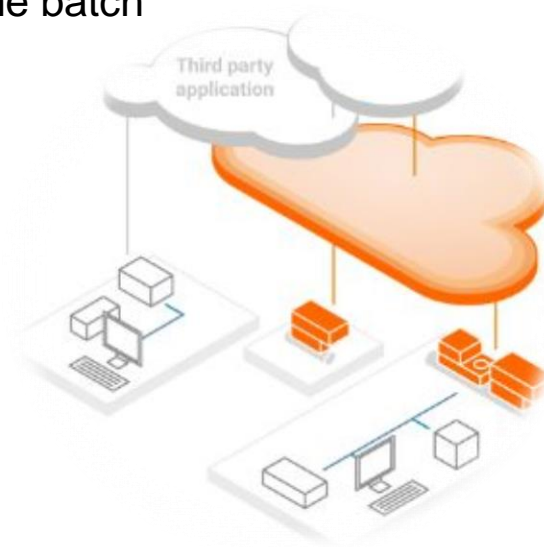


Statistically proven during approval process

Recalibration period depending on health state



- Supervision of the installed meters
 - Within the meter itself
 - zero flow at known operating points
 - amplitude of ultrasonic signal
 - ...
 - Remote through available communication technologies
 - comparison of operating points over time
 - comparison with meters in same system
 - comparison with meters from same batch
 - ...



BELIMO Geräte

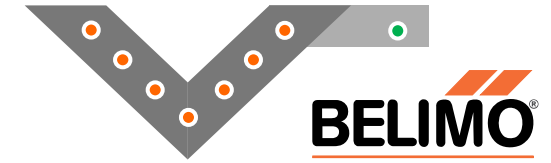
Status

OK	8 Geräte
Warnung	Keine Geräte
Fehler	Keine Geräte
Unbekannt	Keine Geräte

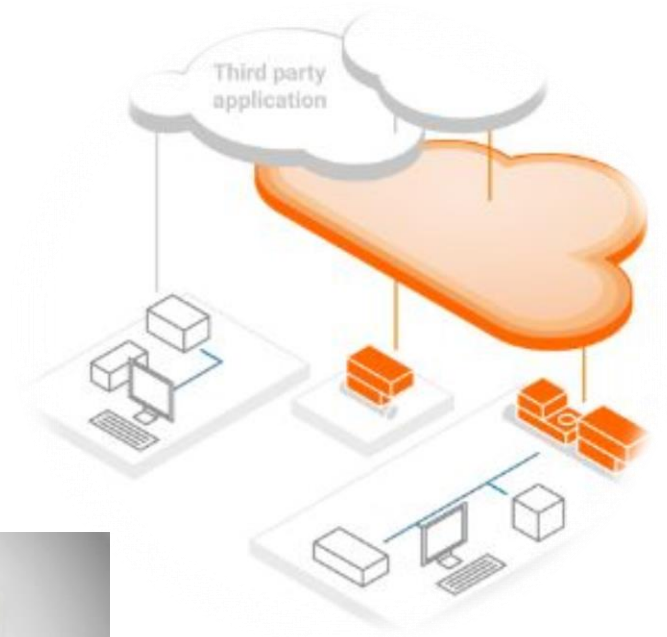
Geräte

Gerät	Seriennummer
Frischwasserstation	22141-40022-034-186
Haus 10 Caprez / Holoch	22206-50024-034-182
Haus 10 DG Holoch	22212-00035-034-182

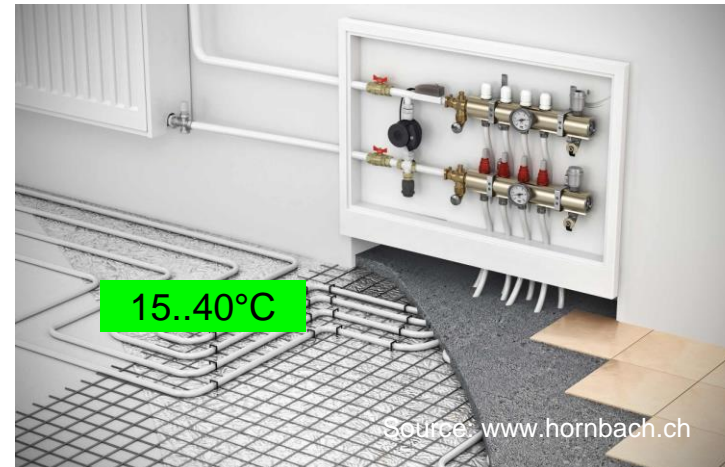
Recalibration period depending on stress level



- Compare operational data with meter specification to judge stress level

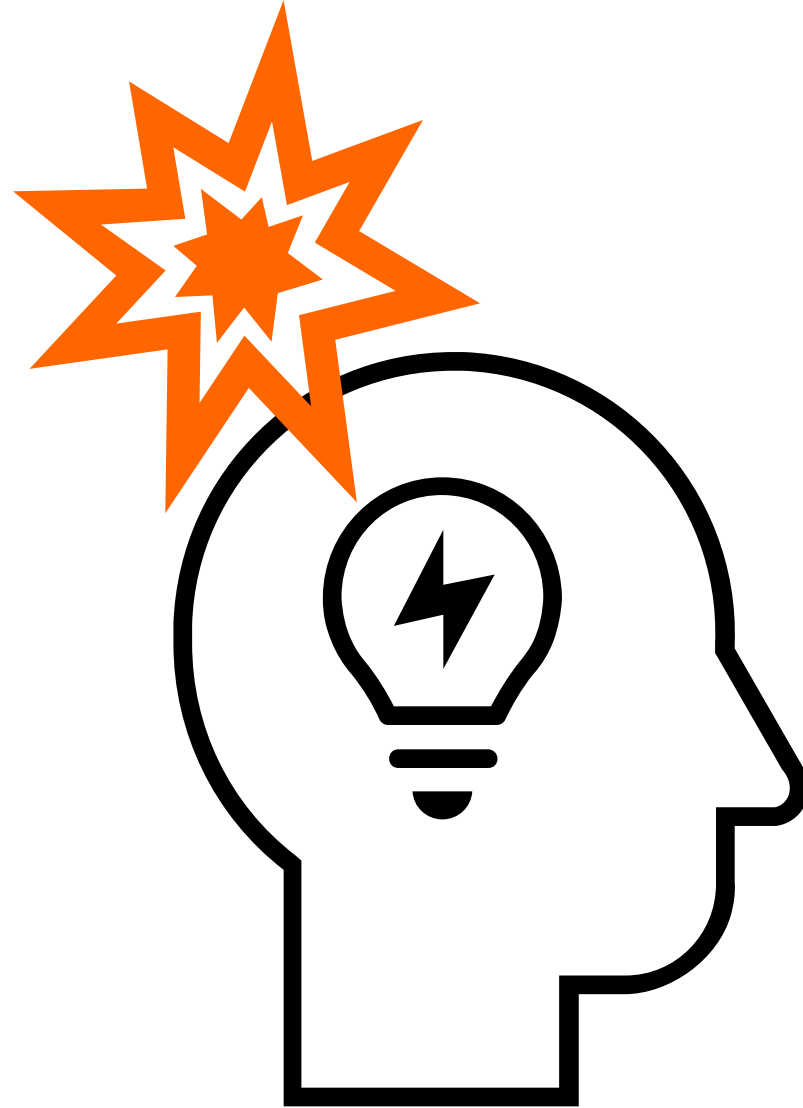


Safety data	Protection class IEC/EN	III, Protective Extra-Low Voltage (PELV)
	Degree of protection IEC/EN	IP54 Logic module: IP54 (with grommet A-22PEM-A04) Sensor module: IP65
	Pressure equipment directive	CE according to 2014/68/EU
	EMC	CE according to 2014/30/EU
	Certification IEC/EN	IEC/EN 60730-1:11 and IEC/EN 60730-2-15:10
	Quality Standard	ISO 9001
	Type of action	Type 1
	Rated impulse voltage supply	0.8 kV
	Pollution degree	3
	Ambient humidity	Max. 95% RH, non-condensing
	Ambient temperature	-30...55°C [-22...130°F]
	Fluid temperature	-20...120°C [-5...250°F] At a fluid temperature of < 2°C [< 36°F], frost protection must be guaranteed
	Storage temperature	-40...80°C [-40...176°F]



Source: www.hornbach.ch

Conclusion



Why do we strive for longer durability?

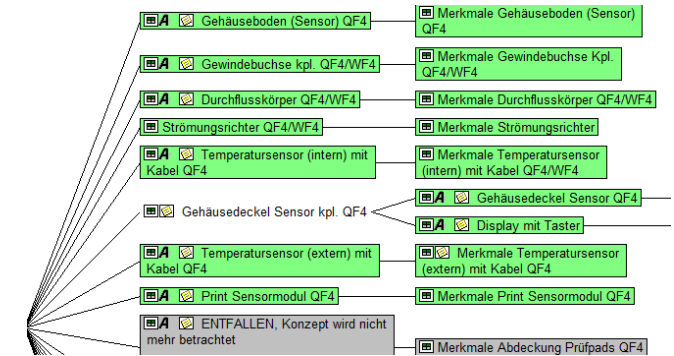
- Long durability of thermal energy meters is a demand
 - For the customer
 - For the environment



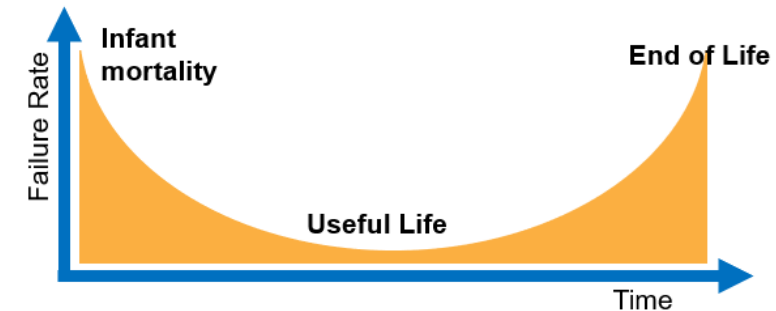
**Waste of Ressources
Waste of Labour
Waste of Money**

What do we have to change in the approval process to get a predicted durability?

- Do a risk assessment to focus on weaknesses
 - D-FMEA needs to become part of the approval
 - Measures from risk analysis need to become part of the approval



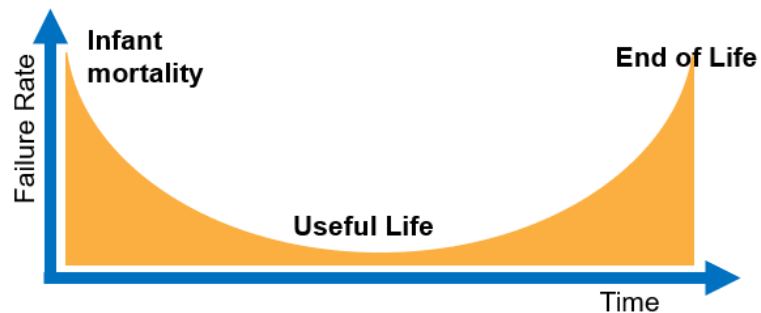
- Tests on component level generate statistical data to predict durability



→ The approval is less standardized but more focused on the design of the specific product

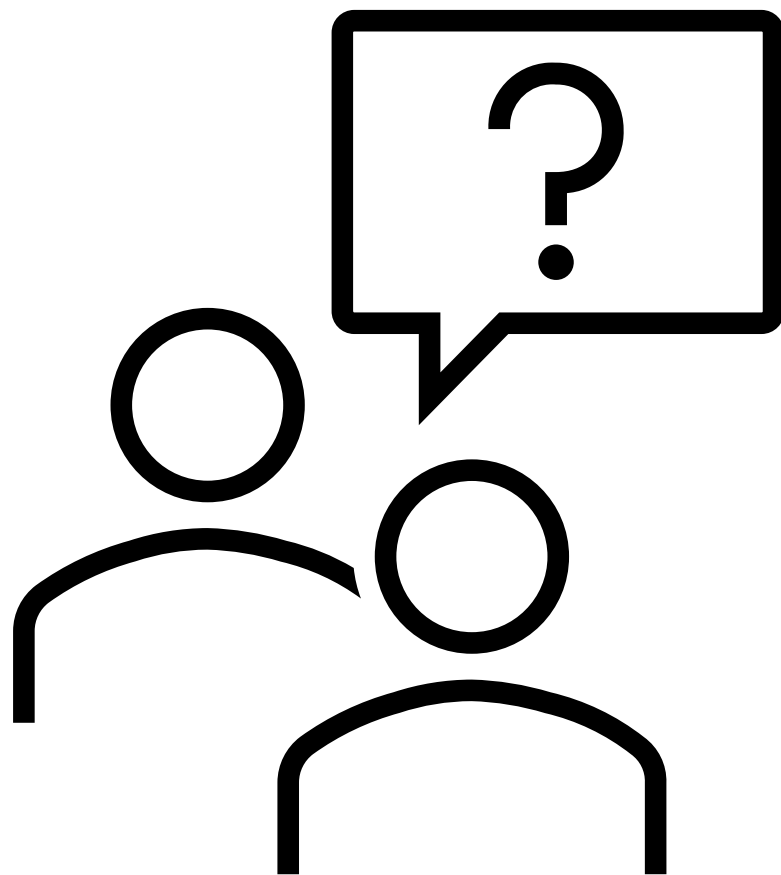
How can we extend recalibration periods to reduce waste?

- Consider the designed and statistically proven durability
- Extend recalibration periods through supervision of the devices
 - Considering the health state of the meter
 - Considering the stress level of the meter



Status	
✓ OK	8 Geräte
⚠ Warnung	Keine Geräte
✖ Fehler	Keine Geräte
❓ Unbekannt	Keine Geräte





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