UF/RO treatment plant Heemskerk
Operation & Maintenance

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- Operation
  - Parameters
  - Labor
  - Encountered problems/troubleshooting
- Maintenance
  - Repair & replacement (preventive)
  - Repair & replacement (curative)
- Operation & maintenance costs

Operational parameters UF plant (1)

number of blocks	8
membrane surface	3360 m^2 / block
membrane type	UFC M5 S225 Xflow
gross flux	96 – 113 $l/m^2.h$
Overall recovery -backwash water -down time -Buffer overflow	83.7 % 8.2 % 6.1% 2.0 %
backwash flux	220 – 300 $l/m^2.h$

Operational parameters UF plant (2)

filtration cycle	18 min or 34 l/m^2
backwash time	25 sec
valve opening/closing	3 sec
EBW frequency	3/d or 26 fc
Cleaning agent	150 ppm NaOCl
Soaking period	10 min

Operation
Performance parameters UF

- Actual filtration TMP (hard shut off at 150 kPa)
- Actual BW TMP (hard shut off at 250 kPa)
- Actual filtration TMP (soft alarm at 100 kPa)
- Normalized flux or permeability (stability)
- Fouling rate within filtration cycle (< 15 kPa/h)
- Log removal particle count
- MFI permeate

Operation

Labor during normal operation UF

- One operator for the daily operation
- Two shifts (WTP 16h/d occupied)
- In the night 1 operator for whole region (includes other WTP and pumping stations)
- In total 8 operators and 1 process engineer
- Operator on duty has complete responsibility of treatment process
- Process engineer advises operators and has full knowledge about the technology

Operation
Labor during normal operation UF

- **Duty operators:**
  - Check performance parameters
  - Fill manual log sheets
  - Follow checklists
  - Control monitor equipment
  - Ordering of chemicals
  - Perform small maintenance
  - Quality control out sourced maintenance
  - Report incidents
  - Notify maintenance coordinator in case of unplanned maintenance

Operation
Labor during normal operation UF

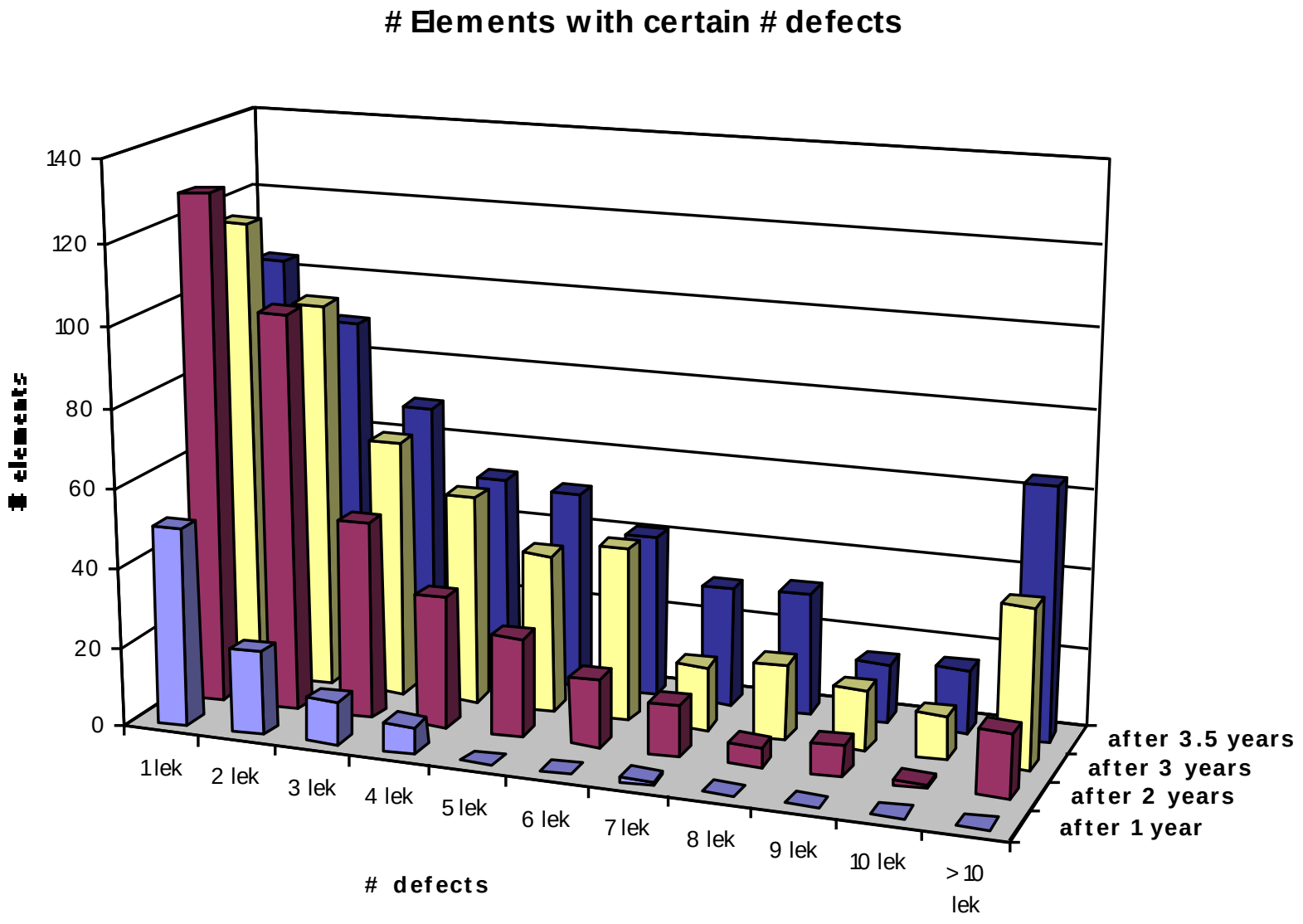
- **Duty process engineer:**
  - Check performance parameters
  - Check manual log sheets
  - Check water quality
  - Report performance WTP (operation and quality)
  - Optimize process, operation and monitors
  - Small engineering jobs
  - Consults operators
  - Reports to staff
  - Intermediary between process and third party’s

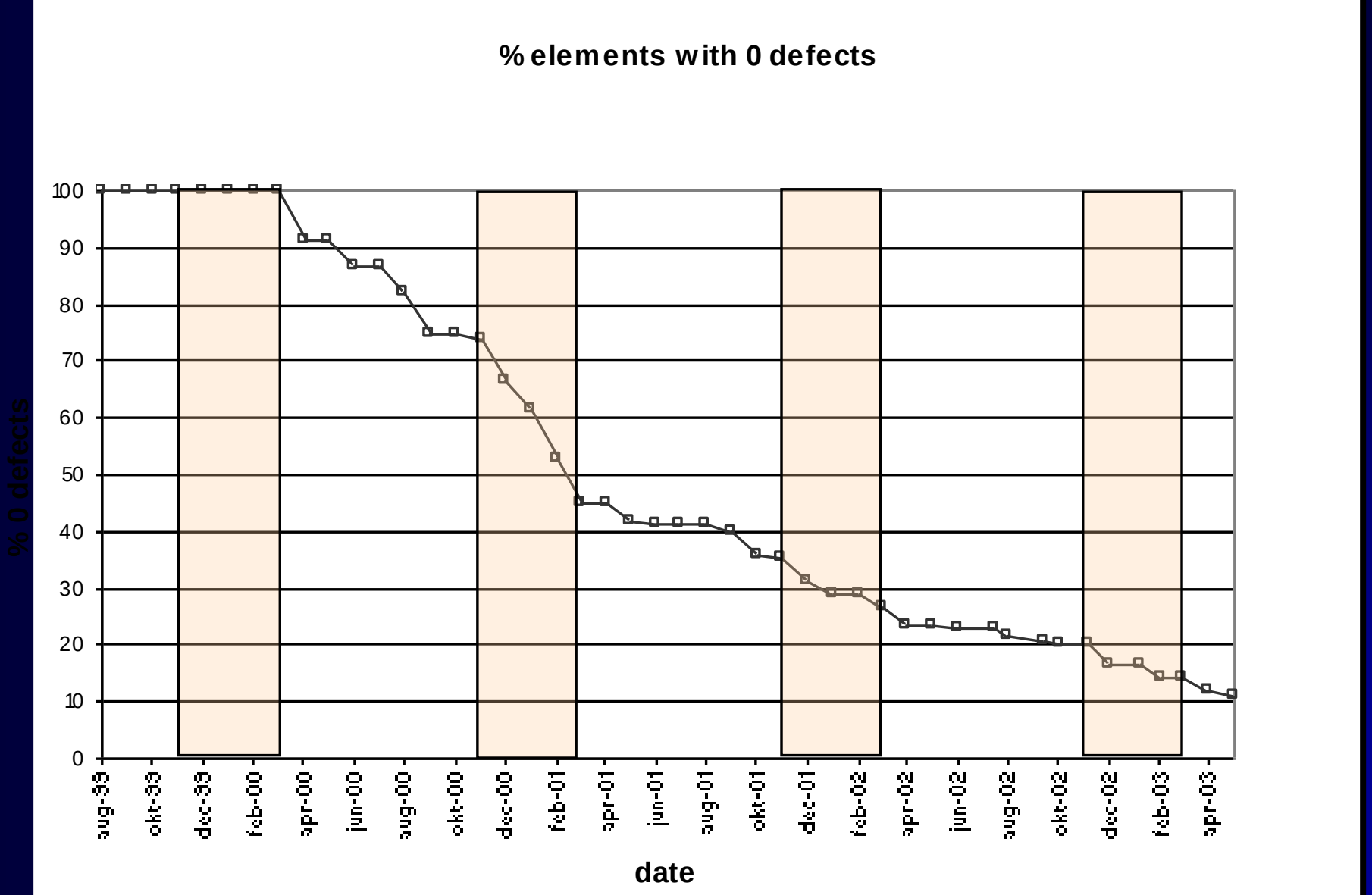
Operation
Labor during normal operation UF

- Duty maintenance coordinator :
  - Responsible for preventive maintenance program
  - Contact person maintenance contractors
  - Reports maintenance issues

Operation
Troubleshooting

- Integrity loss (compromised fibers)
- New X-flow standard UFC M5 (2001), block 3
- Performance problems at colder periods
- Particle counters

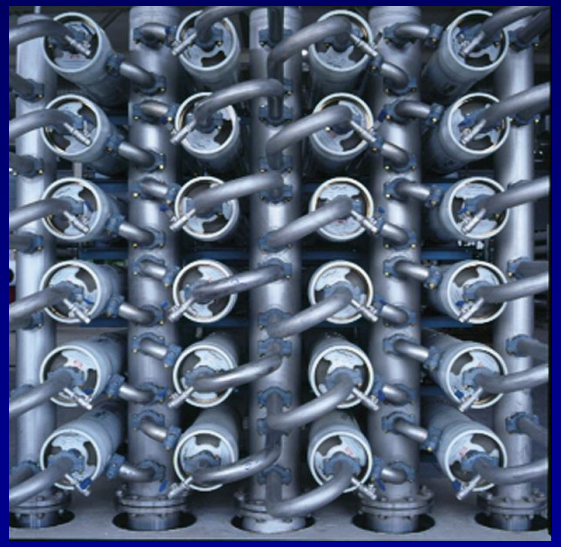

Elements with certain # defects
elements
140
120
100
80
60
40
20
0
1 lek
2 lek
3 lek
4 lek
5 lek
6 lek
7 lek
8 lek
9 lek
10 lek
> 10 lek
defects
after 3.5 years
after 3 years
after 2 years
after 1 year


% elements with 0 defects
% 0 defects
100
90
80
70
60
50
40
30
20
10
0
aug-99
oct-99
dec-99
feb-00
apr-00
jun-00
aug-00
oct-00
dec-00
feb-01
apr-01
jun-01
aug-01
oct-01
dec-01
feb-02
apr-02
jun-02
aug-02
oct-02
dec-02
feb-03
apr-03
date

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)***	



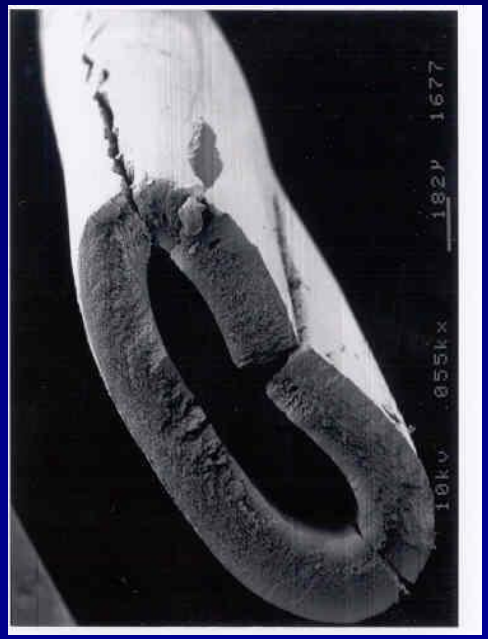
Analysis position of defects

- **Distribution of defects in pressure vessel**

		april 2001
– **Pos 1:**	**31%**	***30%***
– **Pos 2:**	**19%**	***18%***
– **Pos 3:**	**18%**	***21%***
– **Pos 4:**	**32%**	***31%***

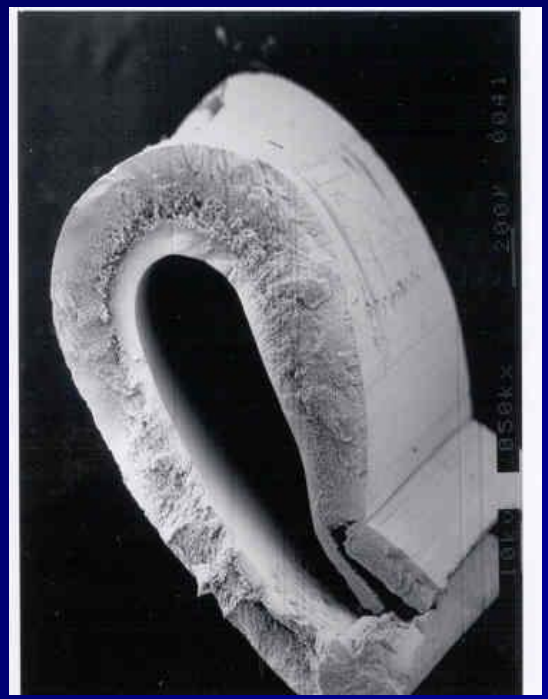
Results from autopsies-1

- A number of elements from PWN were opened in order to investigate the cause for the defects.
  - 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



Results from autopsies-2

- Defects - product related cause
  Excentricity



Results from autopsies-3

- **Defects – product related cause damaged fibre**

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

Results from autopsies-4

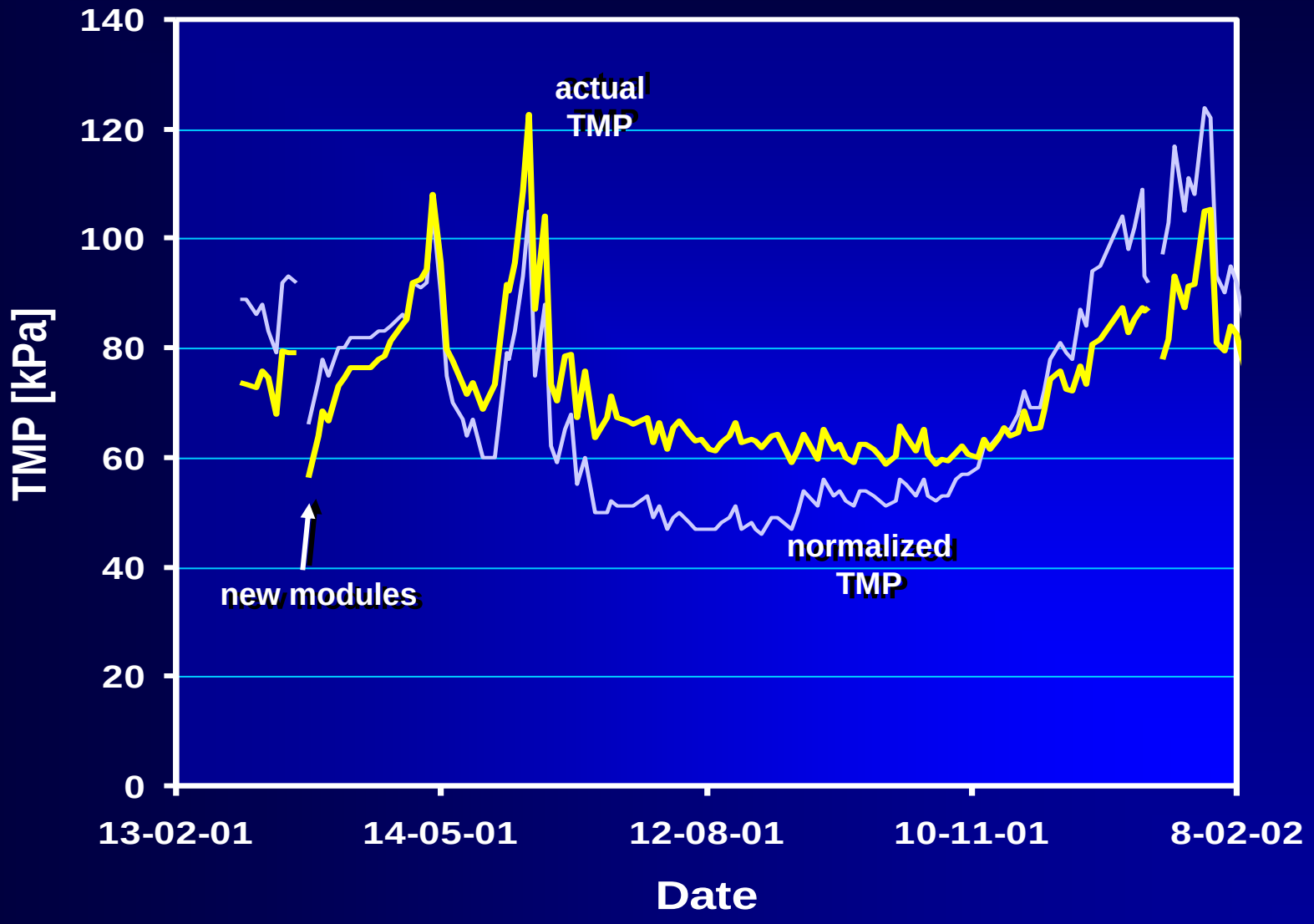
- Defects – external cause

- Foreign materials found in elements

Summary results autopsies

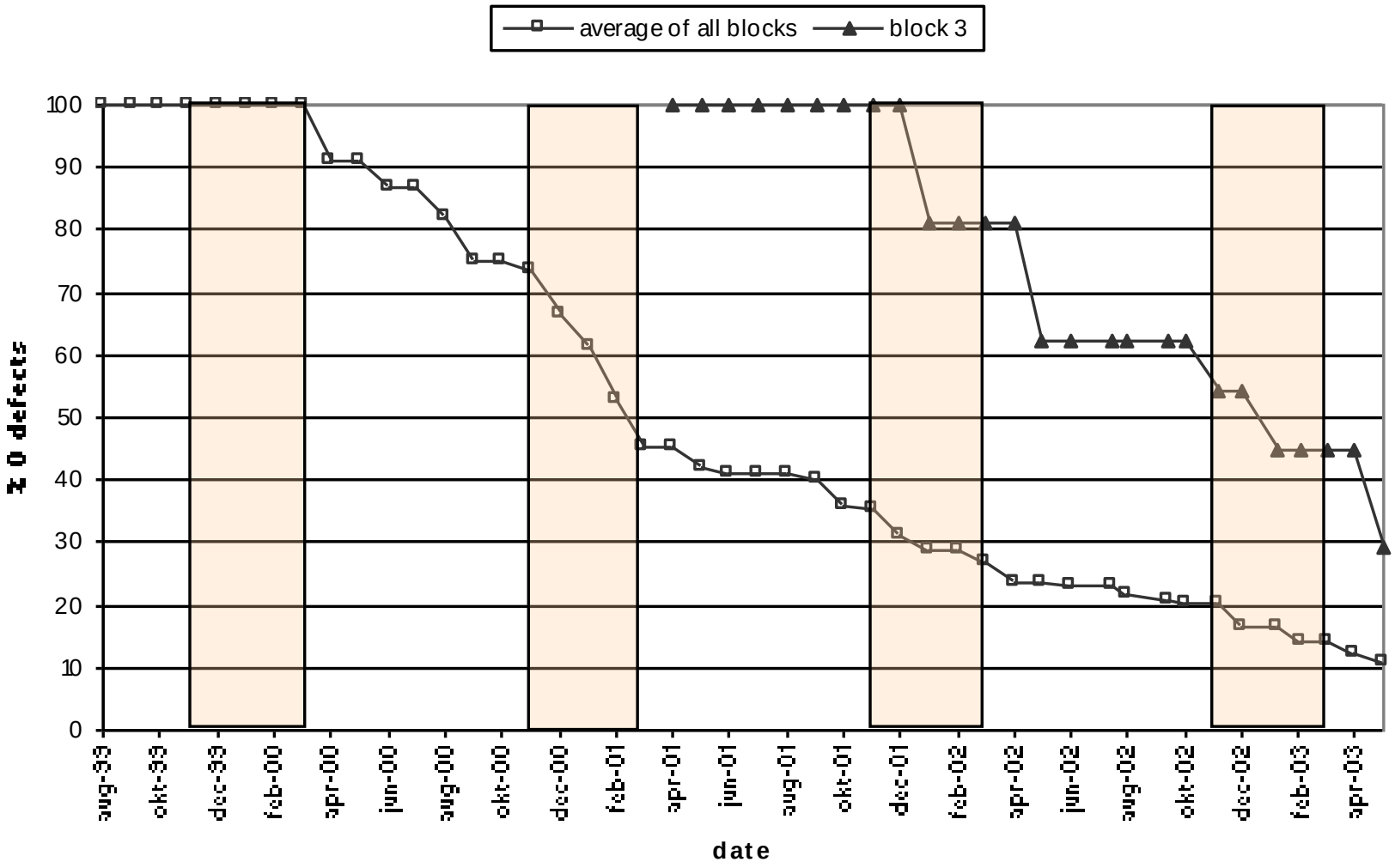
- Most defects are flat fibres with a crack (appr. 70% of defects, based on the 34 elements autopsied from block 3 in 2001).
- For most of these flat fibres, no direct cause could be determined by Xflow.
- Causes that were found are:
  - Product related: excentricity, low epoxy, damaged fibres
  - External causes
- Actual TMP influences defects most, winter

TMP UF block 3

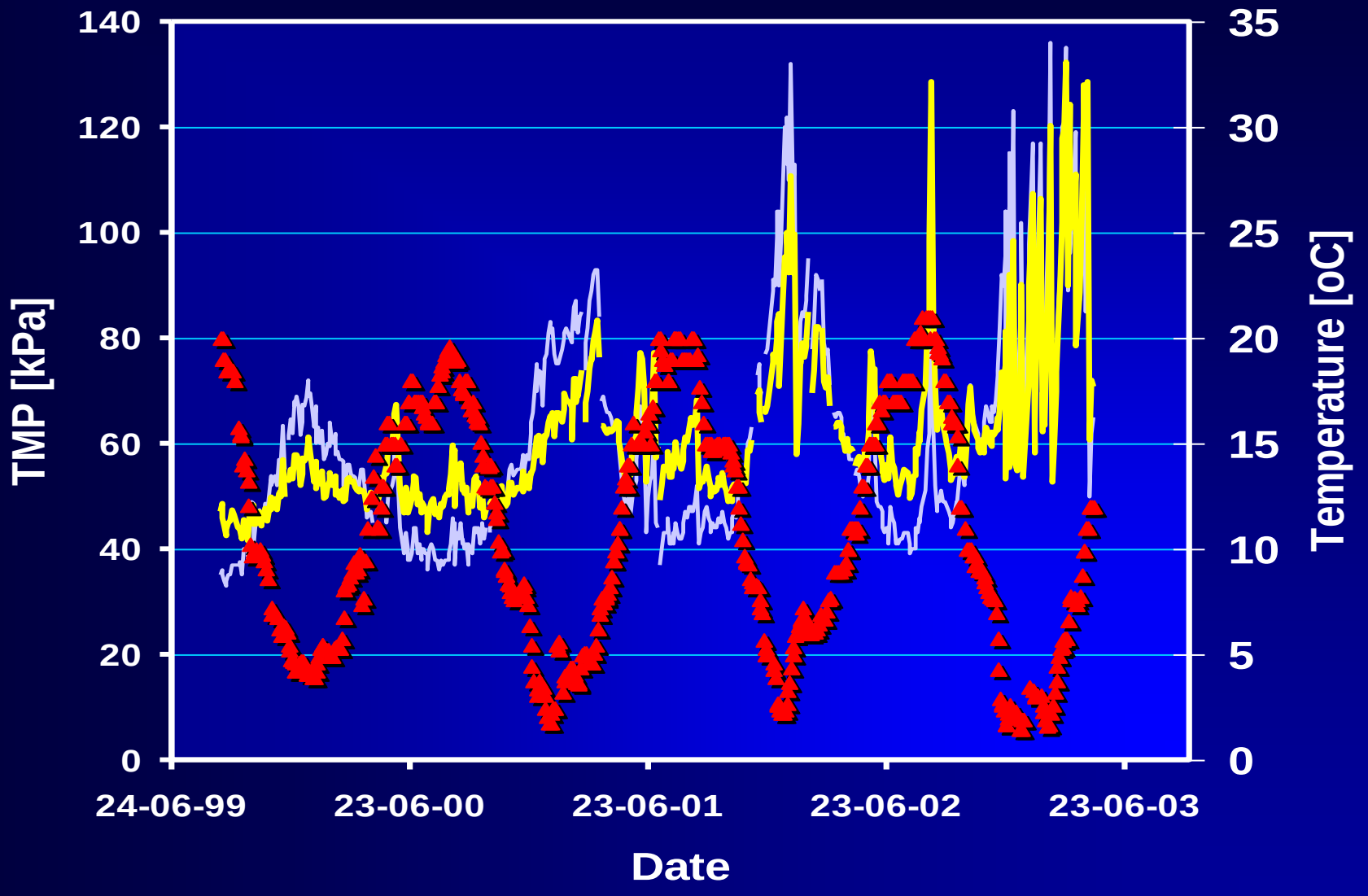


Operation
New X-flow standard

- Permeability lower than old standard, resulting in:
  - Higher actual TMP, during filtration
  - Higher TMP, during backwash
  - Capacity problems at colder water temperatures (<10^{o}C)
  - Higher amount of compromised fibers
- Permeability is initially twice as low (300 vs 600)
- Not announced by X-flow
- New standard is no alternative for current design


% elements with 0 defects
average of all blocks
block 3
% 0 defects
100
90
80
70
60
50
40
30
20
10
0
aug-99
oct-99
dec-99
feb-00
apr-00
jun-00
aug-00
oct-00
dec-00
feb-01
apr-01
jun-01
aug-01
oct-01
dec-01
feb-02
apr-02
jun-02
aug-02
oct-02
dec-02
feb-03
apr-03
date

TMP UF block 1, temperature effect



Operation
Performance decrease at lower T

- Each winter TMP is getting higher
- Direct relationship with T, possible causes:
  - Changing water quality
  - Influence T on effectivity NaOCl
  - Influence T on permeability membrane other then viscocity changes
- Troubleshooting starts winter 2002/2003, severe problems winter 2001/2002

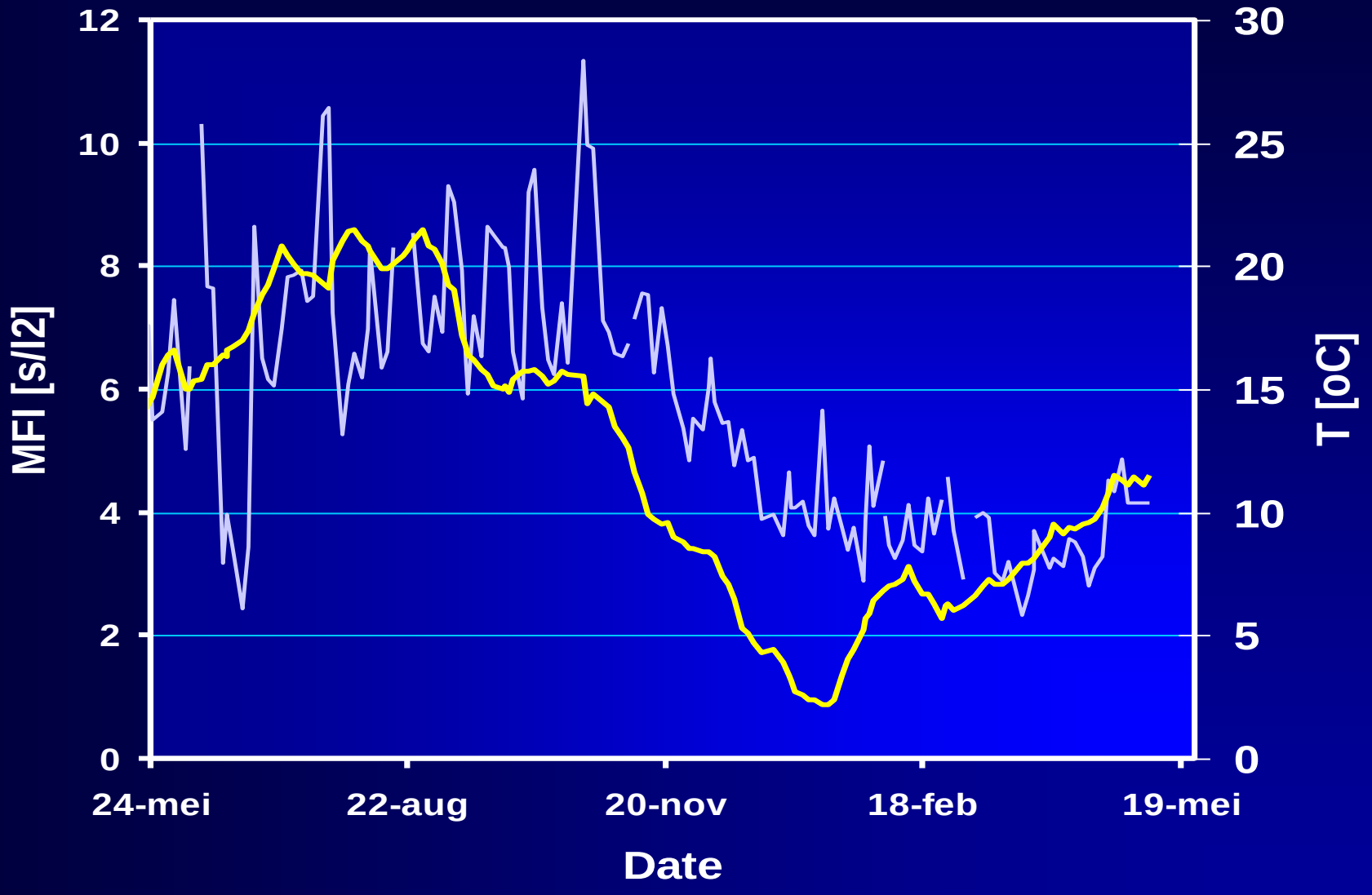
Performance decrease at lower T
Changing water quality

- Feed water has been analysed on:
  - Suspended matter and MFI
  - Organic matter: TOC, DOC, AOC
  - Biological parameters: ATP, TDC, DGGE (DNA)
- In total temperature trajectory during winter
- Including influence distribution

  - Direct after pre-treatment Andijk

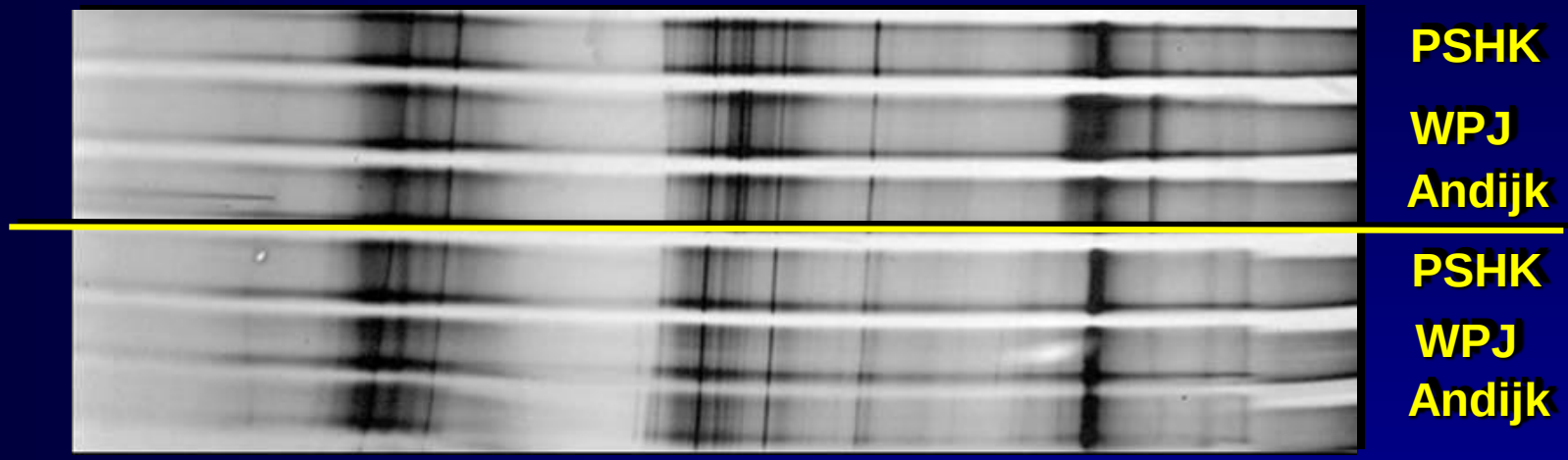
  - Feed UF Heemskerk

changing water quality



Changing water quality

14 january 2003 at 1^{o} C



14 november 2002 at 10^{o} C

DNA profiel DGGE

Performance decrease at lower T
Changing water quality

- **Results:**
  - **All parameters decreased with lower temperatures**
  - **No changes in species (dominant culture is identical)**
  - **No difference after distribution**

- **Water quality improves at lower temperatures**

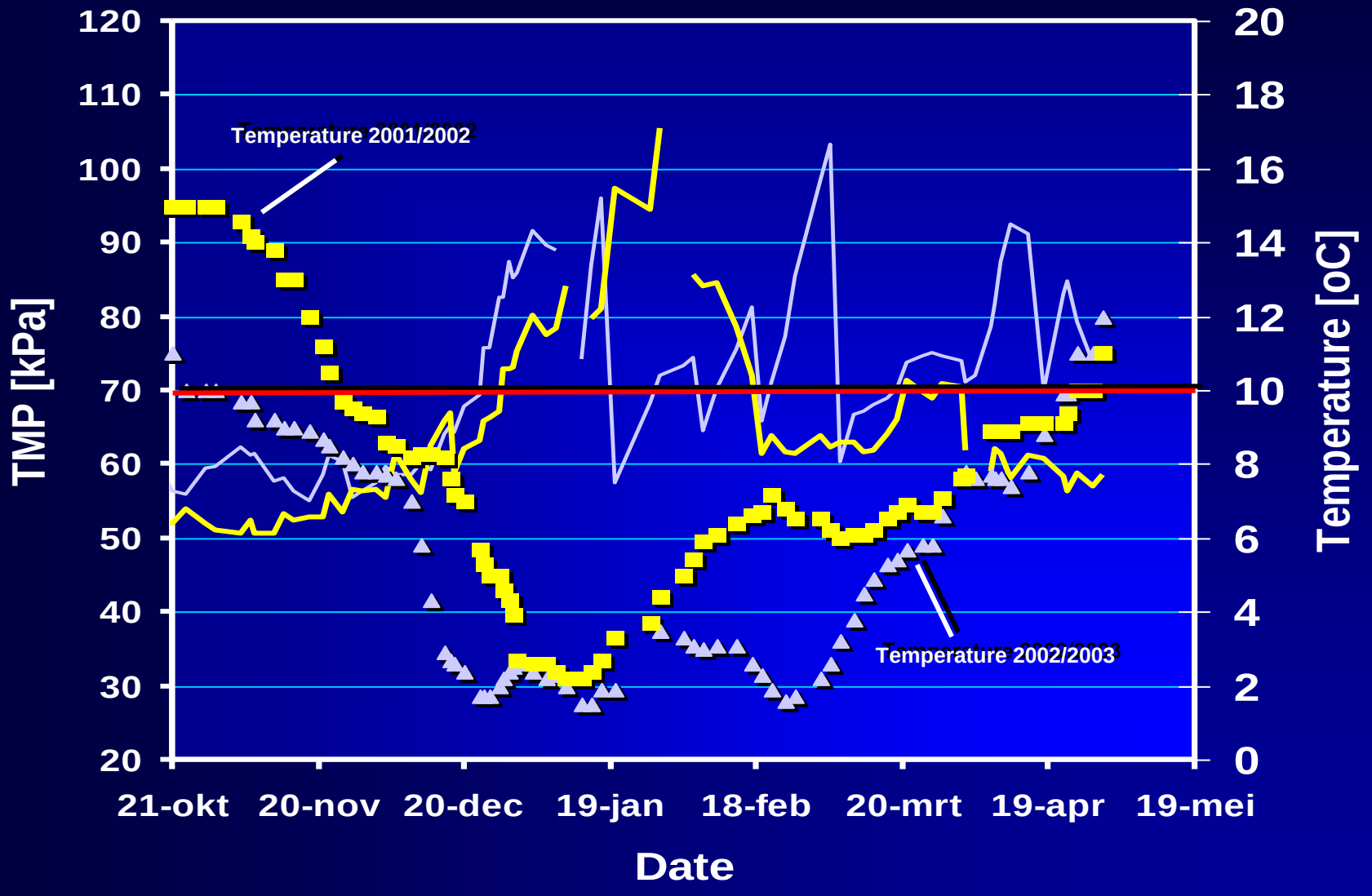
Performance decrease at lower T
Influence operation

- Determine:
  - Fouling rate
  - Efficiency backwash
  - Efficiency enhanced backwash

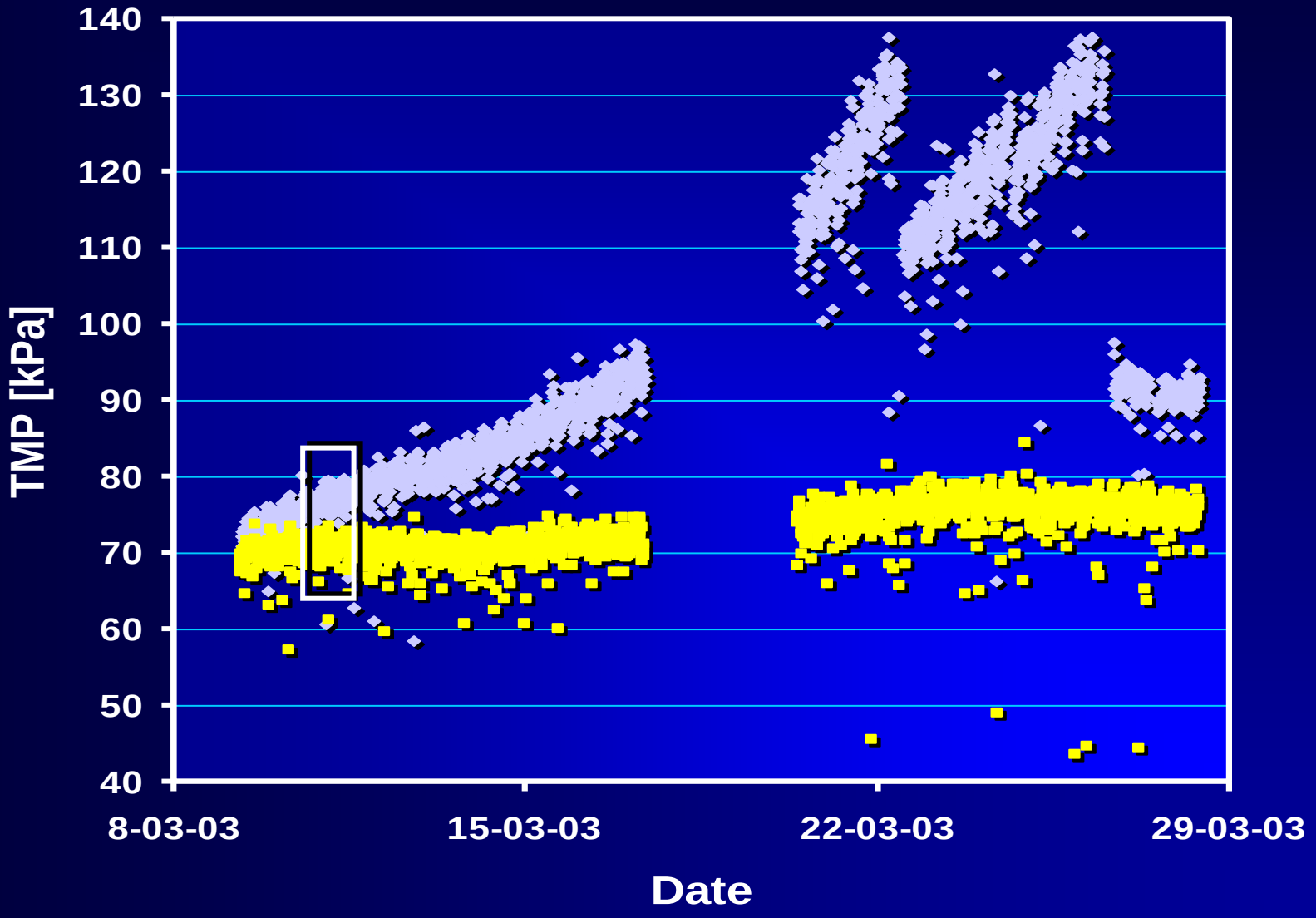
  As function of foul load (l/m^2) and temperature

- 4 different operations (blocks in pairs)
  - Block 1 + 2: reference with winter 2001/2002
  - Block 3 + 4: preventive monthly cleanings with NaOCl
  - Block 5 + 6: lower gross flux 20%, 702 l/m^2 till EBW
  - Block 7 + 8: higher EBW frequency, 702 l/m^2

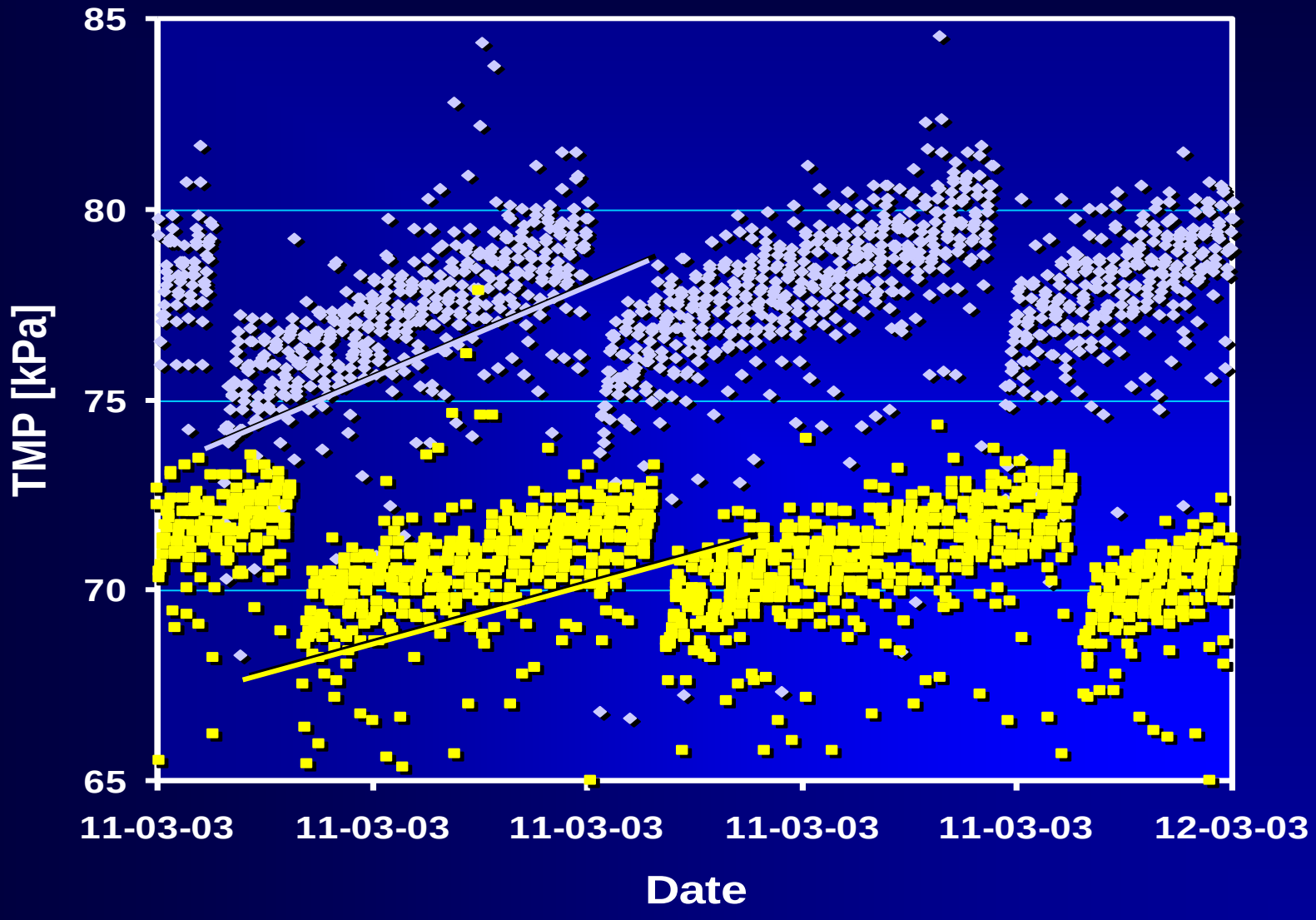
TMP block 2 winter 2001/2002 and 2002/2003



TMP block 1 vs block 2



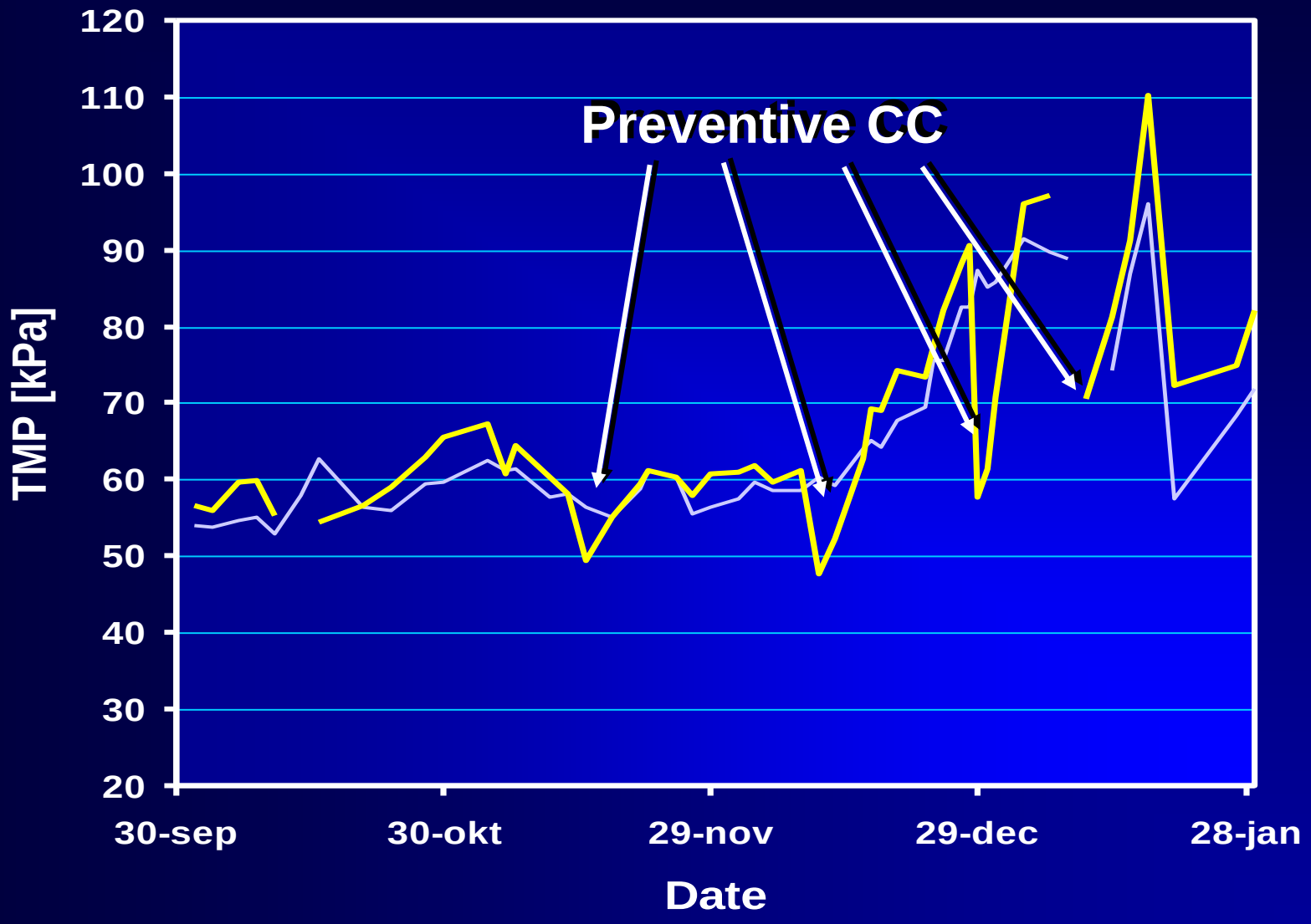
TMP block 1 vs block 2



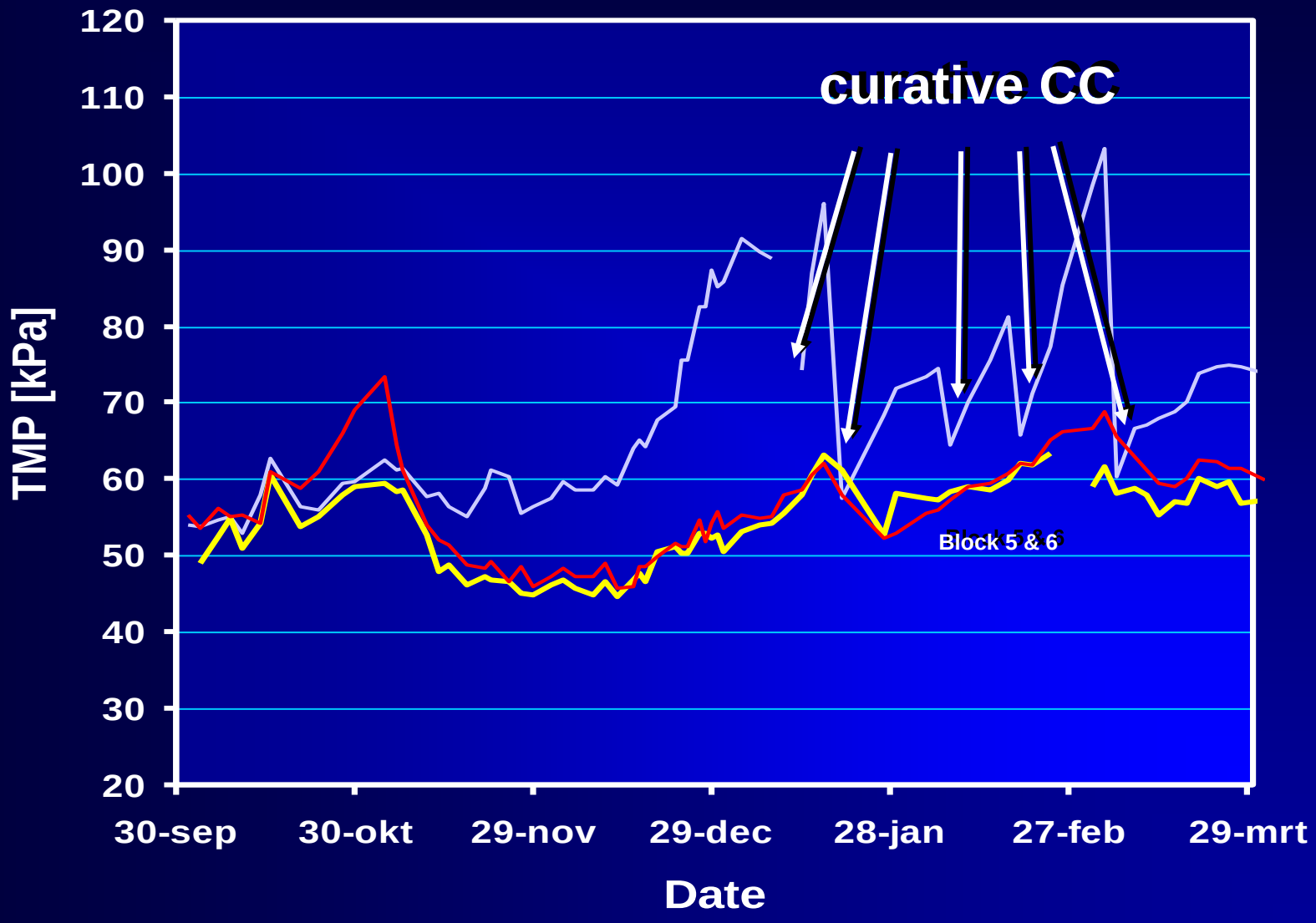
Performance decrease at lower T
Influence operation

- Winter 2002/2003 colder then winter 2001/2002
- Block 1 differs from block 2
- Cause most likely bad backwash efficiency, backwash cycle started with block 1
- Block 2 reference for standard operation in comparison to other blocks

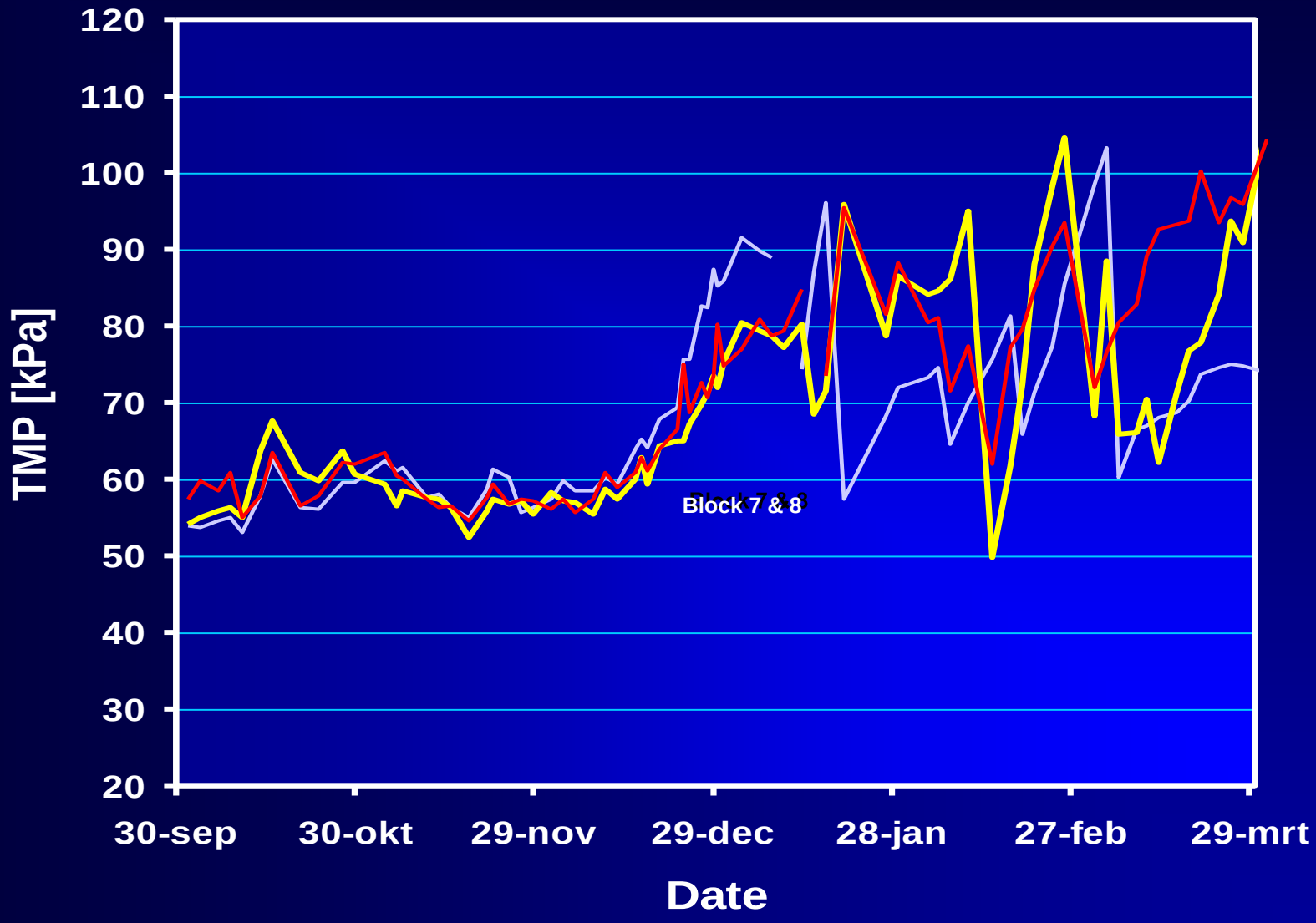
TMP block 2&4 influence preventive CC



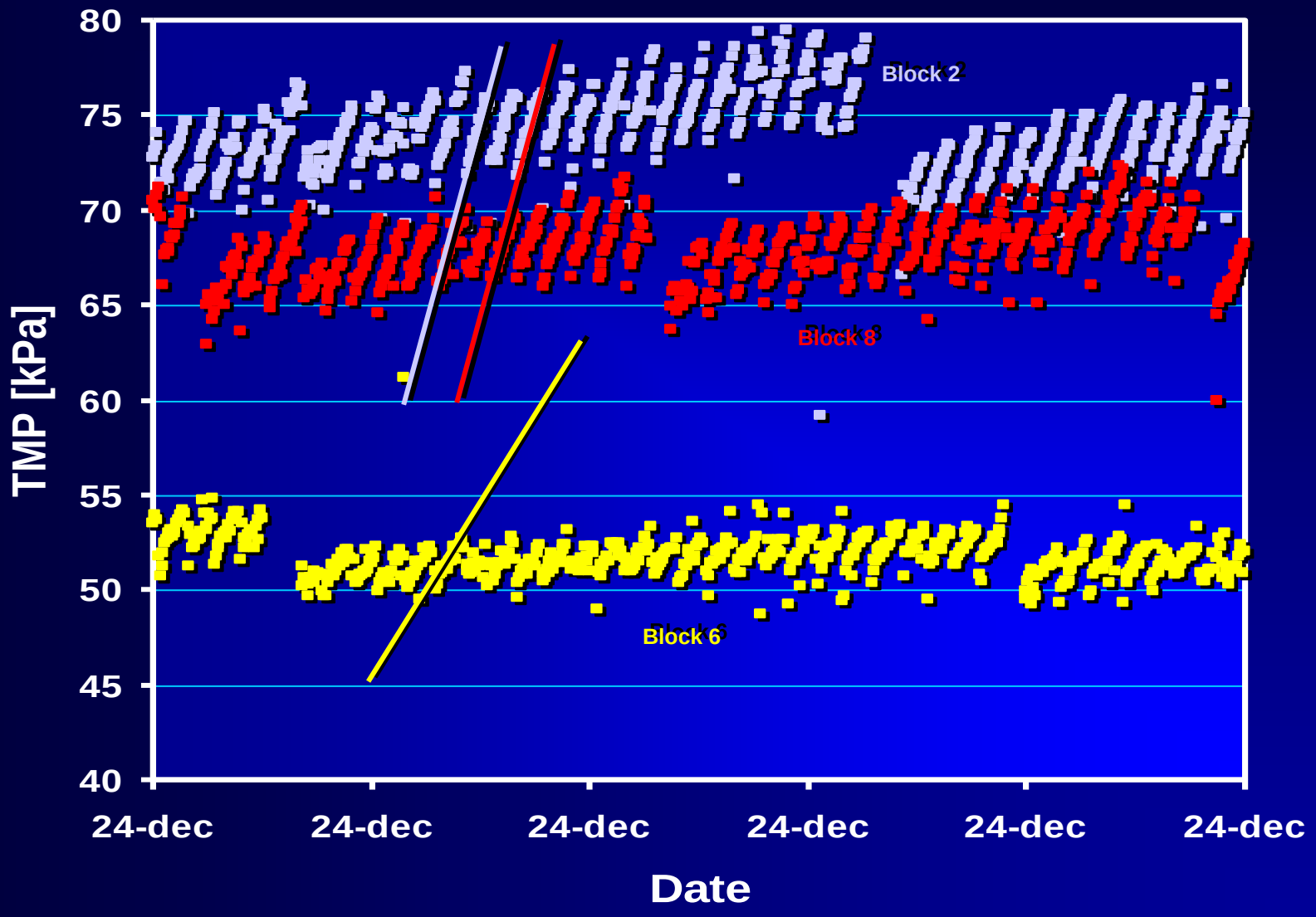
TMP block 2&6 influence gross flux



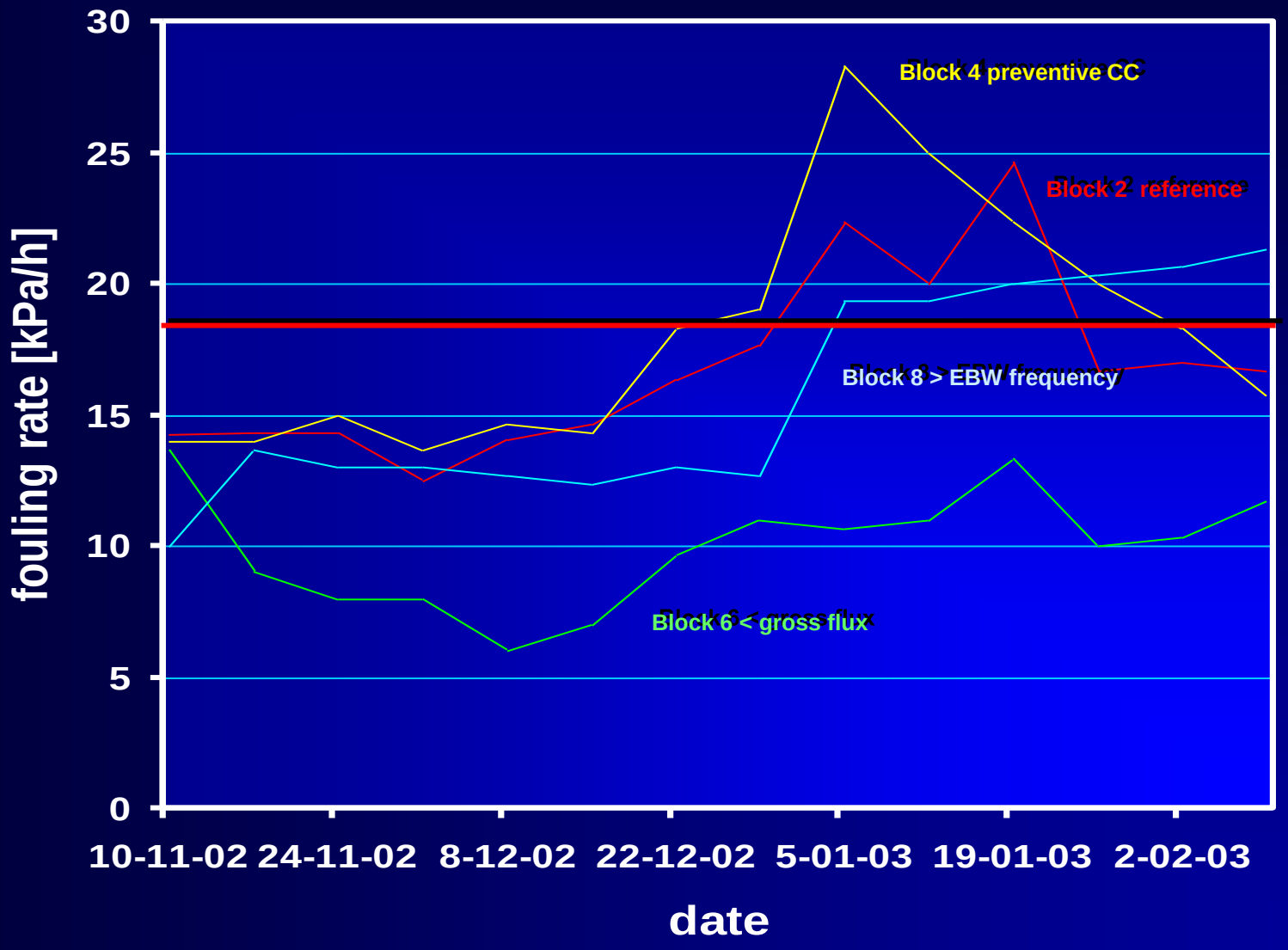
TMP block 2&8 influence EBW frequency



Fouling rate determination



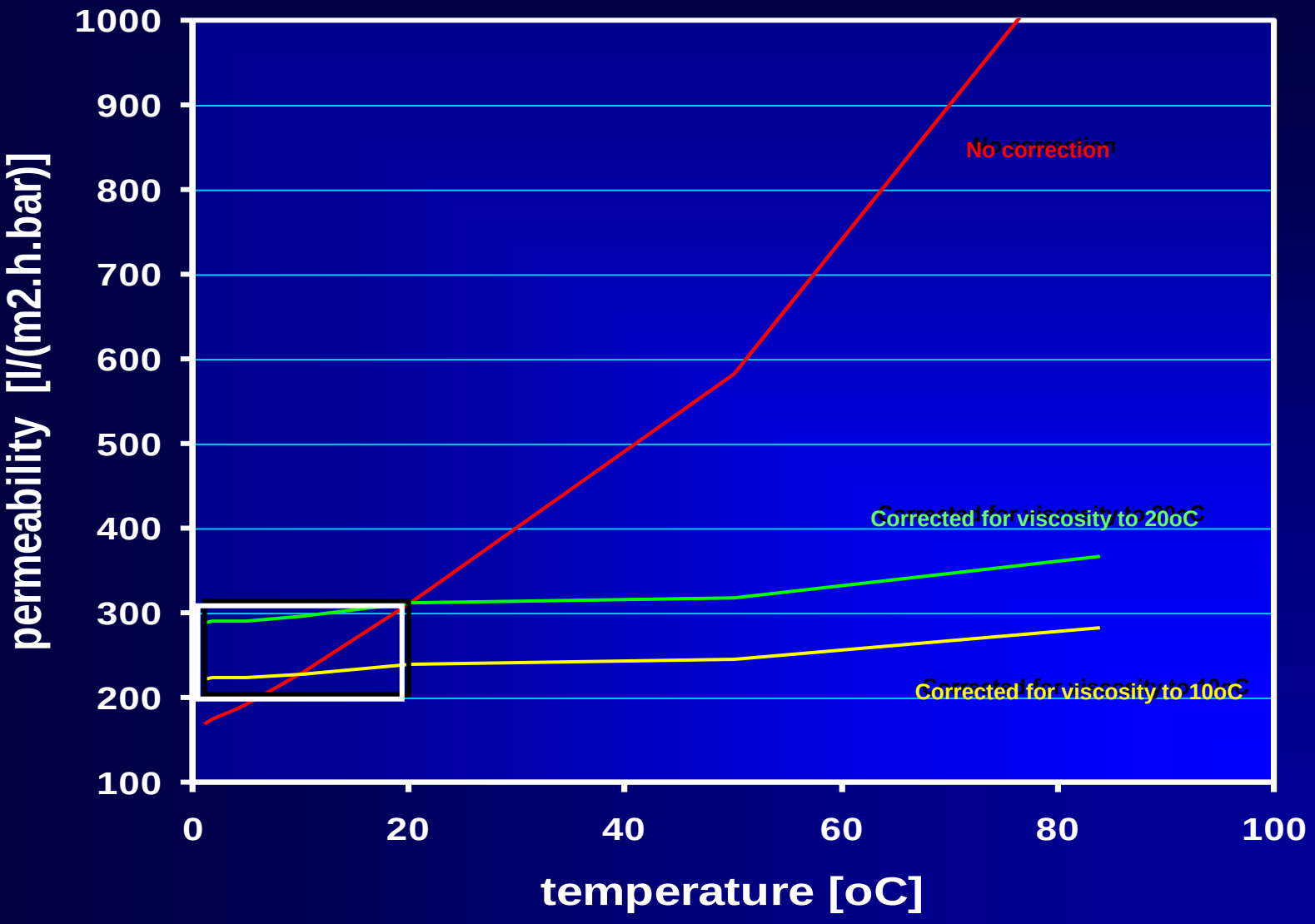
Fouling rate block 2,4,6 & 8



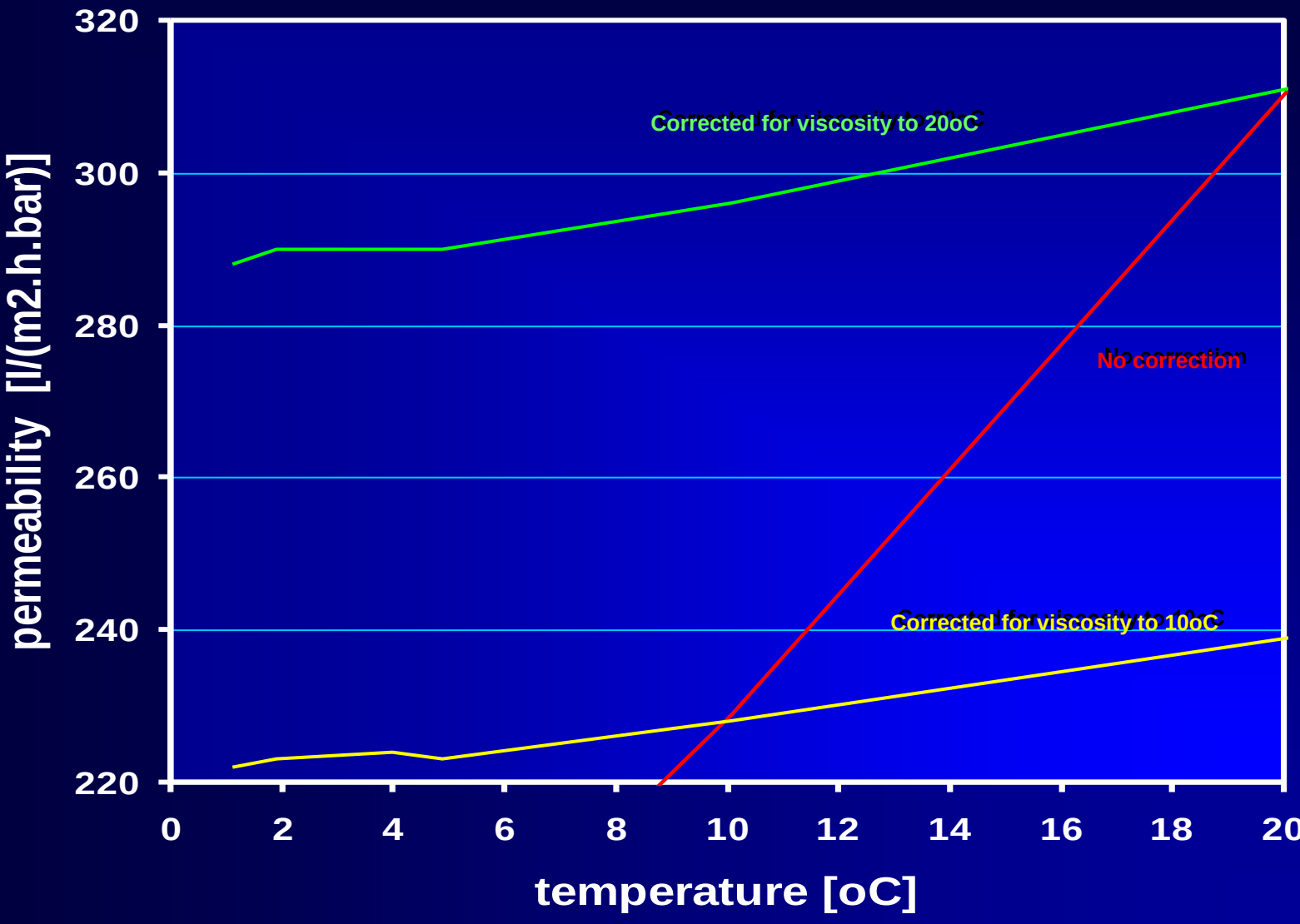
Performance decrease at lower T
Results experiments

- Winter 2002/2003 colder then winter 2001/2002
- Block 1 differs from block 2
- Cause most likely bad backwash efficiency, backwash cycle started with block 1
- Preventive cleaning warm NaOCl, has no effect
- Lowering foul load between backwash, huge effect on stability
- Lowering foul load between EBW, no effect
- Indicates efficiency EBW is not cause of permeability loss
- Fouling rate critical at > 18 kPa/h
- Cause must be temperature effect on permeability (higher fouling rate indicates loss of area, at lower fouling index)

Temperature influence on permeability



Temperature influence on permeability



Performance decrease at lower T
Results experiments

- Effect remarkable but only one measurement and not yet acknowledged by X-flow (more measurements)
- Difference in permeability 20^{o} – 1^{o}C (standard new membrane CWF): 239 – 222 = 17 l/(h.m2) corrected to 10^{o} C for viscosity is 7% loss
- Recalculated this corresponds with an increase in flux from 113 l/h.m^{2} (mid summer) to 121 l/h.m^{2} (mid winter)

Winter problem in a nut shell (anders)

- Average permeability in summer at 20^{o} C 145 l/(h.m^{2}.bar) at 10^{o}C, TMP act 60 kPa
- Calculated TMP act if T decreased to 1,5^{o}C, 101 kPa (alarm high TMP)
- This already indicates that water quality improves at lower T, and the membrane increases its permeability to 200 l/(h.m^{2}) at 10^{o} C
- Calculated TMP act if T decreased to 1,5^{o} C, 78 kPa
- Actual increase, 85 kPa

Conclusies 1

- TMP stijging wordt niet veroorzaakt door een hogere vervuilingspotentie
- Door hoge viscositeit in de winter hoge actuele drukken daardoor ook hogere vervuilingssnelheid
- Proces wordt onstabiel bij vervuilingssnelheden hoger dan 18 kPa/h
- Vervuilingssnelheid wordt direct beinvloed door vervuilingspotentie water en bruto flux

Conclusies 2

- Het doorstroombaar oppervlak wordt lager bij koudere temperaturen
- Bij een lager doorstroombaar oppervlak wordt de schijnbare brutoflux hoger
- Hierdoor hogere vervuilingssnelheden
- Oplossing hierdoor alleen in het verlagen van de brutoflux
- Maximaal haalbare brutoflux in de winter vastgesteld op 90-100 l/(h.m^2), PLENTY?

Maintenance
Preventif

jaar	dienstauto Opel Astra VR-BS-83	psHK	Algemeen	Pv	APK grote beurt
jaar	dienstauto Opel Astra VR-BS-86	psHK	Algemeen	Pv	APK grote beurt
jaar	dienstauto Opel Astra VR-BS-87	psHK	Algemeen	Pv	APK grote beurt
jaar	dienstauto Opel Astra VR-BS-88	psHK	Algemeen	Pv	APK grote beurt
jaar	dienstauto Opel Astra VR-BZ-37	psHK	Algemeen	Pv	APK grote beurt
jaar	dienstauto Opel Astra VR-BZ-38	psHK	Algemeen	Pv	APK grote beurt
jaar	dienstauto Peugeot Partner VT-LZ-80	psHK	Algemeen	Pv	APK grote beurt
jaar	dienstauto Renault Kangoo 29-VL-BJ	psHK	Algemeen	Po	APK grote beurt
jaar	dienstauto Renault Master 22-VD-ZJ	psHK	Algemeen	Po	APK grote beurt
jaar	Hijsmiddelen onderhoud/testen/controleren	pshK	Alle	D	Swart
week	Ogen- en nooddouches testen, doppen teru	psHK	Alle	Pv	
6-m	Luchtbehandelingsinstallatie	psHK	Dienstgebouw	D	GTI klimaatcontract
2-jaar	Onderhoud middenspanningsinstallatie (2	psHK	Dienstgebouw	D	GTI
jaar	Overspanningsbeveiligingen	psHK	Dienstgebouw	D	Digit
2-jaar	Verlichtings onderhoud (2001, 2003, 2005,	psHK	Dienstgebouw	D	ATH
6-m	Luchtbehandelingsinstallatie	psHK	Energiegebouw	D	GTI klimaatcontract
2-jaar	Onderhoud middenspanningsinstallatie	psHK	Energiegebouw	D	GTI
2-jaar	Verlichtings onderhoud (2001,	psHK	Energiegebouw	D	ATH
2-jaar	Verlichtings onderhoud (2001,	psHK	HF transportp.	D	ATH
m	Calibratie EGV metingen psHK	HF-installatie	Pv		
m	Calibratie pH metingen 2x HF tr	psHK	HF-installatie	Pv	
3xpw	Controle van doseringen chem	psHK	HF-installatie	Pv	
jaar	Inspectie op aantasting beton	psHK	HF-reservoir	Pv	
6-m	Lenspompen en water op vloer testen	psHK	Innamegebouw	Pv	
jaar	Overspanningsbeveiligingen	psHK	Innamegebouw	D	Digit
dag	Controle ronde langs installaties	psHK	Installaties	Pv	
2-jaar	Verlichtings onderhoud (2001, 2003, 2005,	psHK	Kantoren	D	ATH
4-wek	Accu controlle noodstroom	psHK	Noodstroom	Pv	
jaar	Diesels/generatoren	psHK	Noodstroom	D	GTI
week	Draaien en controlle noodstroom NSA 1 t	psHK	Noodstroom	W	
2-jaar	Verlichtings onderhoud (2001, 2003, 2005,	psHK	Ontvangstgeb.	D	ATH

Maintenance
Preventif

jaar	Overspanningsbeveiligingen	psHK	Telecomruimte	D	Digit
2-jaar	Verlichtings onderhoud met hoogwerker (2000,	psHK	Terrein	D	ATH
2-jaar	Onderhoud middenspanningsinstallatie (2001,.)	psHK	Transformatoren	D	GTI
maand	1e dag van de maand tellerstanden en/of gegeve	psHK	Transportpompen	Pv	
jaar	Frequentieomvormers onderhoud	psHK	Transportpompen	D	2x EP
week	HF pompen 1/2 omschakelen	psHK	Transportpompen	W	
6-m	Lenspompen en water op vloer testen	psHK	Transportpompen	Pv	
jaar	Overspanningsbeveiligingen	psHK	Transportpompen	D	Digit
6-m	Kaeser compressoren onderhoud	psHK	UF	D	Gietart
week	Anti scalant uitliteren	psHK	UF/HF	Pv	
week	Chemicalien bestellen	psHK	UF/HF	W	
2-wek	Controle buffervaatjes chemicaliendoseerpomp	pshK	UF/HF	Pv	
jaar	Frequentieomvormers onderhoud	psHK	UF/HF	D	16x EP
week	HCL pompen 1/2 omschakelen	psHK	UF/HF	W	
6-m	Lenspompen en water op vloer testen	psHK	UF/HF	Pv	
6-m	Luchtbehandelingsinstallatie	psHK	UF/HF	D	GTI klimaatcontract
week	Maand/Woensd/Vrijd. TMP UF-blokken	psHK	UF/HF	Pv	
week	Maandag EGV-metingen HF-blokken	psHK	UF/HF	Pv	
week	NaOCL pompen 1/2 omschakelen op maandag	psHK	UF/HF	W	
week	NaOH pompen 1/2 omschakelen op maandag	psHK	UF/HF	W	
2-jaar	Onderhoud middenspanningsinstallatie (2001,	psHK	UF/HF	D	GTI
jaar	Overspanningsbeveiligingen	psHK	UF/HF	D	Digit
2-jaar	Verlichtings onderhoud (2001, 2003, 2005, etc)	psHK	UF/HF	D	ATH
week	Controle restchloormetingen en opvullen vat	psHK	UF-installatie	Pv	
week	Deeltjes meten blokken (Dinsdag)	psHK	UF-installatie	Pv	
week	Inspectie koolfilters	psHK	UF-installatie	Pv	volgens lijst
2-wek	Spoelen koolfilters	psHK	UF-installatie	Pv	
week	UF blok 1 t/m 8 handmeting gedoseerde spoelin	psHK	UF-installatie	Pv	
4-wek	UF blok 3 reiniging warmchloor	psHK	UF-installatie	Pv	
4-wek	UF blok 4 reiniging warmchloor	psHK	UF-installatie	Pv	
6-m	UF blok1 doseerlans + membranen afsluiter ver	psHK	UF-installatie	Pv	
6-m	UF blok1 terugslagklep veer vervangen	psHK	UF-installatie	Pv	

Maintenance
Preventif

6-ma	UF blok2 doseerlans + membranen afsluiter vervangen		psHK	UF-installatie	Pv	
6-m	UF blok2 terugslagklep veer vervangen		psHK	UF-installatie	Pv	
6-m	UF blok3 doseerlans + membranen afsluiter vervangen		psHK	UF-installatie	Pv	
6-m	UF blok3 terugslagklep veer vervangen		psHK	UF-installatie	Pv	
6-m	UF blok4 doseerlans + membranen afsluiter vervangen		psHK	UF-installatie	Pv	
6-m	UF blok4 terugslagklep veer vervangen		psHK	UF-installatie	Pv	
6-m	UF blok5 doseerlans + membranen afsluiter vervangen		psHK	UF-installatie	Pv	
6-m	UF blok5 terugslagklep veer vervangen		psHK	UF-installatie	Pv	
6-m	UF blok6 doseerlans + membranen afsluiter vervangen		psHK	UF-installatie	Pv	
6-m	UF blok6 terugslagklep veer vervangen		psHK	UF-installatie	Pv	
6-m	UF blok7 doseerlans + membranen afsluiter vervangen		psHK	UF-installatie	Pv	
6-m	UF blok7 terugslagklep veer vervangen		psHK	UF-installatie	Pv	
6-m	UF blok8 doseerlans + membranen afsluiter vervangen		psHK	UF-installatie	Pv	
6-m	UF blok8 terugslagklep veer vervangen		psHK	UF-installatie	Pv	
jaar	Controle op voortgang proces van aantasting		psHK	UF-reservoir	Pv	
2-jaar	Verlichtings onderhoud (2001, 2003, 2005, etc)		psHK	Werkplaatsen	D	ATH
maand	1e dag van de maand tellerstanden en/of gegevens opnemen		psHK	WRK verdeelst.	Pv	
jaar	Frequentieomvormers onderhoud		psHK	WRK verdeelst.	D	1x EP
6-m	Lenspompen en water op vloer testen		psHK	WRK verdeelst.	Pv	
2-jaar	Verlichtings onderhoud (2001, 2003, 2005, etc)		psHK	WRK verdeelst.	D	ATH
jaar	Bliksembeveiliging testen/doormeten		psHK		D	Droog installatie b.v
6-m	HCL gasdetektie onderhoud		psHK		D	Buveco
jaar	NEN 3140 gereedschapskeuringen		psHK		D	Digit
5-jaar	NEN 3140 keuringen installaties (1999, 2004, 2009, etc.)		psHK		D	Digit
jaar	Objectbewaking		psHK		D	Varel
jaar	Onderhoud aan gevelkraan		psHK		D	Kranenburg
jaar	Onderhoud Brandmeldcentrale.		psHK		D	Fabricom
jaar	Onderhoud drukregelaars		psHK		D	Drager
6-m	onderhoud LUTO armaturen		psHK		D	
jaar	Overhalen van de doseerpompen		psHK		D	Kalteren
jaar	testen stopknoppen , klaxons en lampen		psHK		Pv	
jaar	Troebelheidsmeters onderhoud		pshK		D	
jaar	Veiliggestelde spanning 220V	no-break K18	psHK		D	Saft Nife b.v
3-m	Veiliggestelde spanning 220V	no-break K18 Snelladen	psHK		Pv	

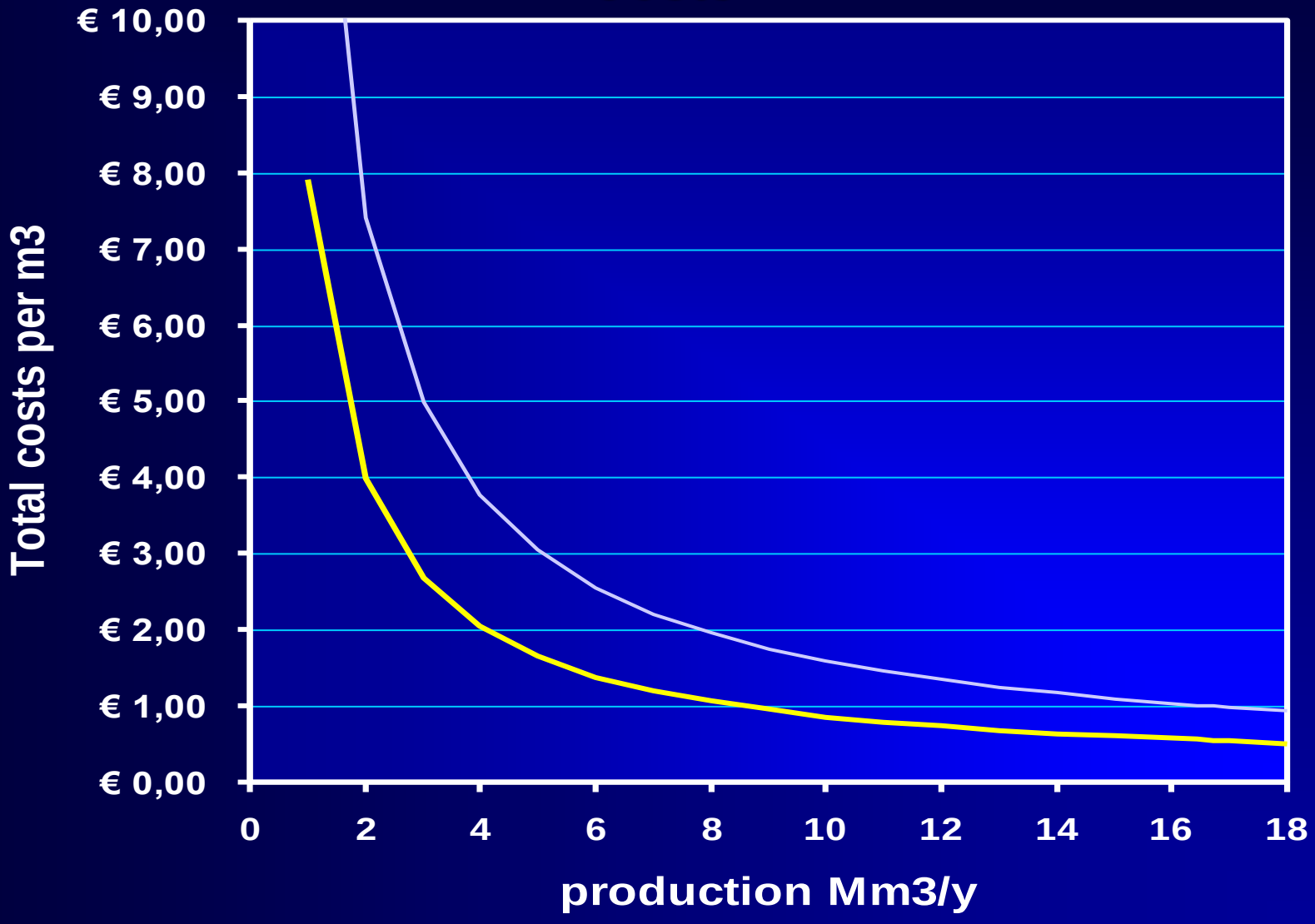
Maintenance

Curative

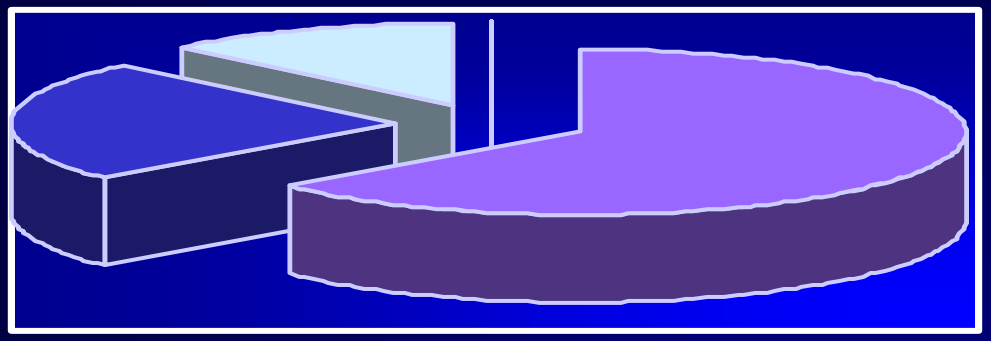
- Repair compromised fibers:
  - 1 block every 3 months (2 people of Xflow, 2 of 3th)
  - Replace O-ring once a year (check free space)
- Dosing equipment (pump, valves, and injection)

Operation & Maintenance

Costs



Operation & Maintenance
Costs



Operation & Maintenance
Costs

wtp Heemskerk

three years experience beyond expectations