

membrane integrity monitoring at the UF/RO Heemskerk plant

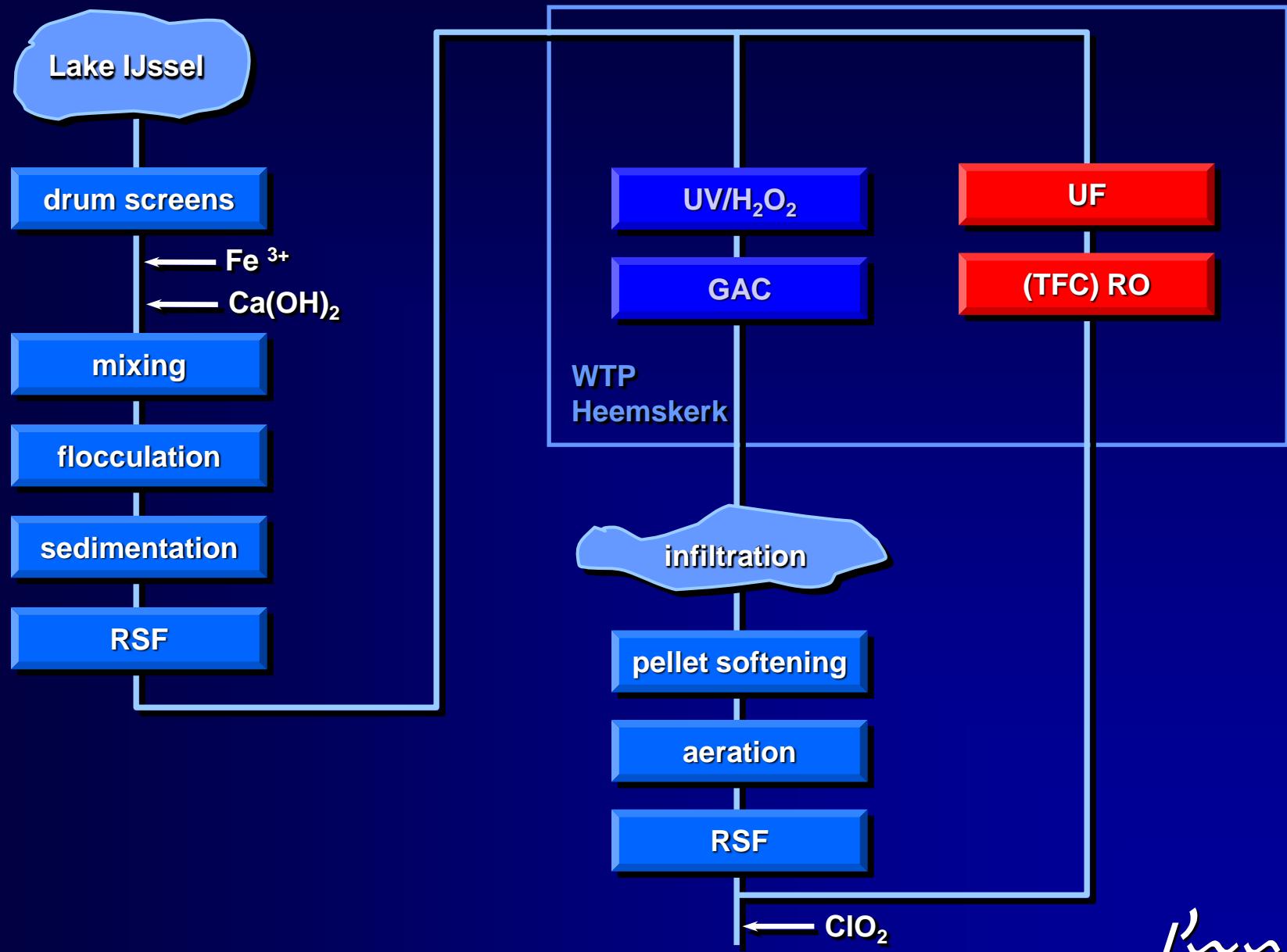
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N.V. PWN Water Supply Company North Holland**





Photo

water treatment scheme 1999



conditions UF

- **total capacity UF permeate 22 Mm³/year**
- **8 blocks 3360m²/block (total of 768 elements)**
- **membrane: X-flow UFC M5 S225**
- **gross flux: 96 – 113 L/(h.m²)**
- **recovery:**
 - **84% overall**
 - **8% backwash water**
 - **6% down time**
 - **2% overflow buffer**





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conditions RO

- **total capacity RO permeate 18 Mm³/year**
- **8 blocks 9364m²/block (total of 2016 elements)**
- **concentrate staging 2-1**
- **membrane: Hydranautics ULP ESPA3 8040**
- **average flux: 30 L/(h.m²)**
- **recovery 82%**





disinfection requirements for IJssel Lake water

micro-organism	maximum content IJssel Lake	requirement	required total inactivation	inactivation capacity pretreatment	required additional inactivation
	[n/l]	[n/l]	[log]	[log]	[log]
E-coli	6000	$<10^{-2}$	5.8	2	3.8
viruses	0.1	$2.6 \cdot 10^{-7}$	5.6	2.1	3.6
Giardia	1	$6.7 \cdot 10^{-6}$	5.2	2.5	2.7
Cryptosporidium	1	$3.3 \cdot 10^{-5}$	4.7	2	2.7

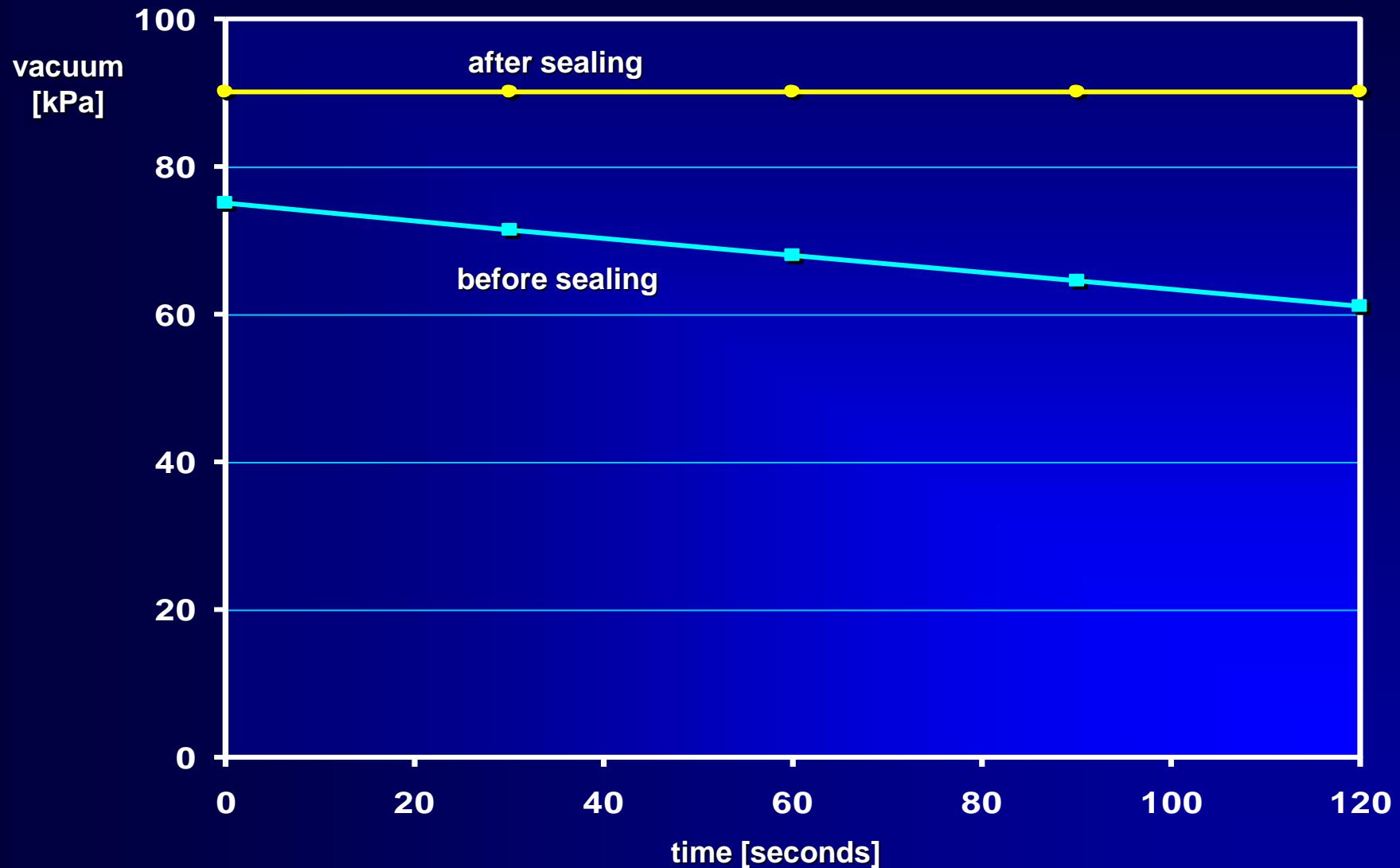


membrane acceptance tests

- removal of micro-organisms critical issue
- membranes were tested before loading
- pressure vessels were tested after loading
- conducted tests:
 - permeability and MTC (UF&RO)
 - retention and feed-concentrate pressure drop (RO)
 - vacuum hold testing (UF&RO)
- acceptance vacuum decrease rate < 10 kPa/min

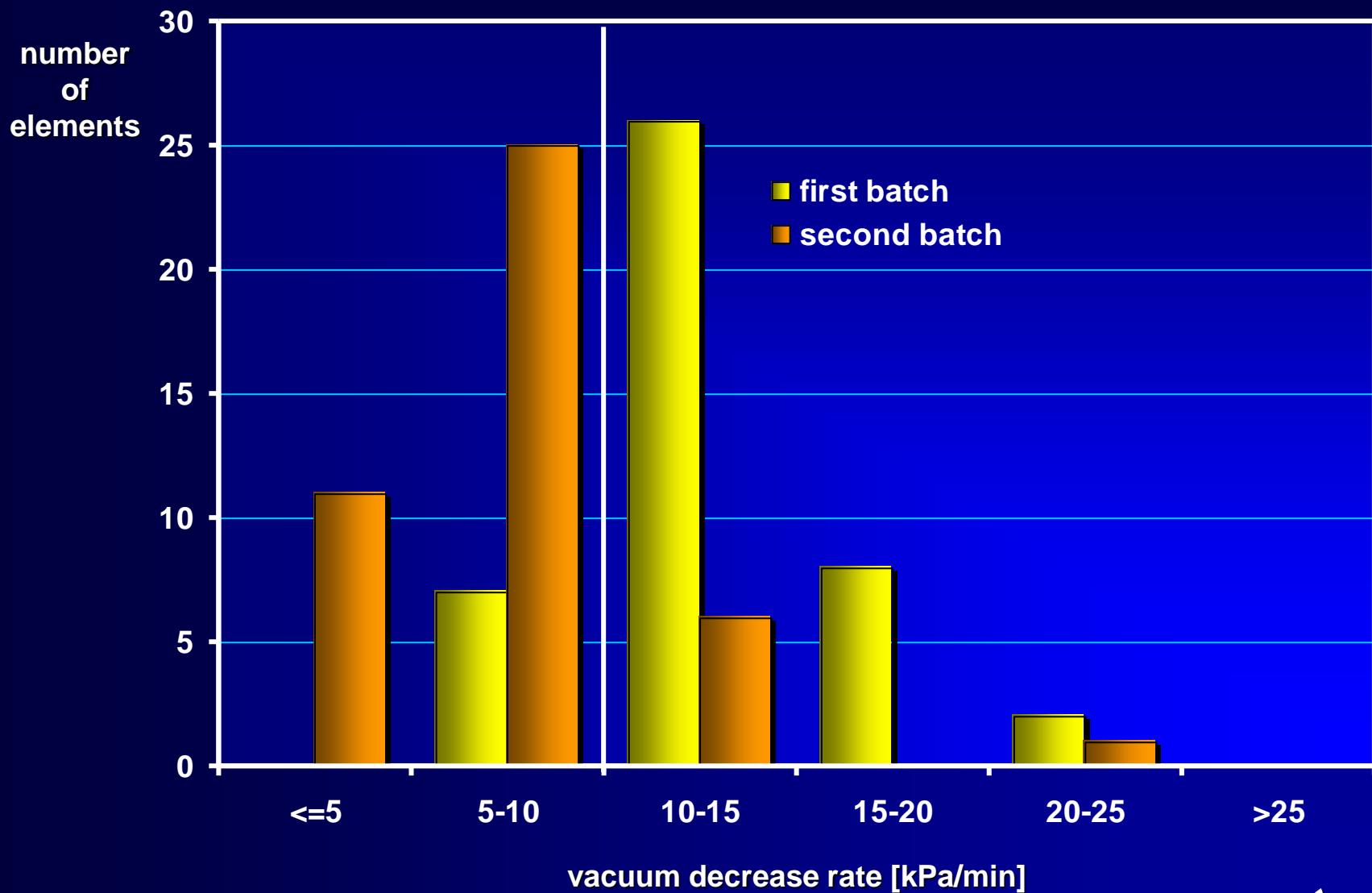


vacuum test compromised UF element



120

vacuum test of two batches RO elements



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integrity monitoring

- **removal of micro-organisms critical issue**
- **requirements for integrity monitoring**
 - continuous
 - fast
 - automation possible
 - no negative influence on water quality
 - user friendly



selected methods for integrity monitoring

for ultrafiltration

- **particle counting > 0,05 µm (PMS HSLIS)**
- **particle counting > 1,0 µm (MetOne 215W)**

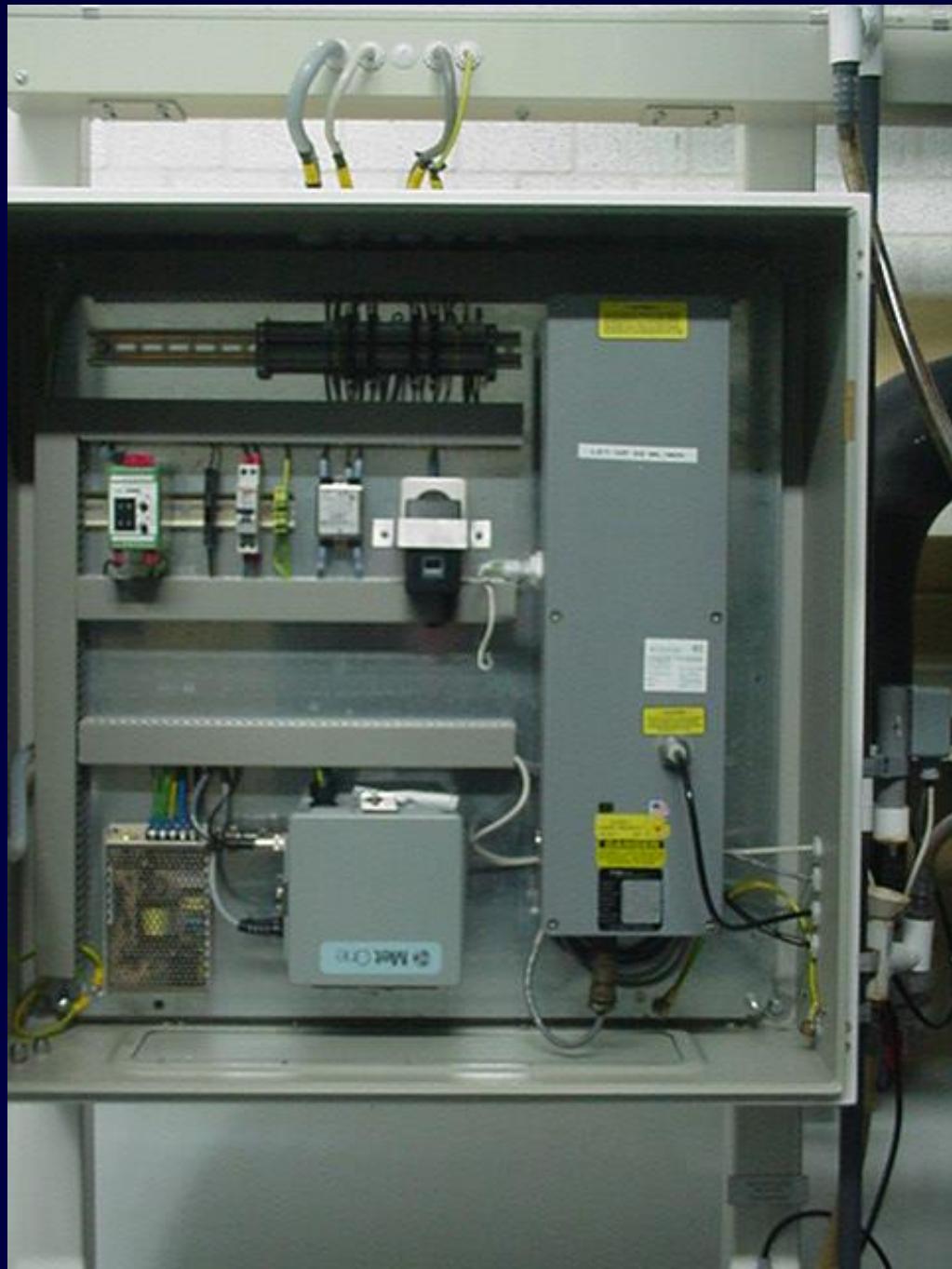
for reverse osmosis

- **conductivity measurement**
- **sulphate measurement (Dionex DX-800)**

kmw

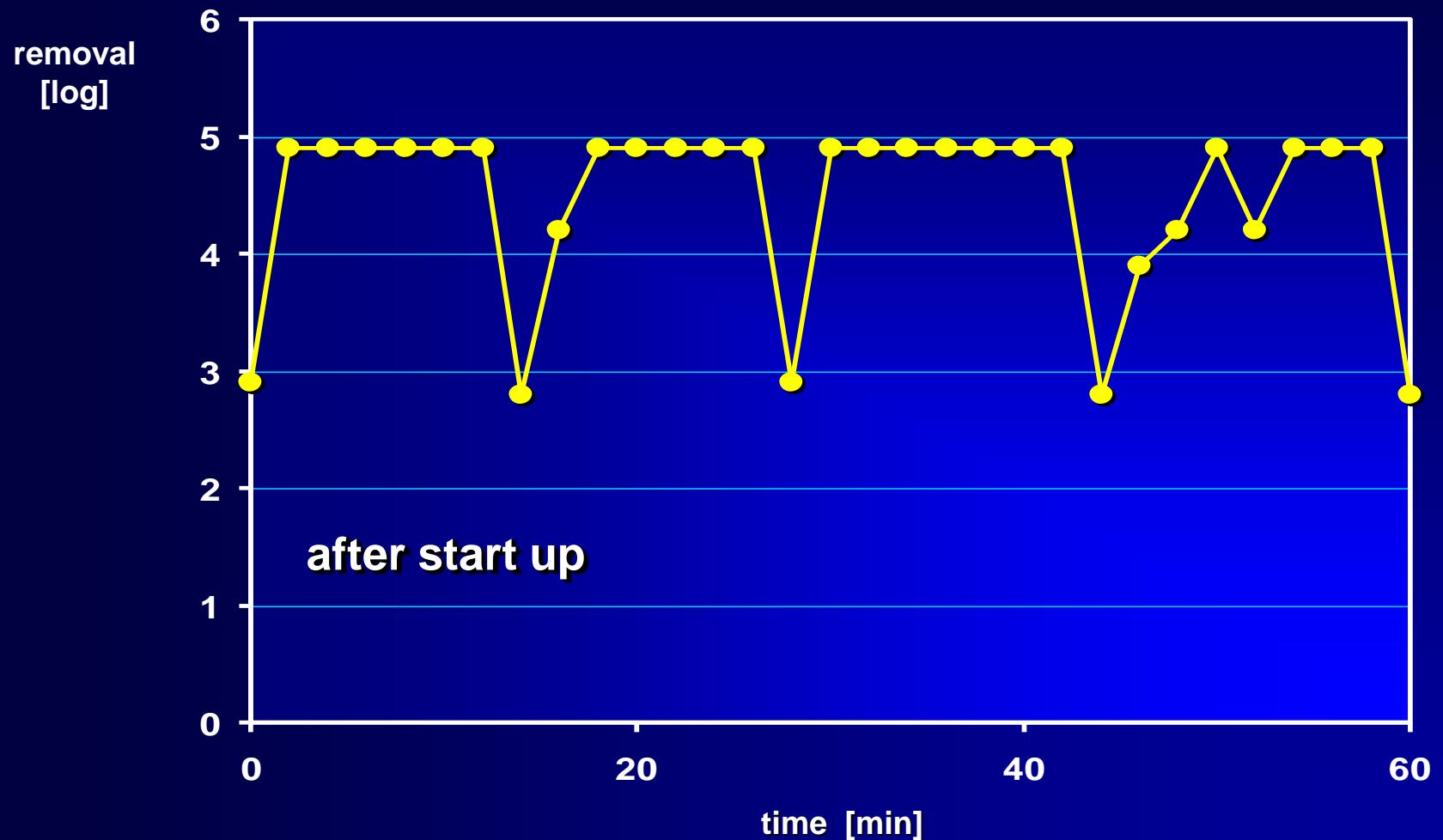


Rum



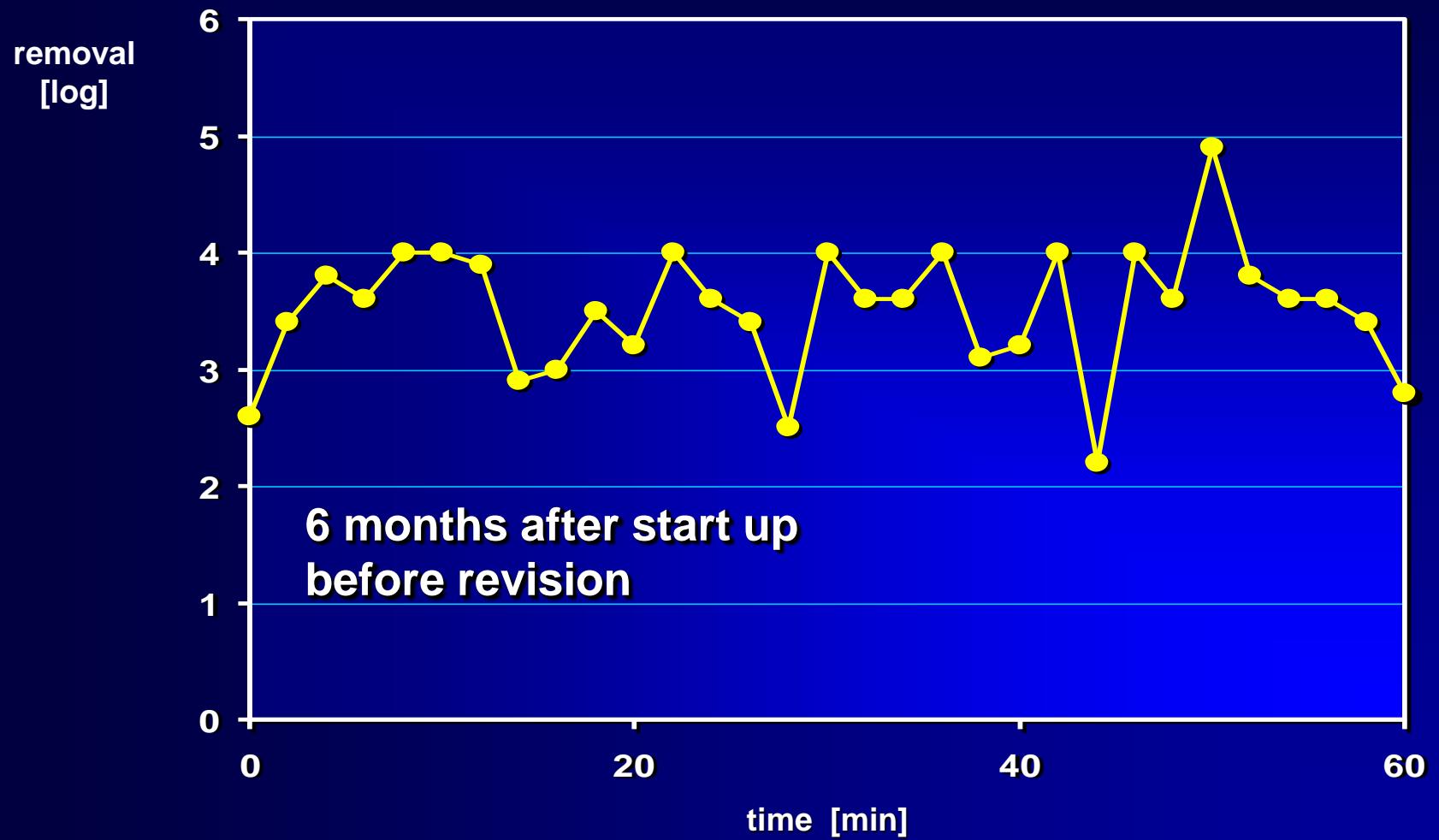
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integrity monitoring of UF blocks by particle counting 1.0 µm



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integrity monitoring of UF blocks by particle counting 1.0 µm

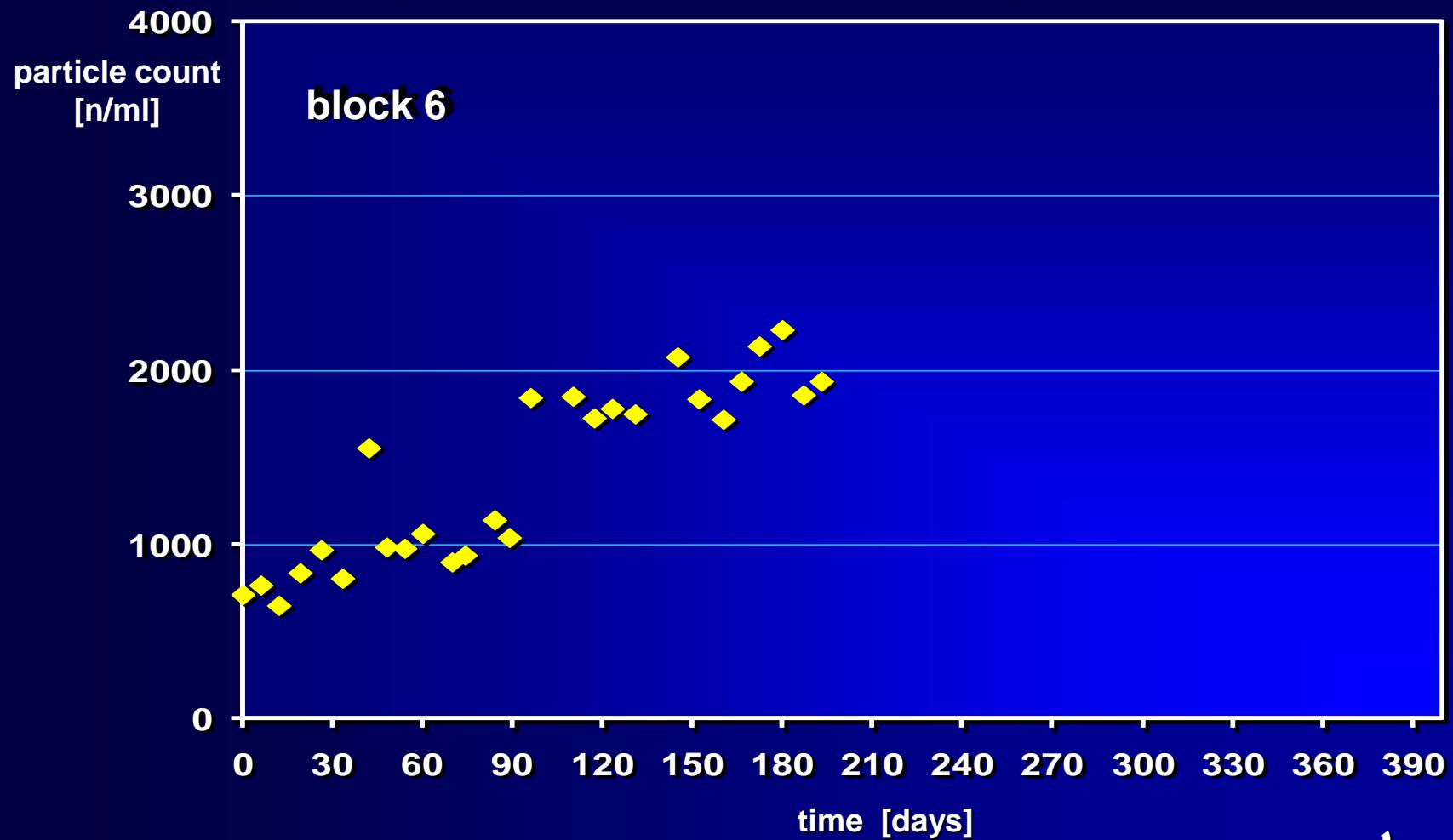


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integrity monitoring of UF by particle counting 0.05 µm



1'~



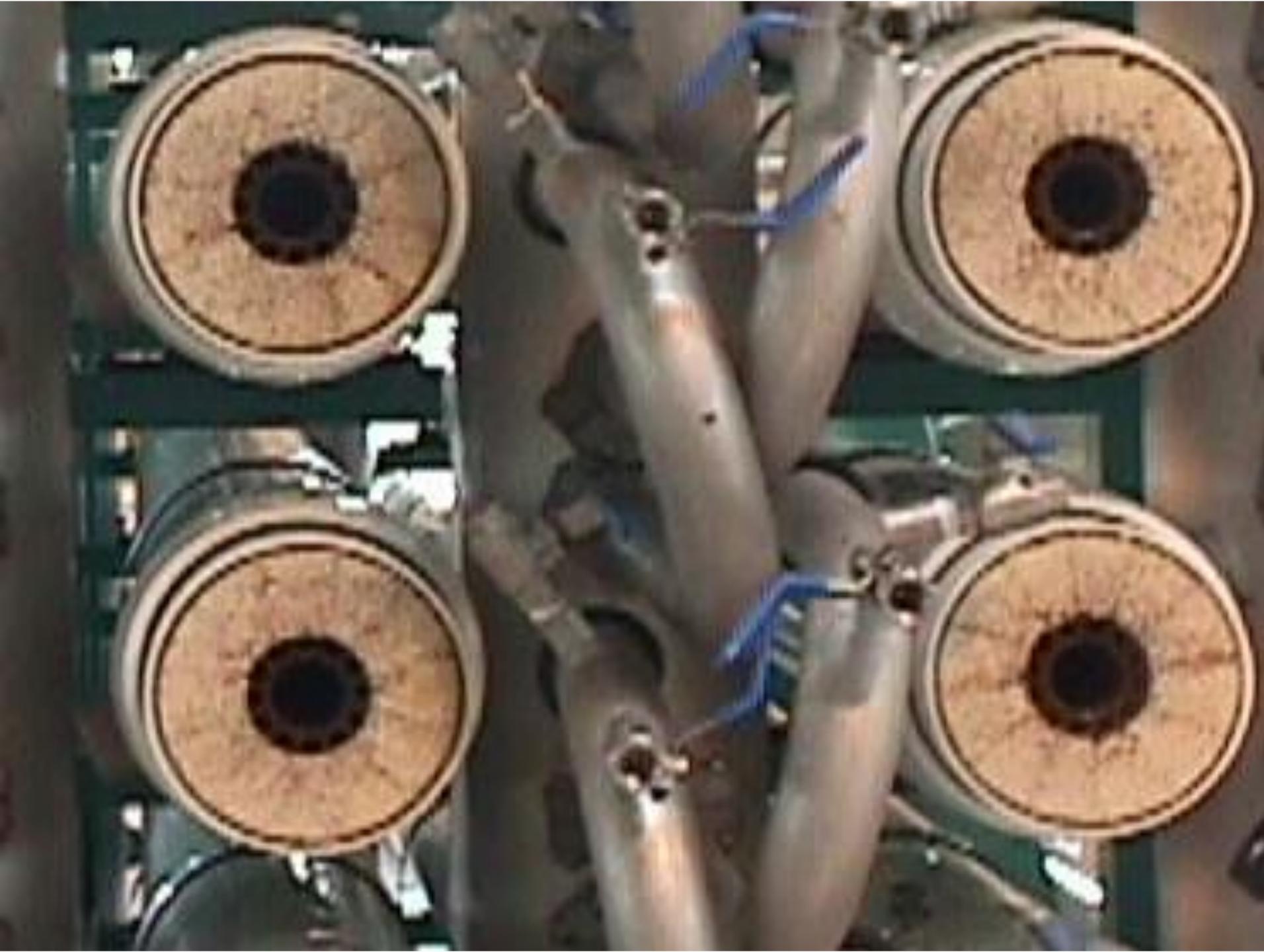
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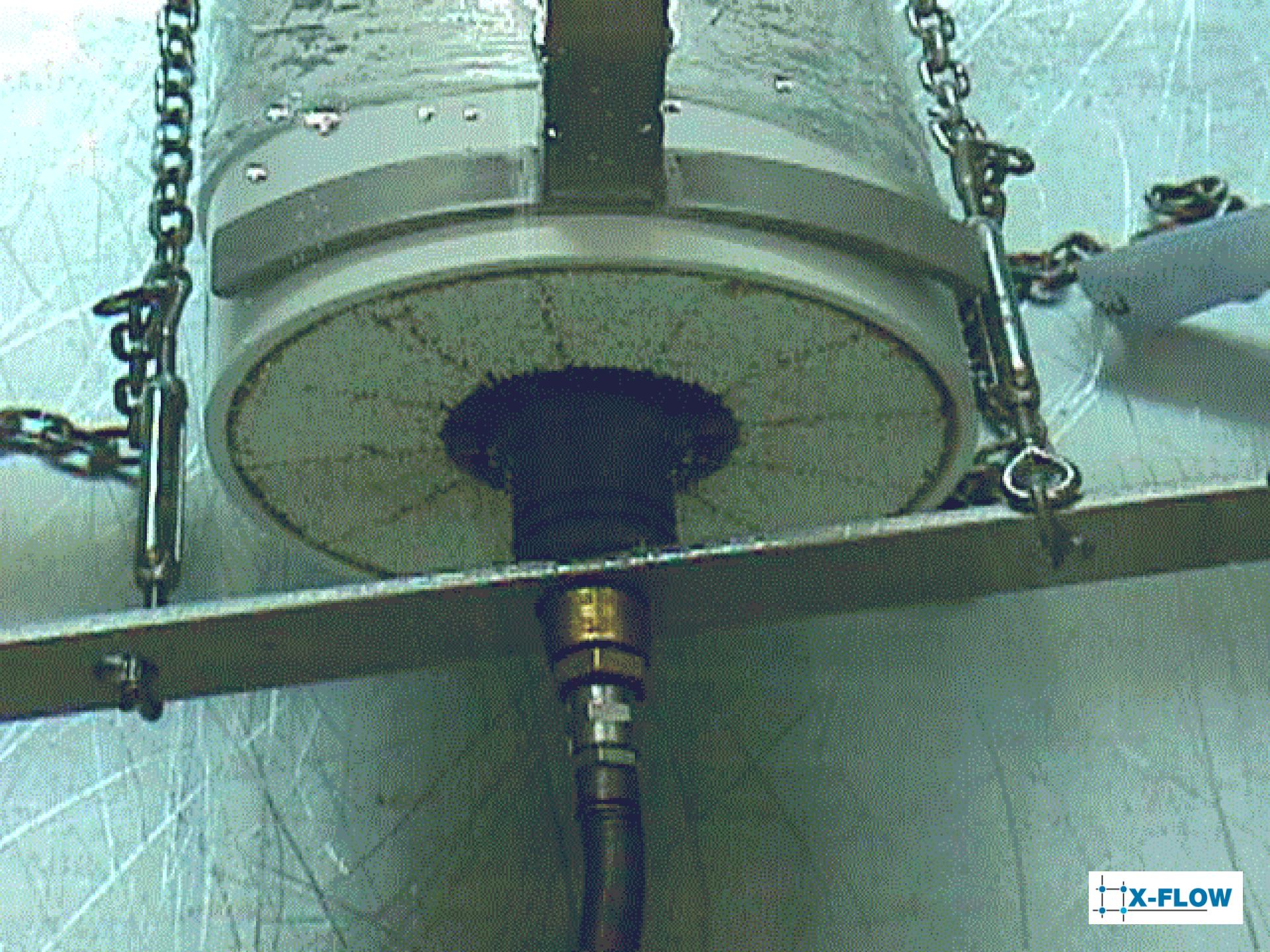
integrity monitoring of individual UF pressure vessels by particle counting 0.05 µm (block 6 after 6 months)

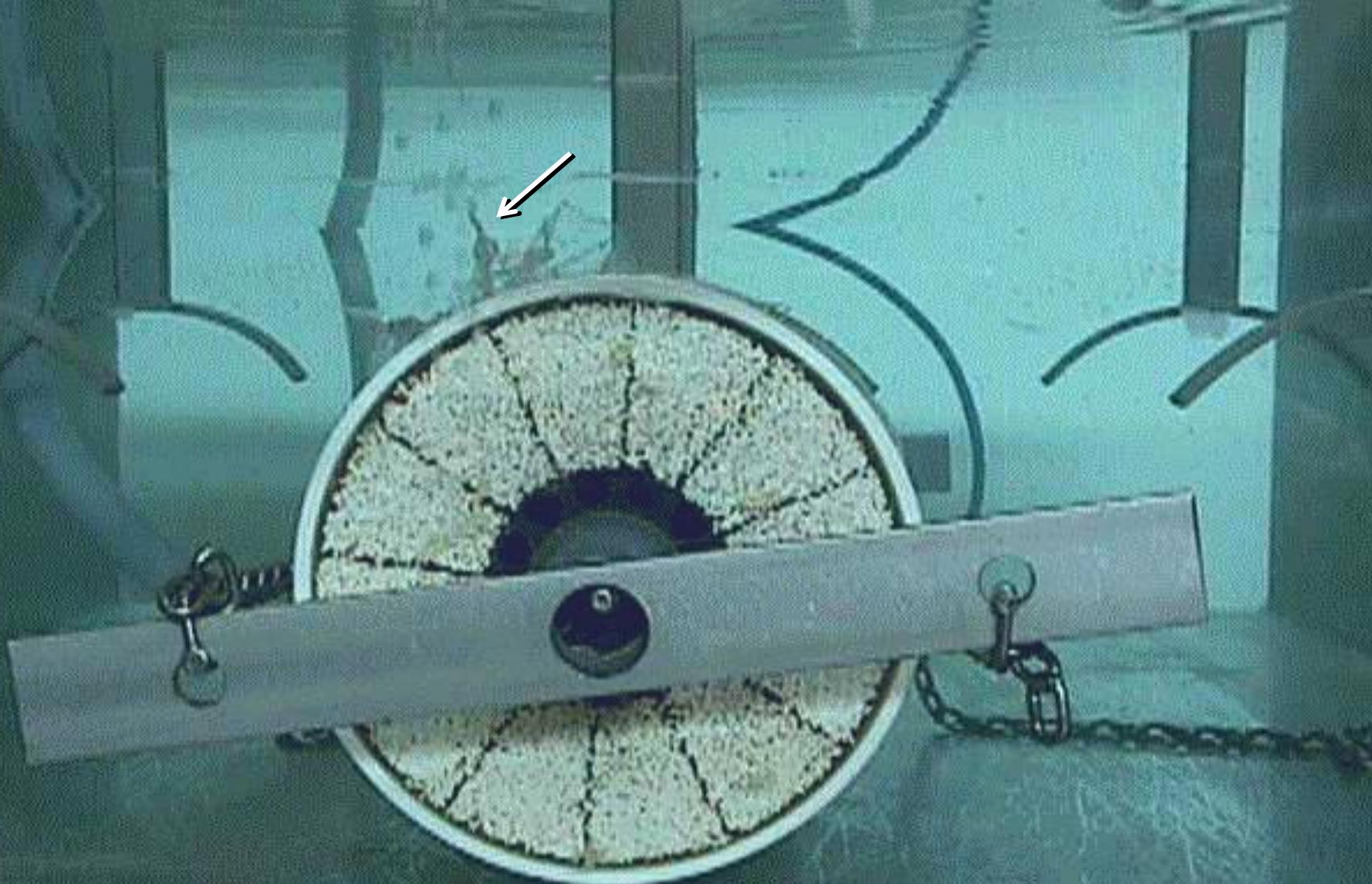
vessel	row front side [particles>0.05 µm/ml]				row back side [particles>0.05 µm/ml]			
	A	B	C	D	A	B	C	D
1	172	243	8670	4687	221	6234	1628	139
2	137	142	125	71	166	334	5263	205
3	142	201	163	438	193	96	285	16996
4	1650	77	11386	78	5724	339	159	67
5	604	10380	136	94	188	1916	2217	55
6	218	7077	234	83	137	225	38	72











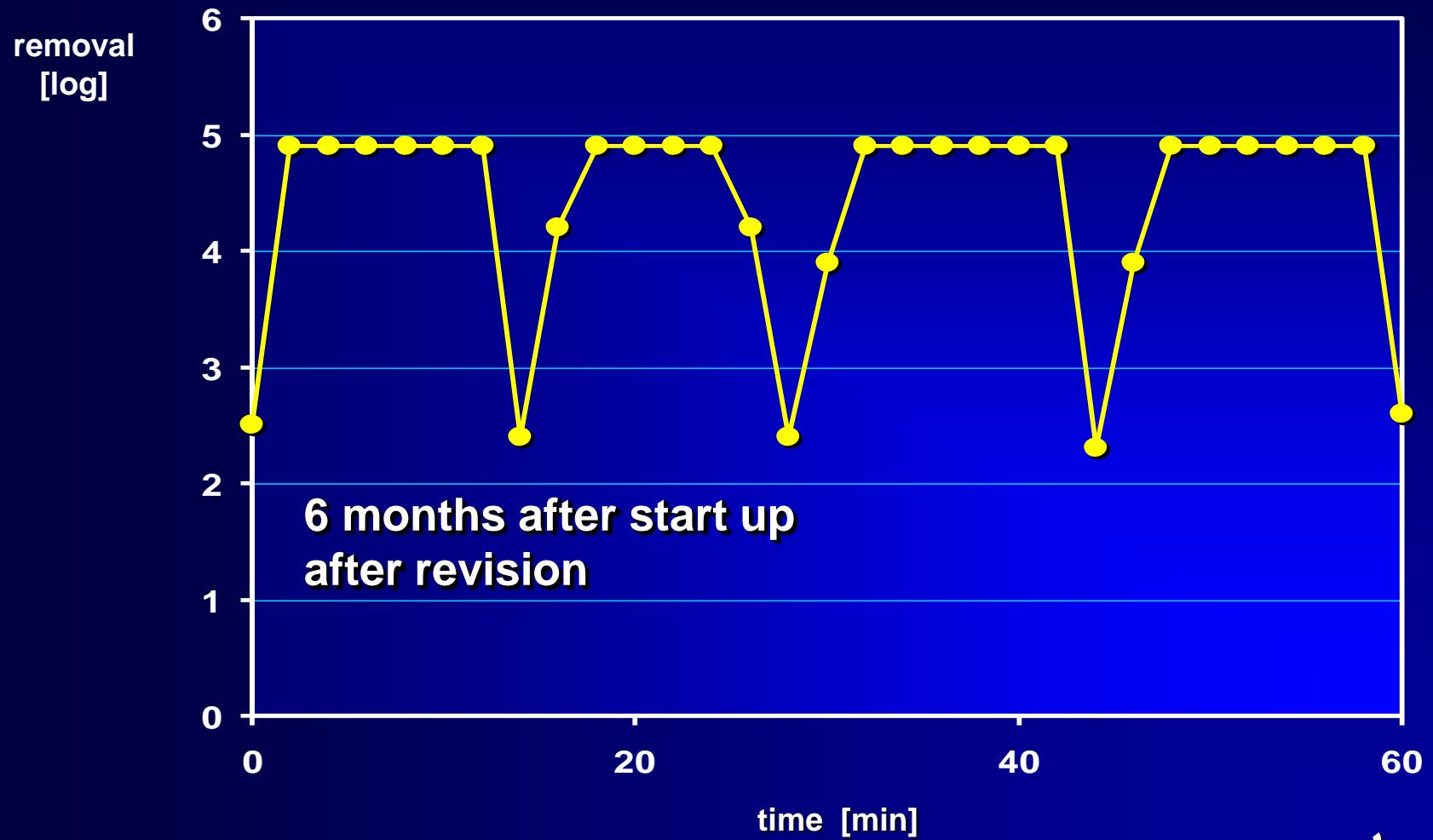






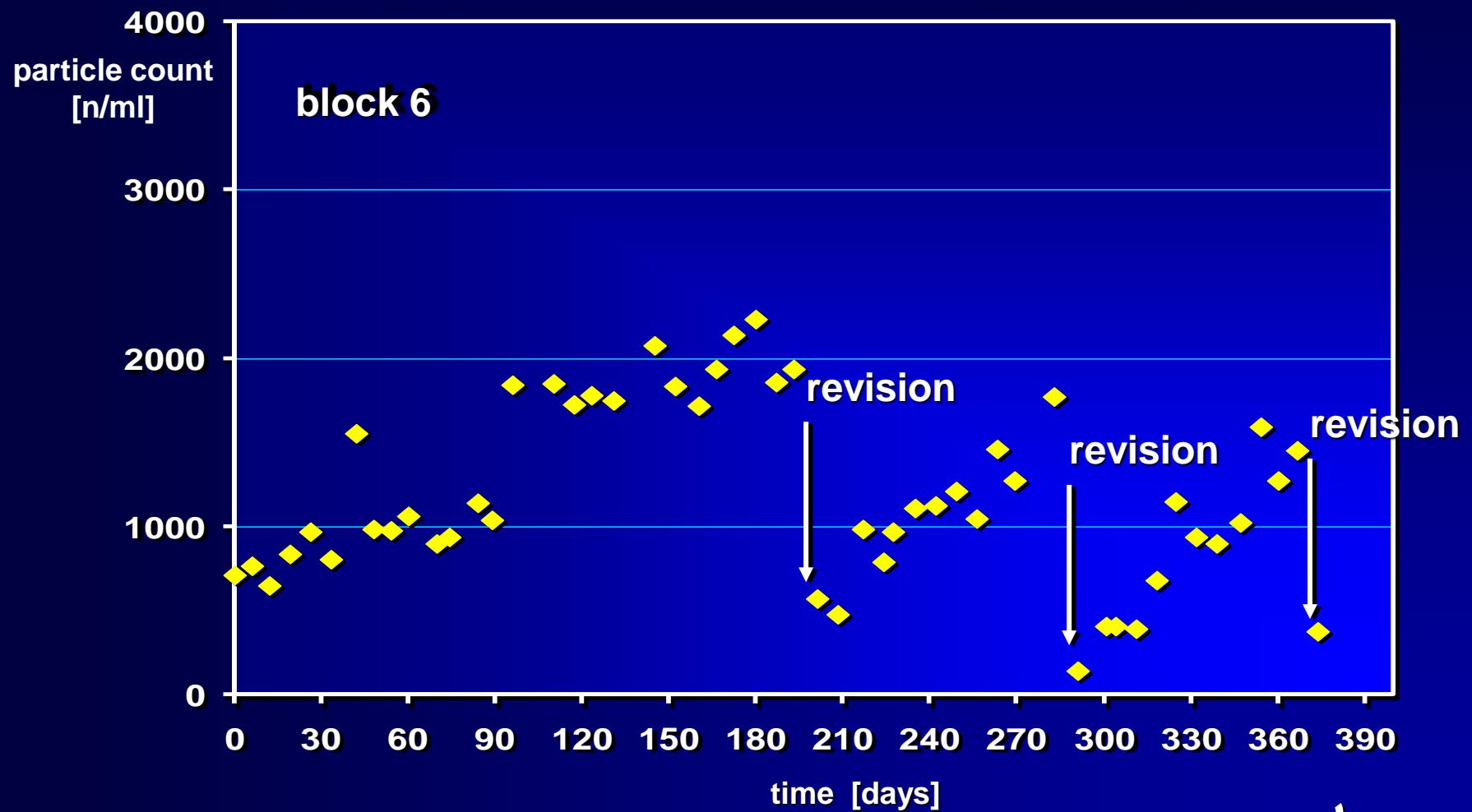
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integrity monitoring of UF blocks by particle counting 1.0 μm



1 μm

integrity monitoring of UF by particle counting 0.05 µm



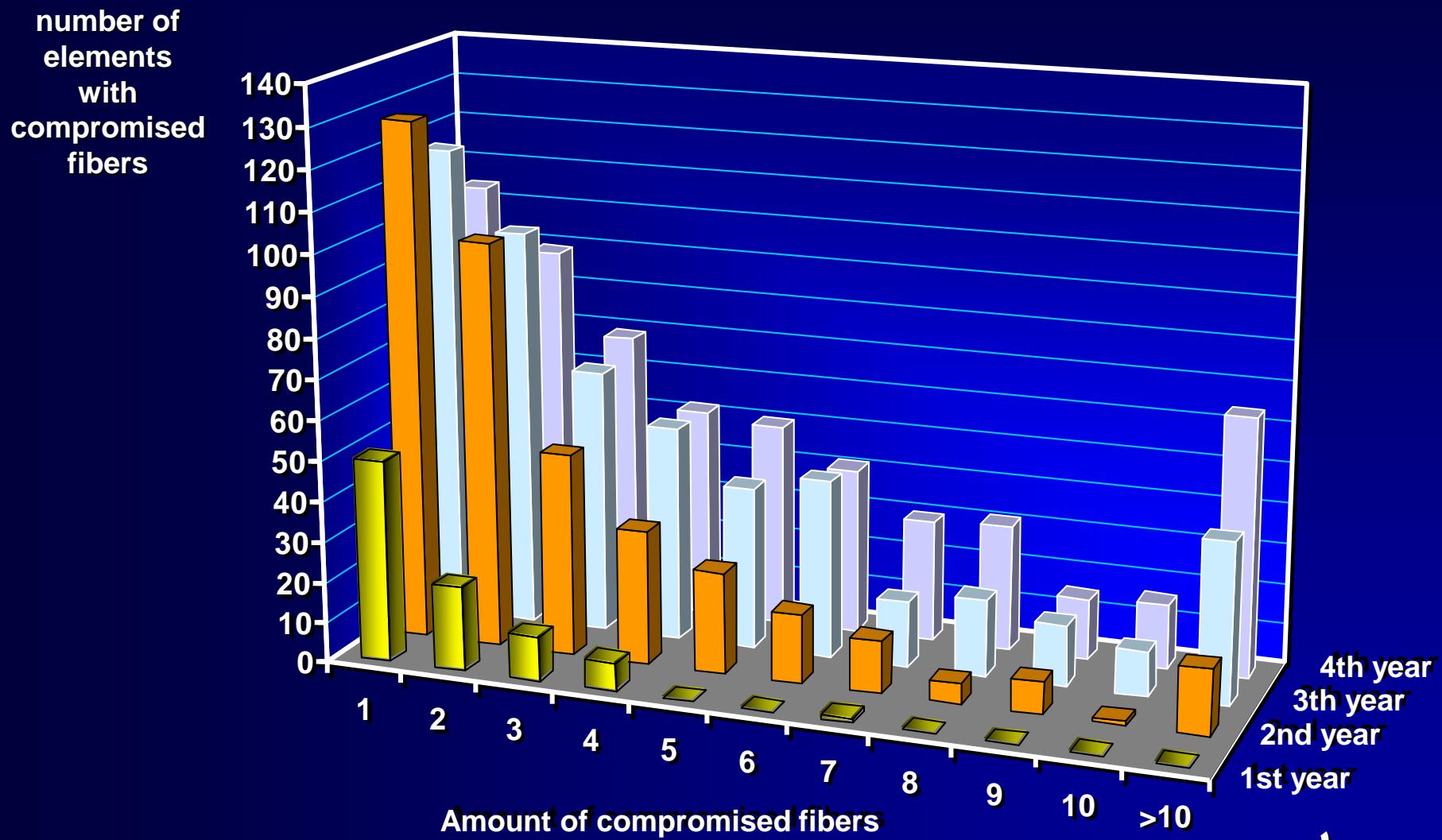
1000

integrity monitoring UF

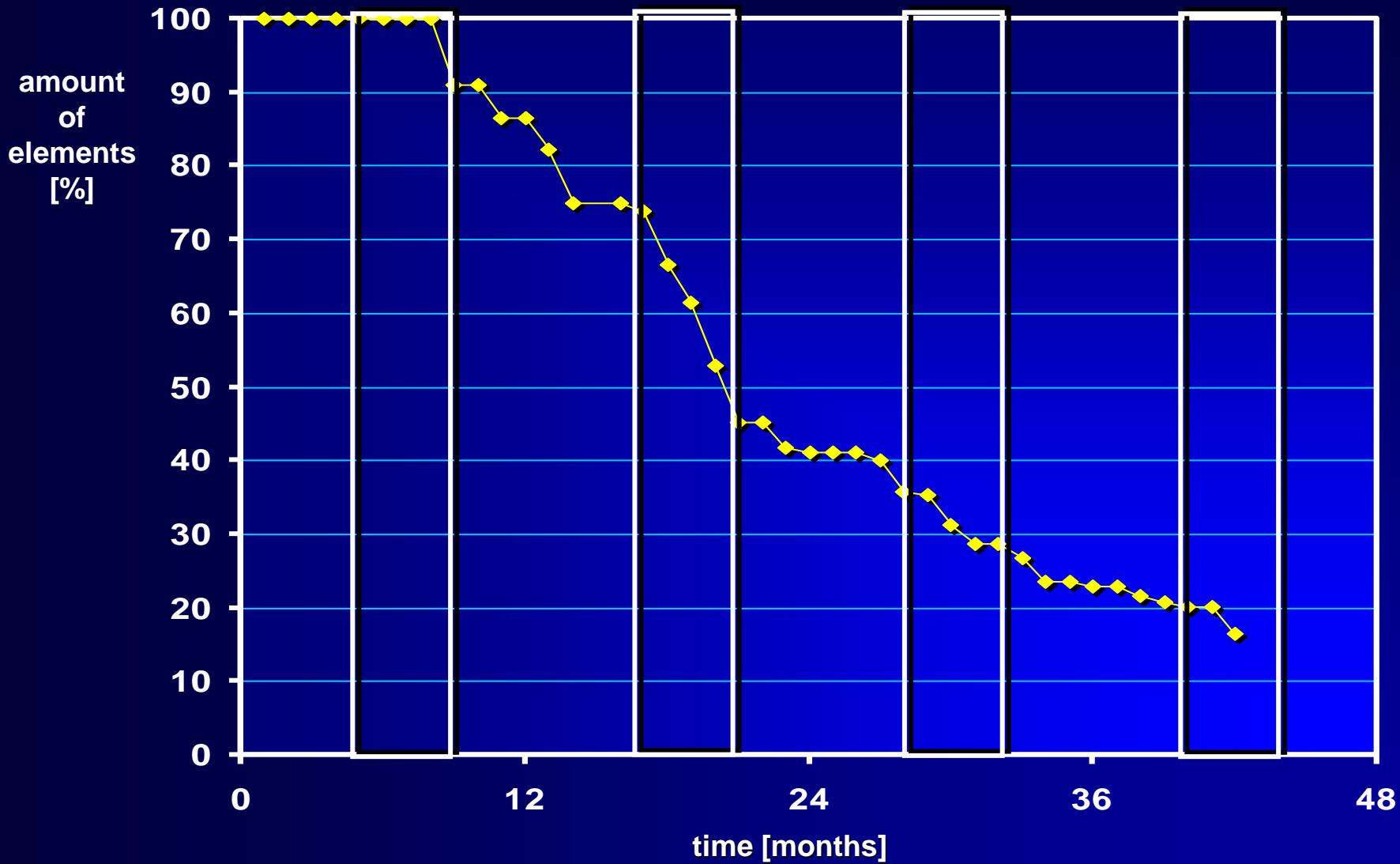
- **strategy:**
 - cont. measurement log-removal particles > 1,0 µm
 - log removal drops from 5 to 4
 - discont. measurement of particles >0,05 µm
 - revision after 0,05 µm counts exceed 1500/ml
- **number of compromised fibers**
 - Total of 3016 after 4 years
 - Is 0,04% of total amount
- **strategy save-guards 4 log removal by UF which is enough for the required additional inactivation**



number of elements with compromised fibers

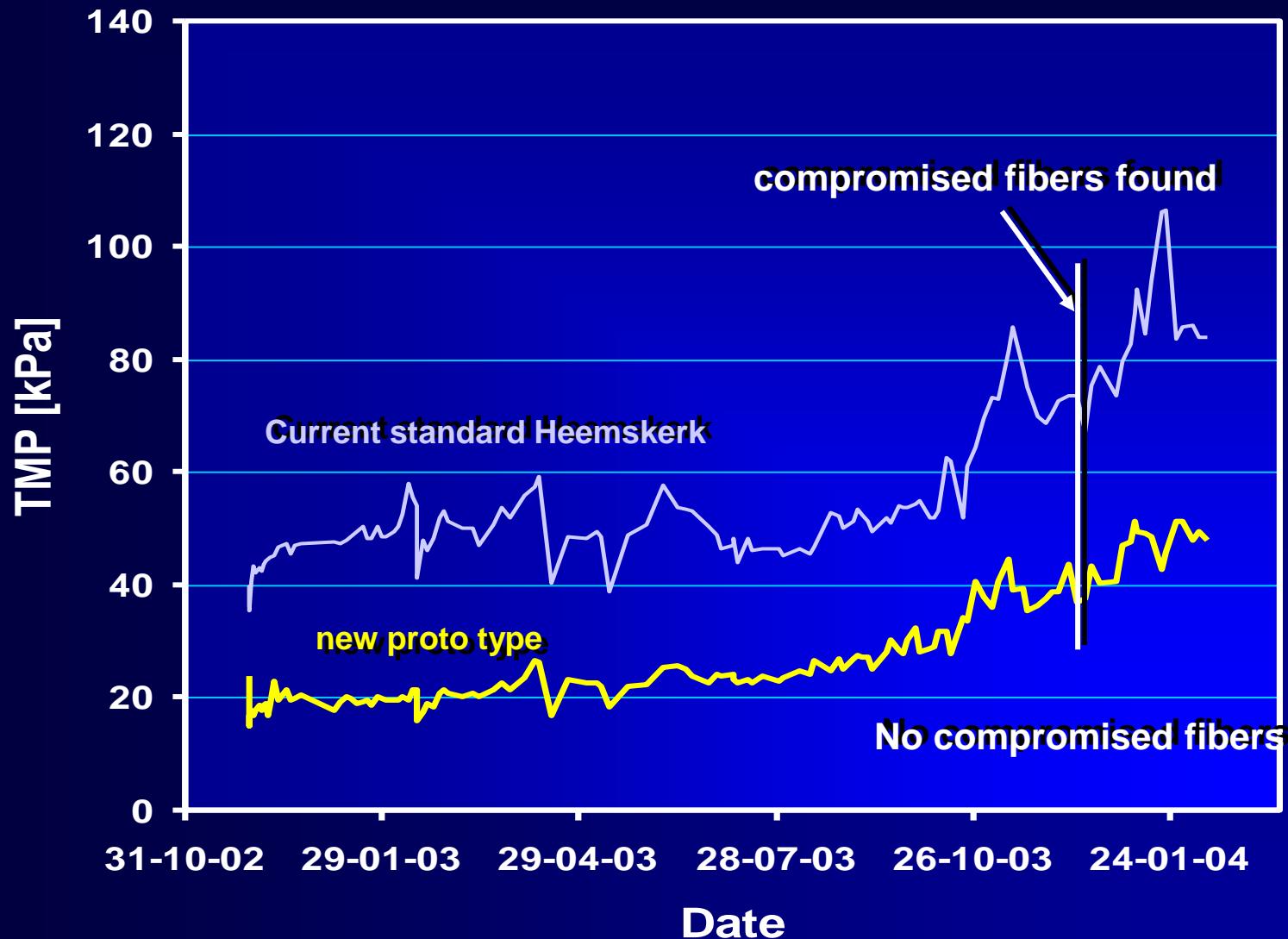


amount of elements without compromised fibers



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test of new proto-type

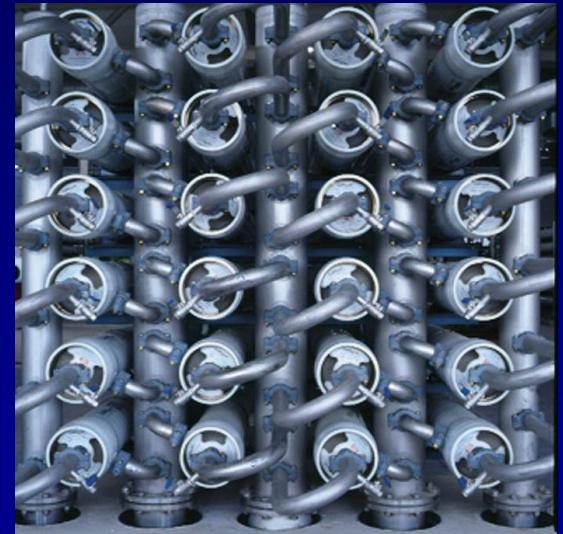


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analysis position of defects

- distribution of defects

	A	B	C	D	Total
1	3.8	5.5	5.4	5.2	19.9
2	3.7	4.1	6.4	3.9	18.1
3	2.9	4.0	5.7	4.2	16.7
4	2.2	3.6	4.0	2.9	12.6
5	3.5	5.2	3.7	3.3	15.7
6	4.1	4.8	4.2	4.1	17.1
total	20.0	27.2	29.3	23.5	100
(april2001:21.6	27.4	27.2	23.8	100)	



analysis position of defects

- distribution of defects in pressure vessel

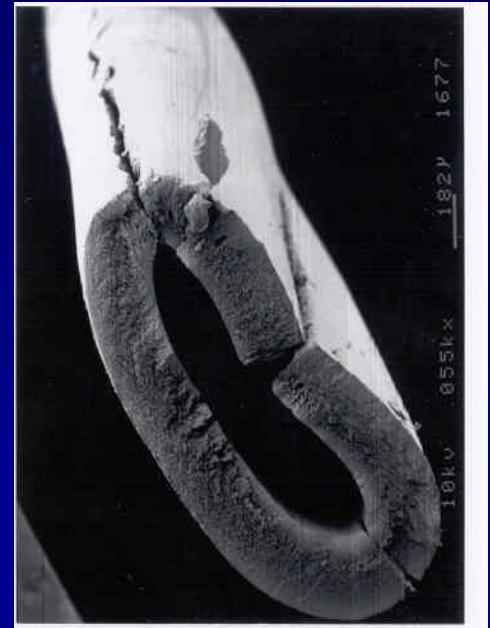
april 2001

– Pos 1:	31%	30%
– Pos 2:	19%	18%
– Pos 3:	18%	21%
– Pos 4:	32%	31%

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results from autopsies

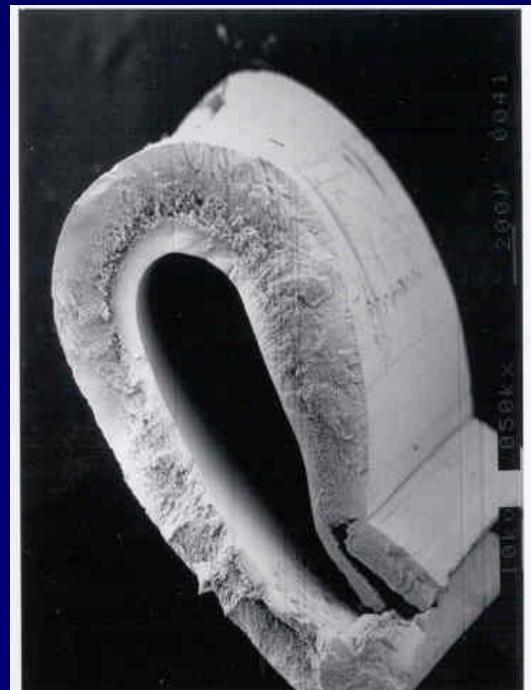
- a number of elements were opened in order to investigate compromised fibers.
 - most defects are flat fibres with a crack over the length of the fibre
 - in most cases no direct cause for these defects could be found



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results from autopsies

- defects - product related cause eccentricity



1
2
3

results from autopsies

- defects – product related cause damaged fibre



Defects near to outer side
of element
due to low epoxy height

results from autopsies

- defects – external cause
- foreign materials found in elements



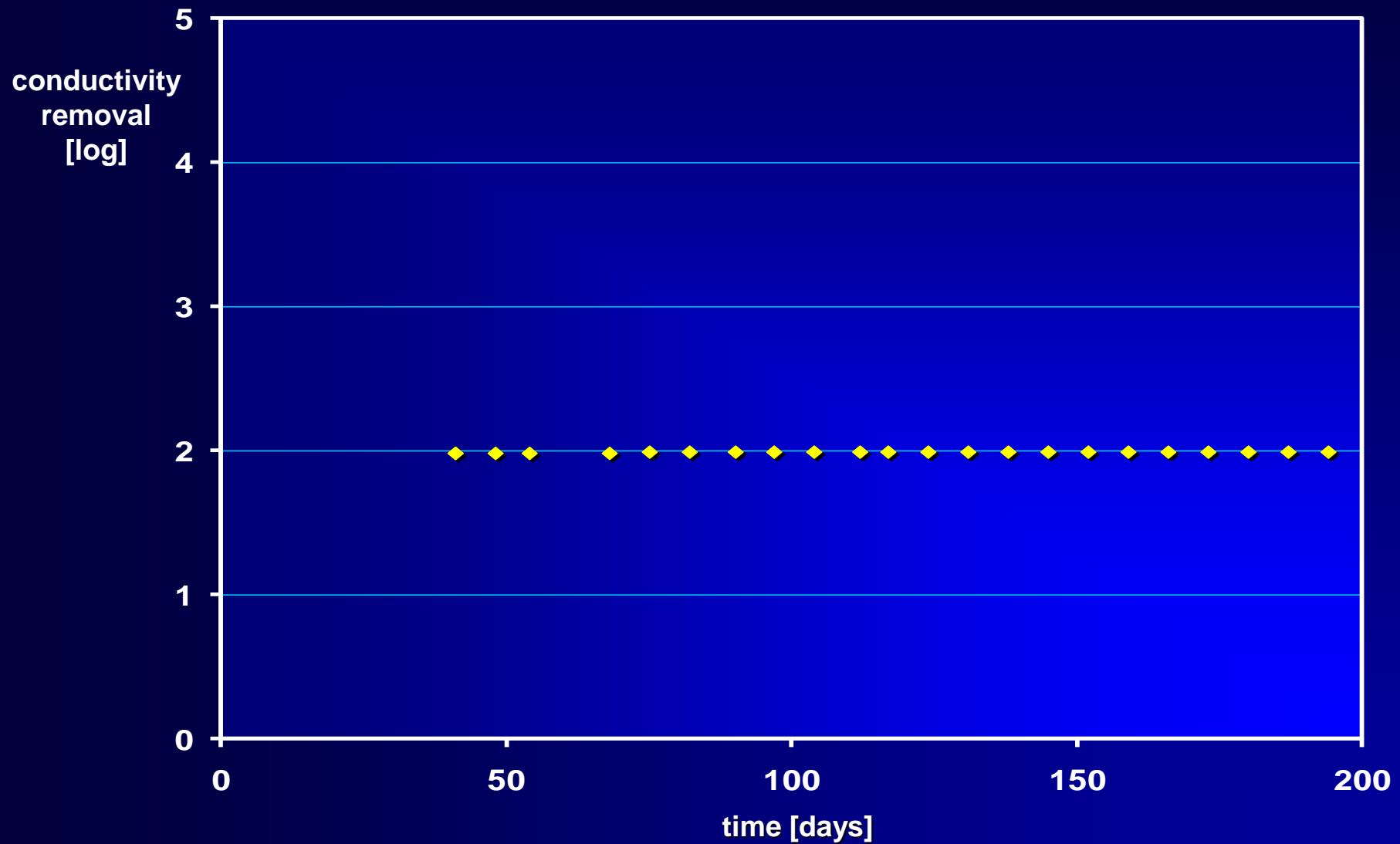
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summary

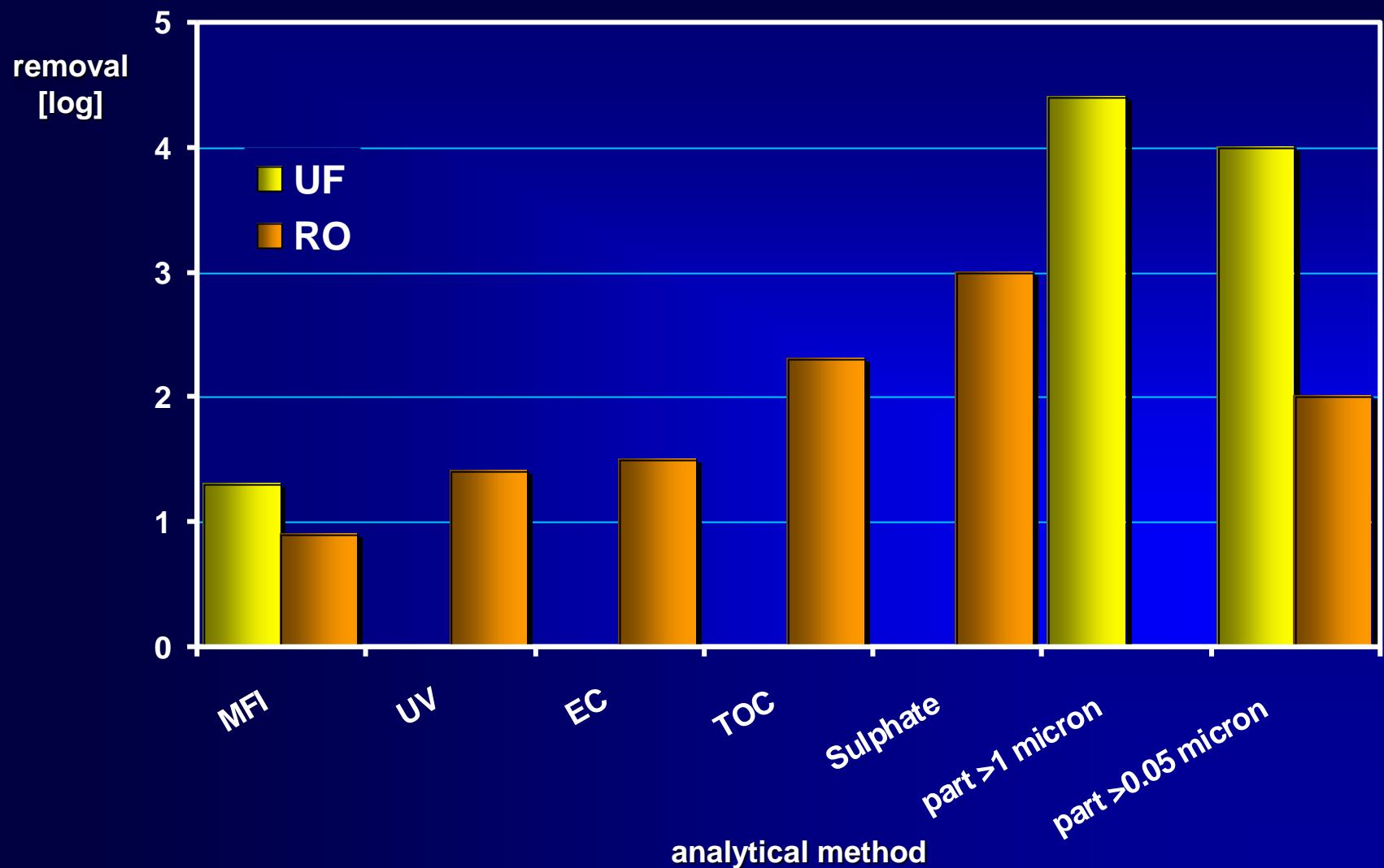
- most compromised fibers are flat fibres with a crack (appr. 70% of defects).
- for this 70%, no direct cause could be determined by autopsy.
- causes that were found by autopsy are:
 - product related: eccentricity, low epoxy, damaged fibres
 - external causes
- actual TMP influences fiber breakage
 - increase during winter
 - decrease when permeability is increased
 - increase at ends of pressure vessel



RO integrity monitoring with conductivity removal

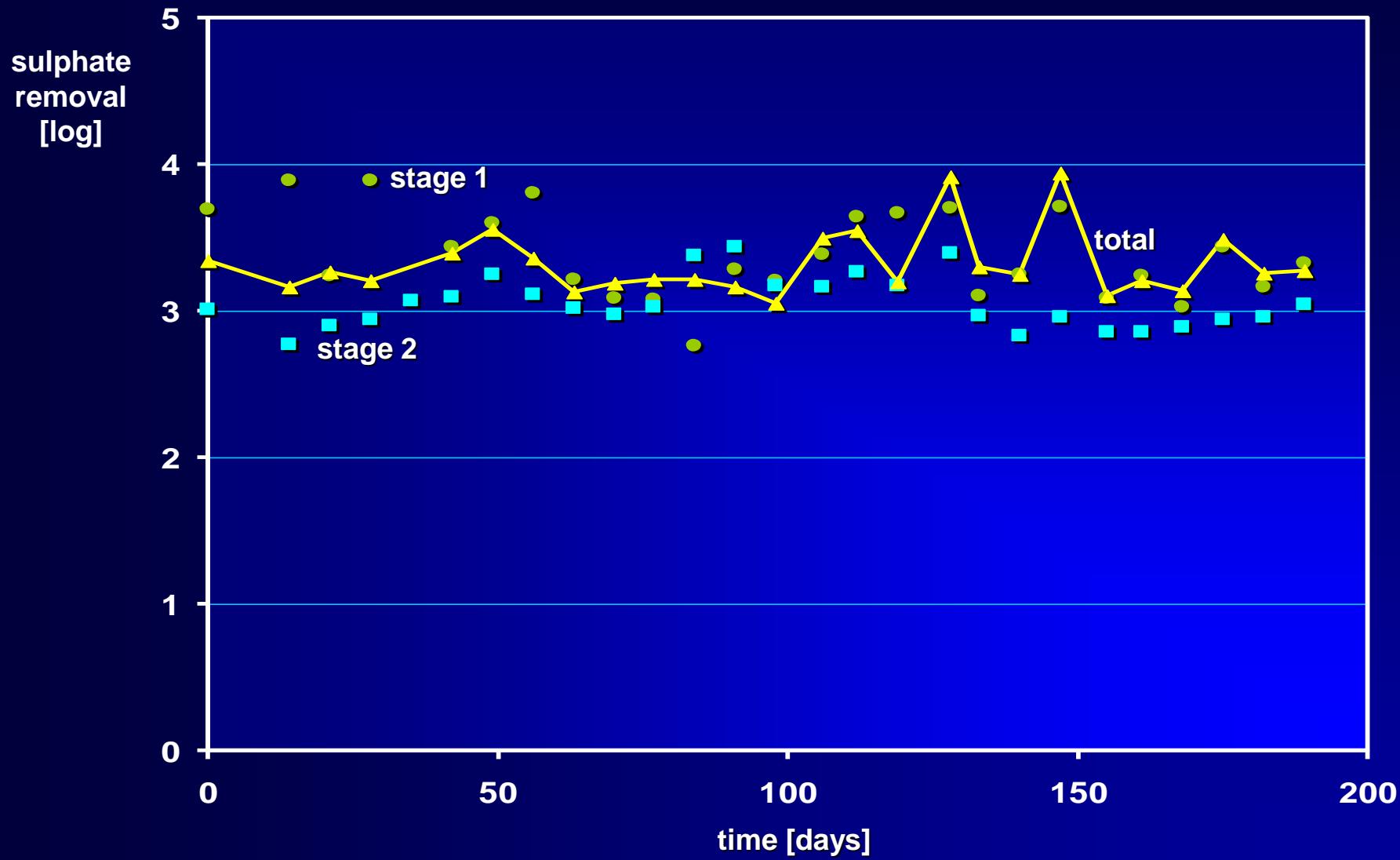


analytical methods for integrity monitoring





RO integrity monitoring with sulphate removal



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integrity monitoring of RO with conductivity and sulphate measurement

- conductivity measurement can only monitor RO integrity up to 2 log removal
- sulphate measurement can monitor RO integrity up to 3 log removal
- so far no integrity problems with RO

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Overall conclusions

- To control disinfection potential membrane integrity measurement is critical
- For UF a strategy is adopted based on continuous particle counting $> 1,0 \mu\text{m}$ for each block
- At a loss of log removal from 5 – 4 probe measurements are carried out to find and repair compromised fibers
- For RO a strategy is adopted based on sulfate monitoring enabling to establish 3 log removal
- The total integrity monitoring enables measurements up to 8 log removal



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