
Pre-tests for durability concerning abrasion
and deposition in flow meters

Vorversuche zur Messbeständigkeit hinsichtlich
Abrasion und Ablagerungen in
Durchflussmessgeräten

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Motivation

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

Every year more than 1 Mio. thermal energy meters are being replaced only in Germany



Motivation

- Thermal energy meters can be designed for a long durability
 - We need a method to test this durability during type approval within reasonable time
- **Task for CEN TC176 Subgroup 1**
- **Design a highly accelerated durability test for flow sensors with a test duration ≤ 3 months to classify in combination with duration of use**
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Test Design

Aging Mechanisms

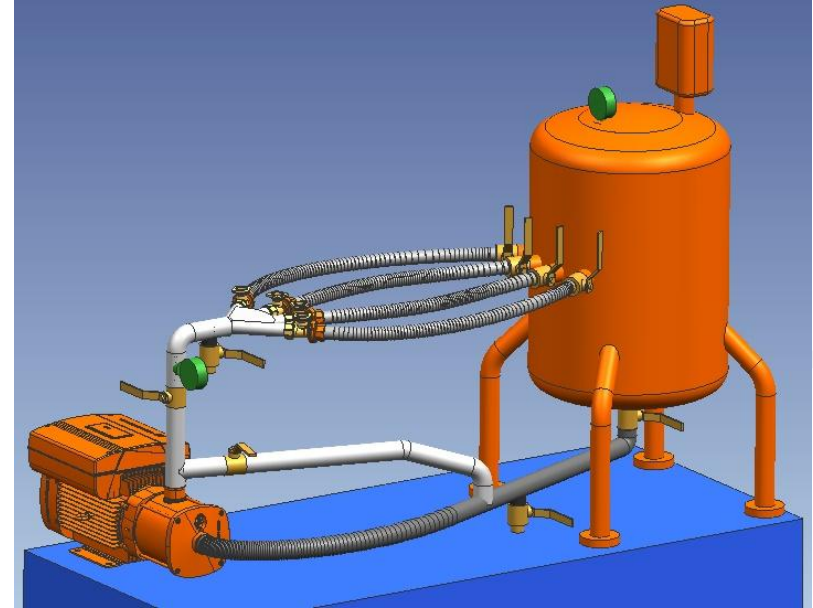
Stress parameter		Wear out mechanism		Effect	Overstress (use outside of specified operation conditions)	
Abrasive particles		Abrasion		Reduced signal amplitude (reflector not working perfectly)	Reflectors damaged, transducers damaged	
Particles	Stress parameter		Wear out mechanism	Effect	Overstress (use outside of specified operation conditions)	
	Abrasive particles	Abrasion	Reduced signal amplitude (reflector not working perfectly)	Reflectors damaged, transducers damaged		
Temperature changes	Particles	Stress parameter		Wear out mechanism	Effect	Overstress (use outside of specified operation conditions)
High temperature		Abrasive particles	Abrasion	Reduced signal amplitude (reflector not working perfectly) Change in flow profile/velocity	Reflectors damaged, transducers damaged	
Liquid composition materials and galvanic elements (pH value, conductivity,...)	High temperature	Particles	Deposition	Change in flow profile/velocity reduced signal amplitude (if deposition in transducer pocket or on reflector)	Transducer pockets filled	
Pressure	Liquid composition, n materials and galvanic elements (pH value, σ conductivity,...)	Temperature changes	Thermal wear due to fast temperature changes	Reduced signal amplitude (misalignment of transducers and reflectors)		
high velocity at low pressure		High temperature		Reduction of signal amplitude in transducer (Curie effect, delamination, permanent mechanical changes,...)	Sealings are breaking	
Vibration (esp. for Meters at resonance frequency – might define a general test)	Pressure	Liquid composition, meter materials and galvanic elements (pH value, el. conductivity,...)	Corrosion of materials Swelling/shrinkage of materials Embrittlement of materials	Reduced signal amplitude due to corroded reflector surfaces Change in flow profile/velocity	Material compatibility not fulfilled	
	Vibration (esp. for me Meters at resonance frequency – might be define a general test)	Pressure	Mechanical stress		Water hammer	
		high velocity at low pressure	Cavitation causing abrasion	Wear of reflectors, transducers and flow body → change in flow profile/velocity or signal amplitude	Mainly caused by misuse (too low pressure)	
	Vibration (esp. for mech. Meters at resonance frequency – might be hard to define a general test)				Is an overstress criteria (included in M1/2/3 classes)	

- Consideration for mechanical meters, mag meters and ultrasonic meters
- Conclusion
- ➔ Focus on abrasion and deposition

Test Setup



- Use existing test rig from Belimo
- Variation factors
 - Duration
 - Water quality and particles
 - Temperature
 - Flow velocity
- **Conclusion**
 - Higher temperatures increase effects ($>80^{\circ}\text{C}$)
 - Use magnetite particles only, quartz sand is too harsh

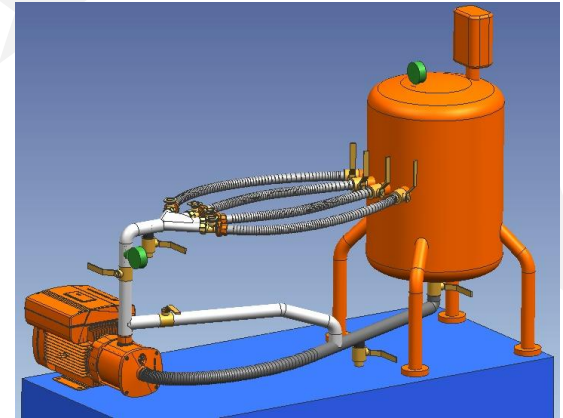


Devices Under Test

- One mechanical meter
- One fluidic oscillation meter
- Two ultrasonic flow meters
- All meters have been calibrated before the test
- All meters have been sent back to manufacturer after accelerated aging for careful flushing, re-testing and analysis

Test Proceeding

1. **Particle deposition – run meters at q_i for 1 month → new meters**
 - 1 kg/m³ magnetite + 1 kg/m³ mineral dust (quartz sand)
 - 60 °C
 - Tap water with pH 8.8
 - Stirrer activated manually
2. **Abrasion – run meters at q_p for 3 months → new meters**
 - Same water as above
 - Stirrer activated automatically 10 minutes per 6h
3. **Particle deposition – run meters at q_i for 1 month → new meters**
 - 1 kg/m³ magnetite + 1 kg/m³ mineral dust (quartz sand)
 - 80 °C
 - Tap water, citric acid added after 3 weeks to lower pH to 8.2
 - Stirrer activated automatically 10 minutes per 6h
4. **Abrasion – run meters at q_p for 3 months → new meters**
 - Same water as above
 - Stirrer activated automatically 10 minutes per 6h
5. **Particle deposition – run meters at q_i for 1 month → meters from step 3**
6. ...



Monitoring during Test

- 1-2 times per week
 - Check temperature from display
 - Check actual flow from display
 - Check pH, salinity and turbidity



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Preliminary Results

Optical Inspection before Re-Testing

DIEHL Metering	Laboratory test	25500 V00	C1	060	
					2 / 5

Photos before rinsing / Fotos vor dem Spülen



Photo rinsing / Foto Spülen

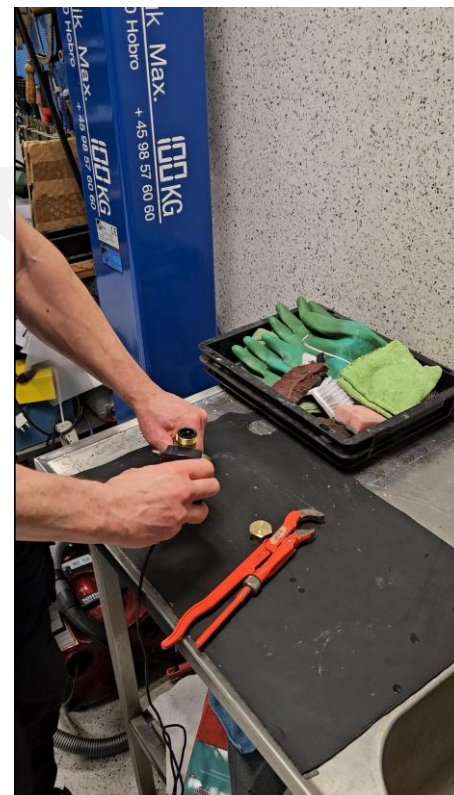


Photos after rinsing / Fotos nach dem Spülen
no sediments in cup / keine Ablagerungen im Becher

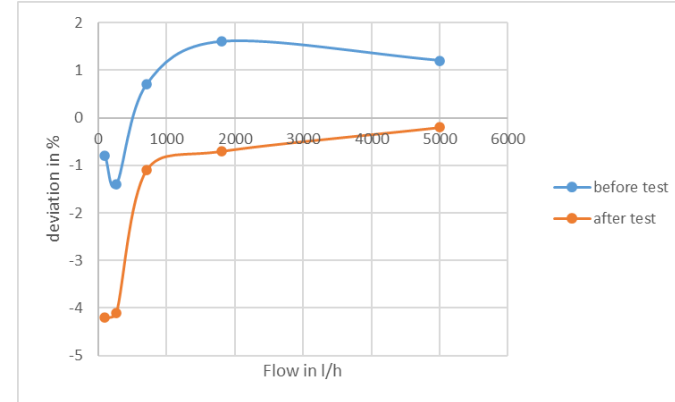
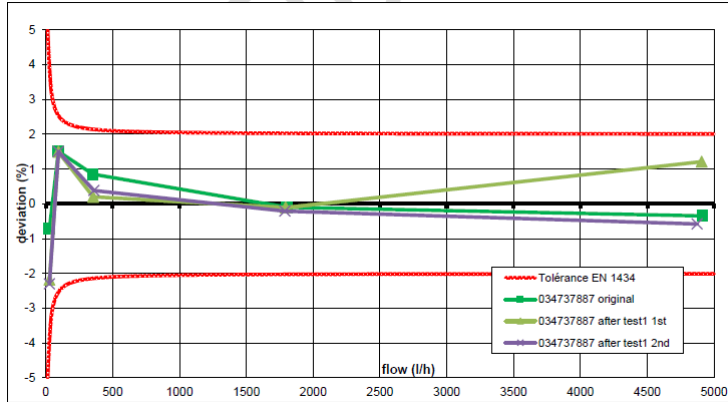


Photos after test / Fotos nach dem Prüfen

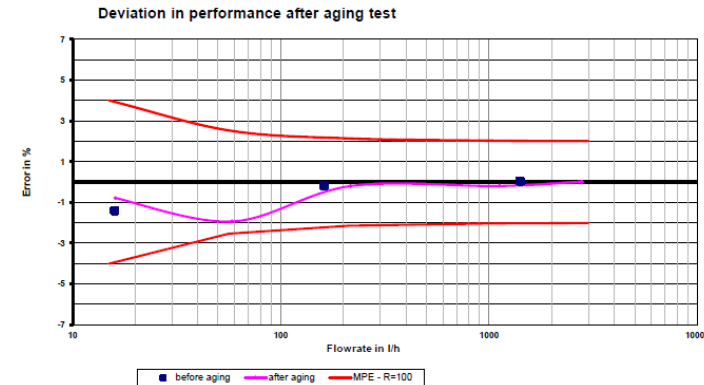
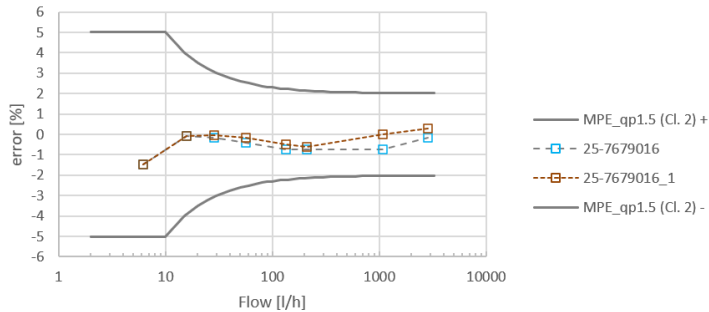
Flushing the Meters



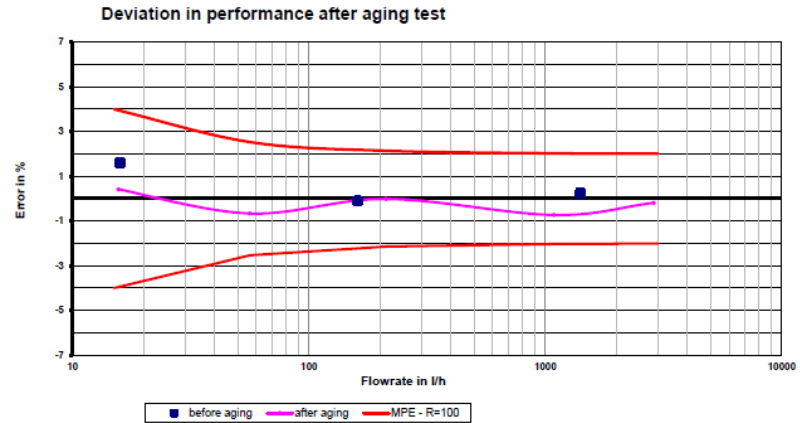
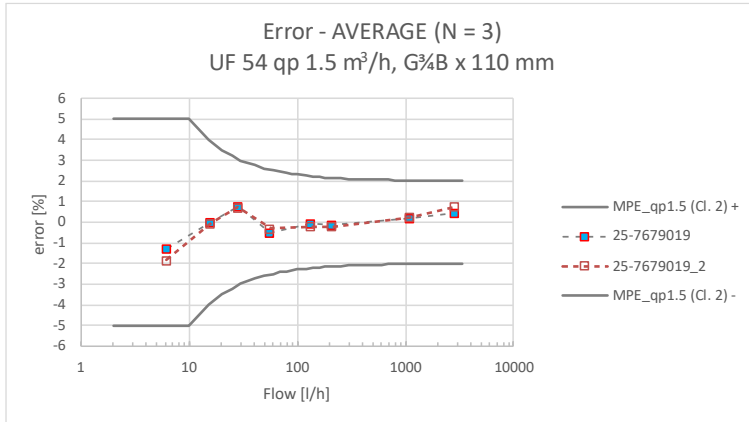
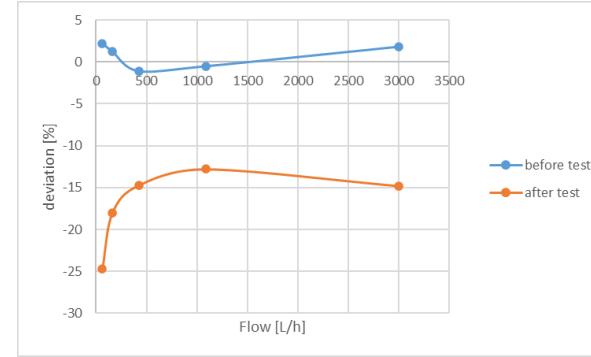
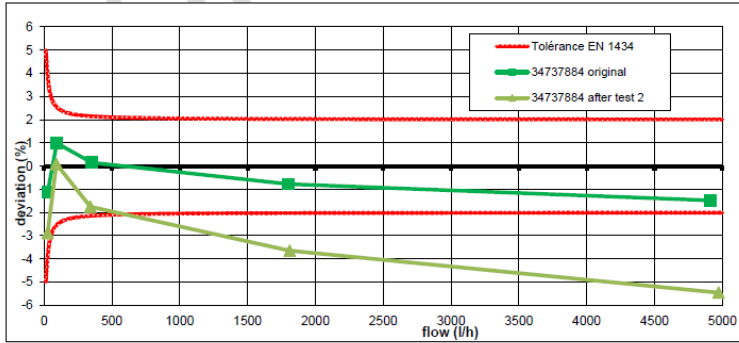
Re-Testing after Deposition Test 1



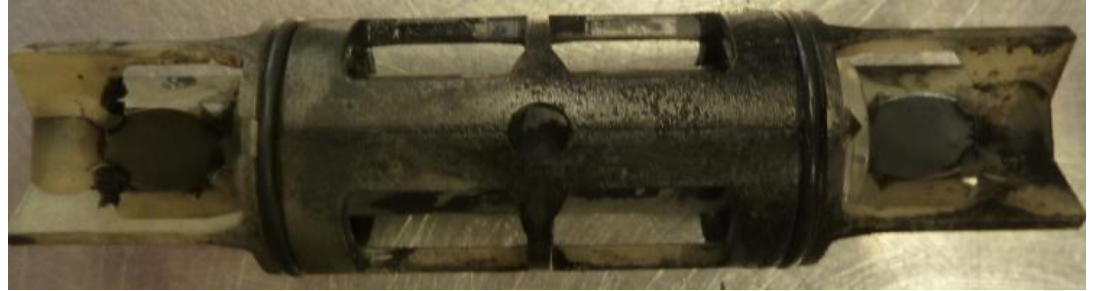
Error - AVERAGE (N = 3)
UF 54 qp 1.5 m³/h, G¾B x 110 mm



Re-Testing after Abrasion Test 1



Optical Inspection after Test



Optical Inspection Mechanical Meter

Abrasion test shows extreme wear on mechanical meter – conditions seem way harder than real world usage

- **These tests included quartz sand**
- **Quartz sand will not be used in future tests**

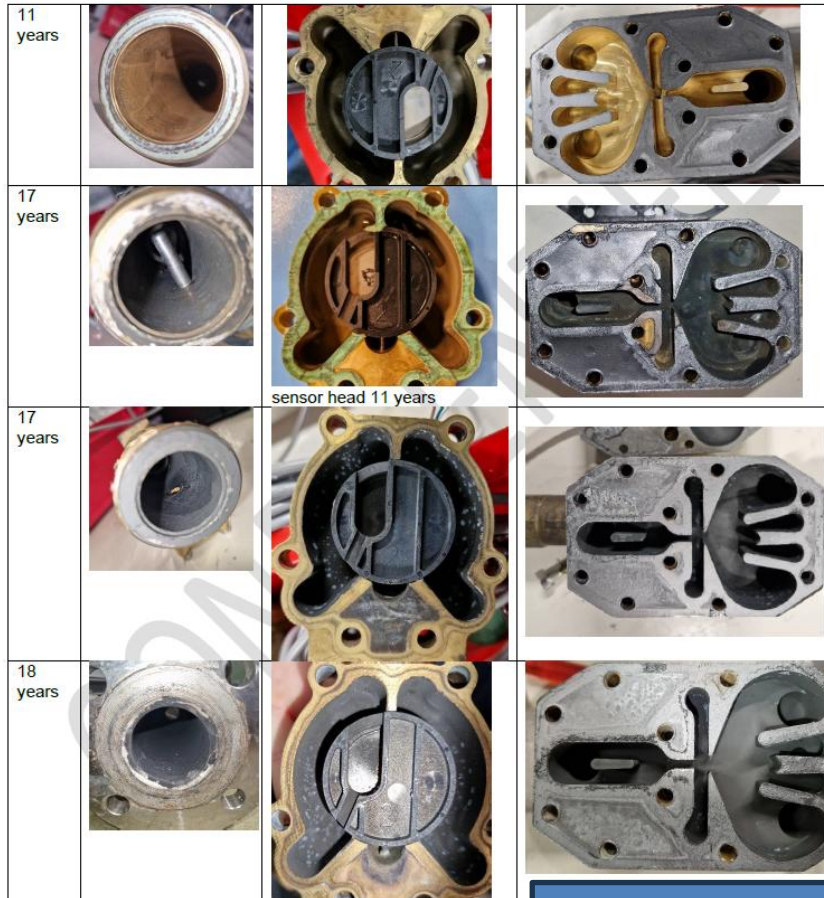
Test results
after 3 months



Real-life results
after 11 years



Comparison with real Life



Test results after 3 months

Magnetite layers similar to real-life use over years have been created

Real-life results after 10+ years

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Conclusion/Outlook

Conclusion

- **We see it feasible to design a Highly Accelerated Lifetime Test for components that are exposed to the fluid with a test duration ≤ 3 months that represents long field exposure**
- We were able to create similar effects as in real world use
 - high temperatures ($\geq 80^{\circ}\text{C}$) and high flows (qp) create more severe aging and depositions
- But we are not yet satisfied

Outlook

- Fine-tune the test parameters duration and water quality/particles
 - Next: Abrasion tests without mineral dust
- Possibly create more test rigs to gain experience faster
 - More samples
 - More parameter variations
- Create a draft test description for EN1434-4