

# Commissioning of Ørsted 40 MW biomass-fired plants

SIAPWS Annual Meeting  
2018



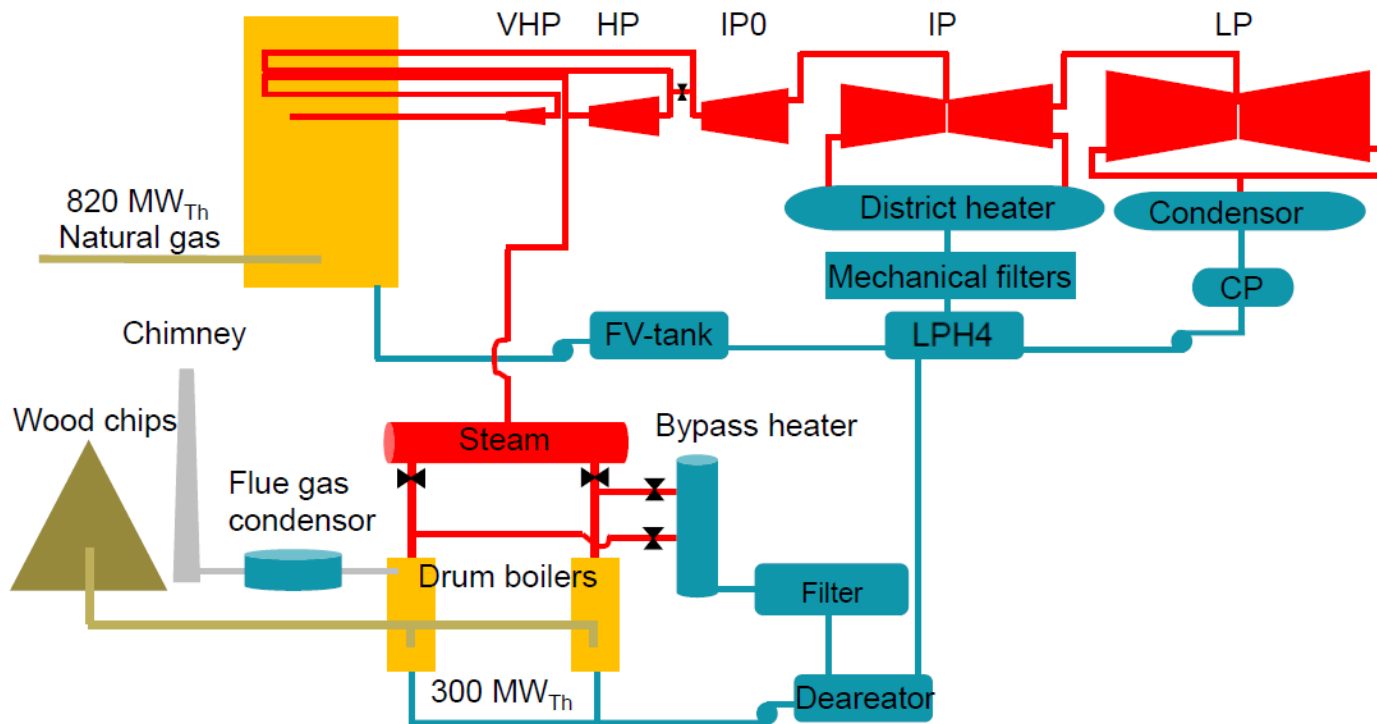
Ørsted

Monika Nielsen  
14. March 2018

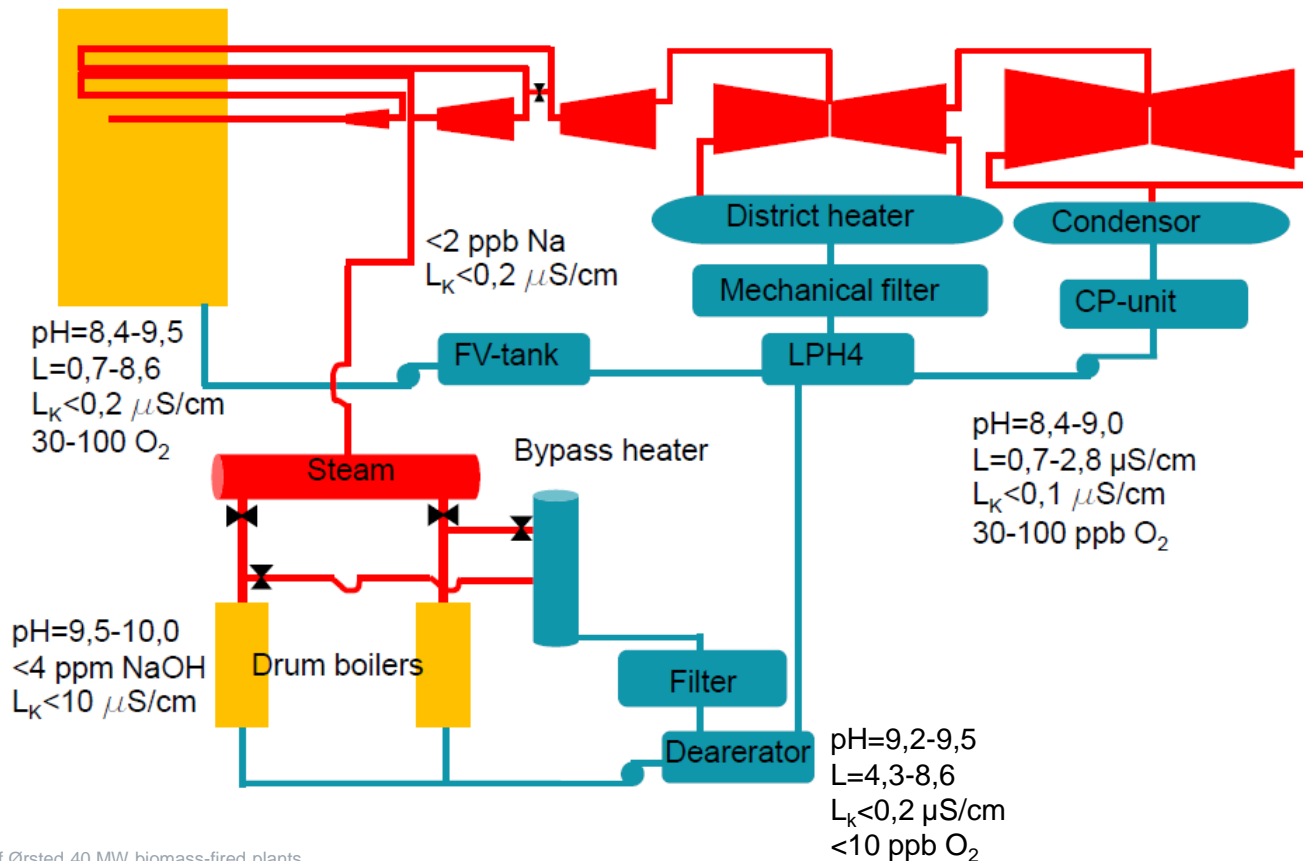
# Agenda

- Introduction to SKV40/SKV3 power plants
- SKV40 and SKV3 water chemistry
- $\text{PO}_4^{3-}$  contamination after first fire
- Rinse and acid clean of bypass heat exchanger
- $\text{SiO}_2$  contamination, and bypass of condensate filter
- Achieved water/steam quality at SKV40
- SKV40 and SKV3 joint operation
- TOC contamination

## Introduction to SKV40/SKV3 power plants

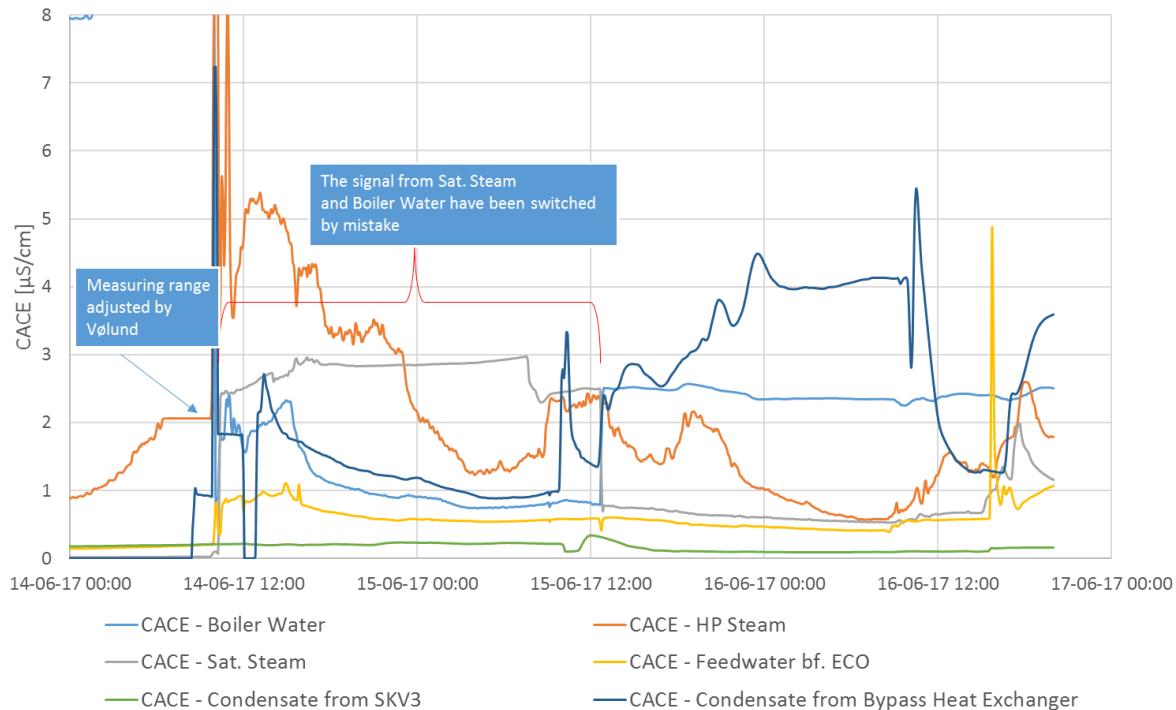


## SKV40 and SKV3 water chemistry



## PO<sub>4</sub><sup>3-</sup> contamination after first fire

SKV402 - CACE



### Comments:

- All condensate from bypass heat exchanger is sent to the drain
- Makeup water is supplied from SKV3

## PO<sub>4</sub><sup>3-</sup> contamination after first fire

Parameter	Unit	Feed Water bf. ECO	Boiler Water	Sat. Steam	HP Steam	Condensate from Bypass Heat Exchanger
Sodium (Na <sup>+</sup> )	µg/l	<2	8,9	<2	<2	90
Potassium (K <sup>+</sup> )	µg/l	<2	<2	<2	<2	<2
Calcium (Ca <sup>2+</sup> )	µg/l	<5	46	<5	<5	15
Magnesium (Mg <sup>2+</sup> )	µg/l	<5	<5	5	<5	<5
Flourid (F <sup>-</sup> )	µg/l	1,4	2,3	1,4	1,1	1,8
Chlorid (Cl <sup>-</sup> )	µg/l	1,3	1,2	1,3	1,1	<1
Sulfate (SO <sub>4</sub> <sup>2-</sup> )	µg/l	<5	190	<5	<5	<5
Nitrate (NO <sub>3</sub> <sup>-</sup> )	µg/l	<5	<5	<5	<5	<5
Phosphate (PO <sub>4</sub> <sup>3-</sup> )	µg/l	6	24	180	5	310
Acetate	µg/l	2	24	18	30	22
Formate	µg/l	30	26	270	1600	100
Iron (Fe)	µg/l	25	110	-	43	620
Silica (SiO <sub>2</sub> )	µg/l	51	730	-	22	120
Specifik Conductivity	µS/cm	6,39	3,73	6,28	6,51	6,98
CACE	µS/cm	0,97	2,68	2,02	5,14	2,71

### Comments:

- High Formate values in the system – Organics!!
- High PO<sub>4</sub><sup>3-</sup> values in the condensate - Zn<sub>3</sub>(PO<sub>4</sub><sup>3-</sup>)<sub>2</sub>–soap from manufacturing of the heat exchanger?
- Zn was measured in the samples – No Zn present!!
- Could it be Na<sub>3</sub>PO<sub>4</sub> instead?
- Intensive rinse of the heat exchanger!

## Rinse and acid clean of bypass heat exchanger

### Rinse of heat exchanger with water

Element	<b>PO<sub>4</sub><sup>3-</sup></b>	<b>Na<sup>+</sup></b>
Unit	[µg/l]	[µg/l]
1. Rinse A (10/7 kl. 13:20)	28	53
1. Rinse B (10/7 kl. 13:55)	110*	67
2. Rinse A (10/7 kl. 15:10)	100*	37
2. Rinse B (10/7 kl. 15:30)	150*	28
3. Rinse A (11/7 kl. 07:20)	54	103
3. Rinse B (11/7 kl. 07:40)	640*	45
4. Rinse A (11/7 kl. 09:35)	200*	23
4. Rinse B (11/7 kl. 09:47)	250*	23
5. Rinse A (11/7 kl. 11:35)	150*	18
5. Rinse B (11/7 kl. 11:45)	200*	13
6. Rinse A (11/7 kl. 13:15)	100*	21
6. Rinse B (11/7 kl. 13:30)	140*	12

Still a lot of Phosphate in the rinse water after the last rinse!!!

### Acid clean of heat exchanger with 2 % Citric Acid

Parameter			<b>Na</b>	<b>P</b>	<b>Zn</b>
Unit	Date	Time	mg/l	mg/l	mg/l
Acid solution	23-08-2018	14:00	2,0	7,2	4,9
Acid solution	23-08-2018	14:15	2,5	9,1	5,8
Acid solution	23-08-2018	14:45	2,5	9,6	6,0
Acid solution	23-08-2018	15:15	2,5	9,9	6,0
Acid solution	23-08-2018	15:45	3,2	14	5,9
Acid solution	23-08-2018	16:15	3,4	14	5,7
Acid solution	23-08-2018	16:50	3,6	14	4,2
Rinse water	23-08-2018	19:10	0,50	1,6	0,55
Rinse water	24-08-2018	13:35	0,53	1,6	0,55

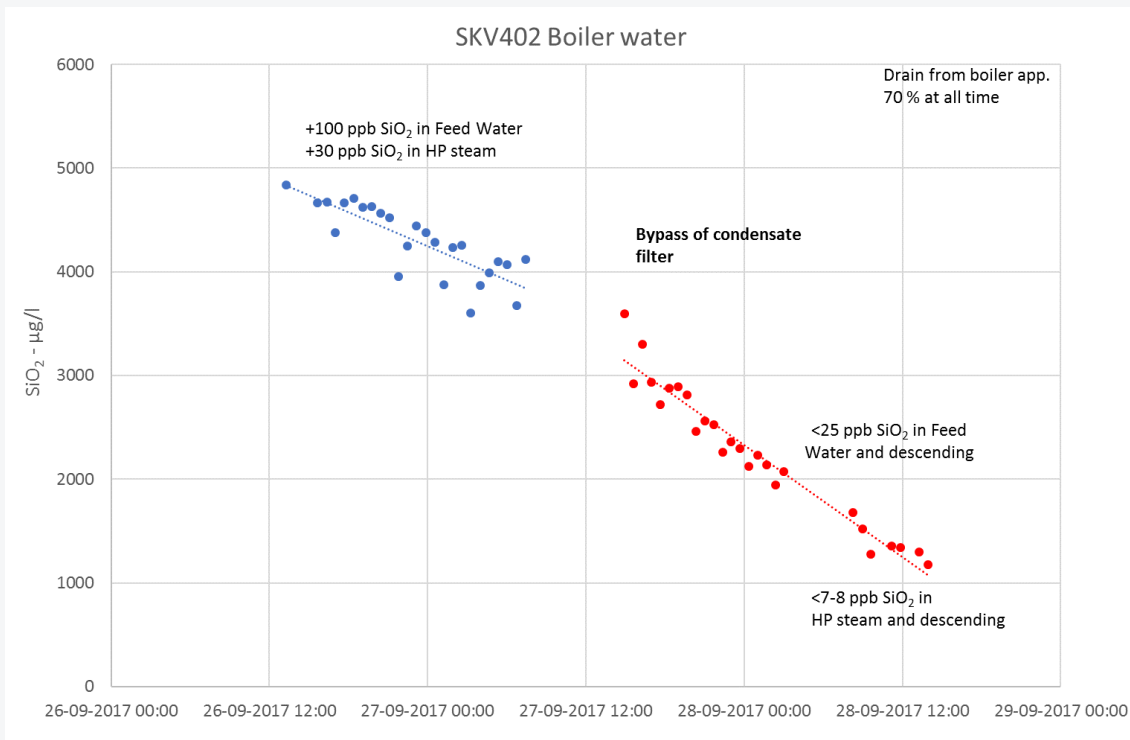
A lot of Phosphate and Zink was removed by the acid clean.

Afterwards, no phosphate was detected in the water steam circuit.

# SiO<sub>2</sub> contamination

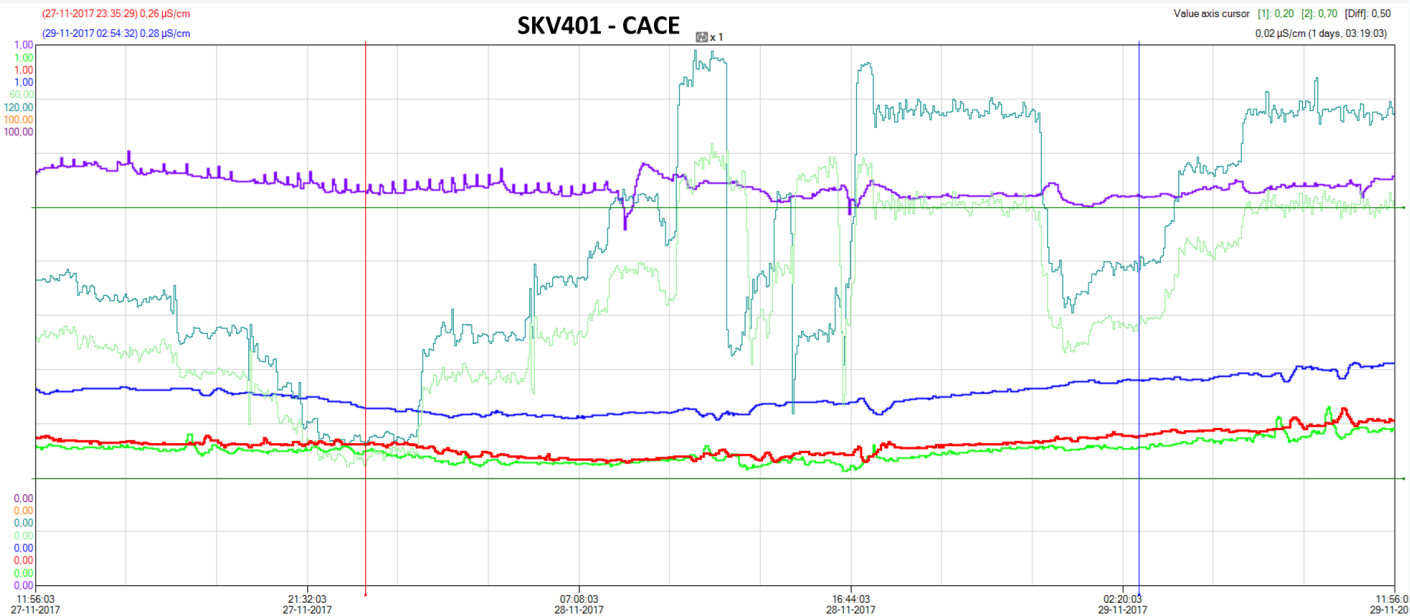
SiO <sub>2</sub>	Feed Water	Boiler Water	HP Steam
07-09-2017	120 µg/l	4000 µg/l	40 µg/l
14-09-2017	150 µg/l	5300 µg/l	35 µg/l
19-09-2017	160 µg/l	4900 µg/l	35 µg/l

- Several SiO<sub>2</sub> sources investigated
- Condensate filter is made of Fiber Glass!!
- Bypass of condensate filter showed a clear effect on the SiO<sub>2</sub>-levels.





# Achieved water/steam quality at SKV40



CENTRAL INSDI SKV401-QUA22C0002X001 ICycle - 00:00:03:14:0511

Tag Name	Description	Number	Server	Color	Units	Minimum	Maximum	IO Address	Time Offset	Source Tag	Source Server	Value atX1	Value atX2
SKV401-QUA12C0002X001	SUR LEDNINGSEVNE KEDELVAND OB	30	CENTRA	µS/cm	0.00	1.00	1.00	\\skv40opc\FSGatewa...	0:00:00:000			0.73	0.72
SKV40-QUA42C0002X001	SUR LEDNINGSEVNE FOEDVAND	2	CENTRA	µS/cm	0.00	1.00	1.00	\\skv40opc\FSGatewa...	0:00:00:000			0.25	0.26
SKV401-QUA22C0002X001	SUR LEDNINGSEVNE HOVEDDAMP	29	CENTRA	µS/cm	0.00	1.00	1.00	\\skv40opc\FSGatewa...	0:00:00:000			0.26	0.28
SKV40-QUA52C0002X001	SUR LEDNINGSEVNE KONDENSAT	10	CENTRA	µS/cm	0.00	1.00	1.00	\\skv40opc\FSGatewa...	0:00:00:000			0.33	0.38
SKV401-LBA10CF001X001	KEDELAGG DAMP FLOW	35	CENTRA	kg/s	0.00	60.00	60.00	\\skv40opc\FSGatewa...	0:00:00:000			13.23	29.11
SKV40-ND020F050X002	DAMPFLOW TIL BYPP F.VV	15	CENTRA	kg/s	0.00	120.00	120.00	\\skv40opc\FSGatewa...	0:00:00:000			31.13	70.22
SKV40-LBA40CF001X001	FLOW DAMP TIL TURBINE	39	CENTRA	kg/s	0.00	100.00	100.00	\\skv40opc\FSGatewa...	0:00:00:000			0.00	0.00
SKV40-LCA10CF001X001	KOND FRA SKV3 FLOW	18	CENTRA	kg/s	0.00	100.00	100.00	\\skv40opc\FSGatewa...	0:00:00:000			-4.13	-4.15

Comments:

-  $CACE_{FW, Steam} \approx 0,3 \mu S/cm$

-  $DCACE_{Steam} \approx 0,1 \mu S/cm$

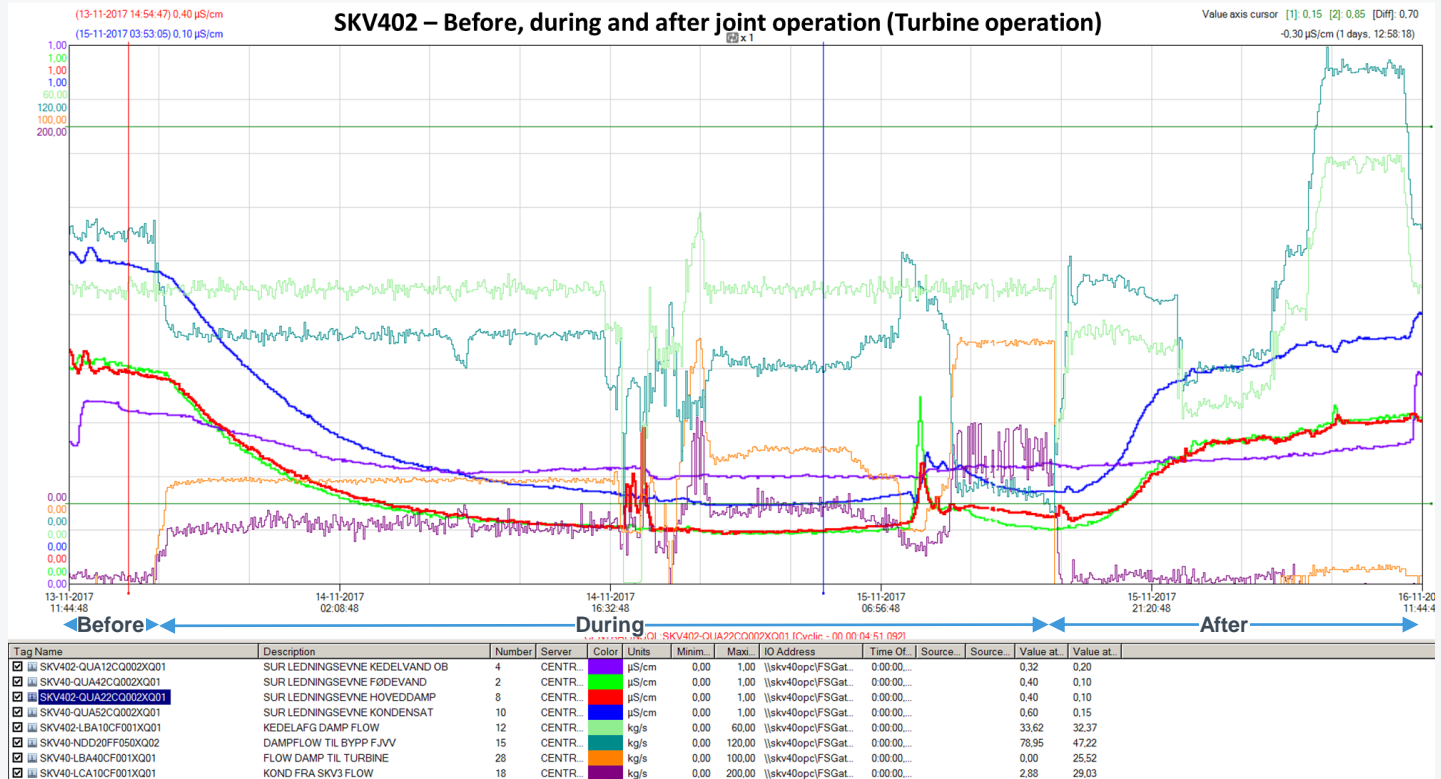
-  $CACE_{Boiler} < 1 \mu S/cm$

## Water sample analysis during stable water/steam chemistry

Parameter	F <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	Acetate	Formate	NO <sub>3</sub> <sup>-</sup>	PO <sub>4</sub> <sup>3-</sup>	Na <sup>+</sup>	Mg <sup>2+</sup>	Ca <sup>2+</sup>	NVOC
Sample Point, 13/11-2017	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
<b>SKV40, Makeup Water</b>	<1	<1	<1	3	<3	<1	<1	<1	<1	<1	83
<b>SKV40, Condensate</b>	<1	<1	<1	8	<3	<1	<1	<1	<1	<1	59
<b>SKV40, Feed Water</b>	<1	<1	<1	8	<3	<1	<1	<1	<1	<1	53
<b>SKV401, Boiler Water</b>	2	<1	7	15	<3	<1	12	26	<1	<1	46
<b>SKV401, Sat. Steam</b>	<1	<1	<1	10	<3	<1	<1	<1	<1	<1	72
<b>SKV401, HP Steam</b>	<1	<1	1	16	5	<1	<1	<1	<1	<1	94
<b>SKV402, Boiler Water</b>	2	<1	4	8	<3	<1	2	24	2	<1	48
<b>SKV402, Sat. Steam</b>	<1	<1	<1	11	4	<1	1	<1	<1	<1	59
<b>SKV402, HP Steam</b>	<1	<1	<1	17	4	<1	6	<1	<1	<1	49
<b>SKV3 Makeup Water</b>	<1	<1	<1	<3	1	<1	1	<1	<1	<1	50

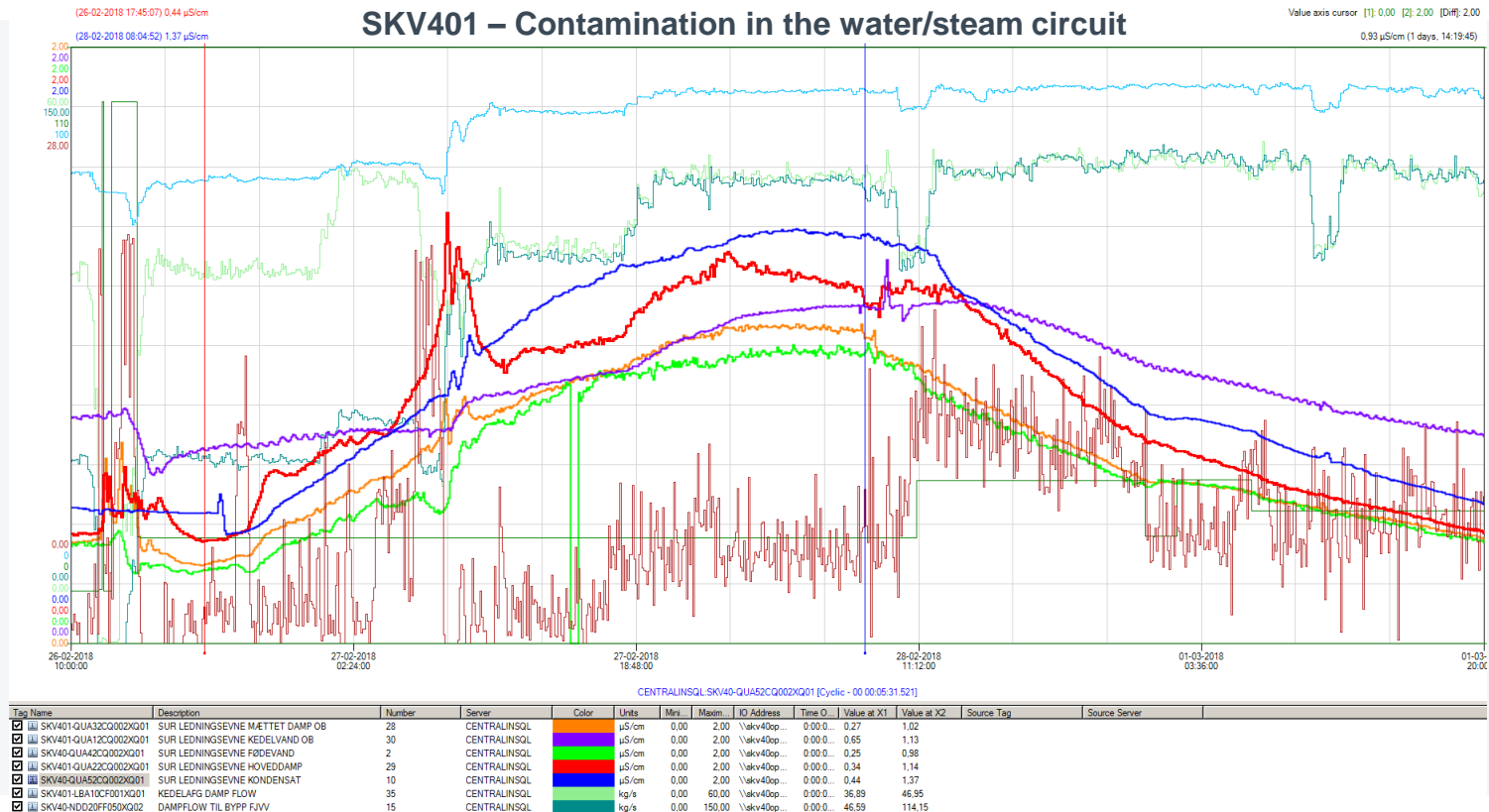
- The main contaminants present under stable water/steam chemistry is organics and organic acids!!!
- Source of contamination assumed to be the makeup water

# SKV40 and SKV3 joint operation



# TOC contamination

## SKV401 – Contamination in the water/steam circuit



## TOC contamination

Parameter	F <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	Acetate	Formate	NO <sub>3</sub> <sup>-</sup>	PO <sub>4</sub> <sup>3-</sup>	Na <sup>+</sup>	Ca <sup>2+</sup>	NVOC
Sample Point, 28/2-2018	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
<b>SKV40, Makeup Water</b>	<1	<1	<1	<3	8	7	<1	<1	<1	1130
<b>SKV40, Condensate</b>	<1	<1	<1	68	7	<1	<1	<1	<1	372
<b>SKV40, Feed Water</b>	<1	<1	<1	63	6	<1	<1	<1	<1	371
<b>SKV401, Boiler Water</b>	<1	5	16	77	<3	<1	28	<1	<1	216
<b>SKV401, Sat. Steam</b>	<1	<1	<1	62	21	<1	1	<1	<1	367
<b>SKV401, HP Steam</b>	<1	<1	<1	70	8	<1	<1	<1	<1	325
<b>SKV402, Boiler Water</b>	<1	3	17	76	3	<1	32	<1	<1	217
<b>SKV402, Sat. Steam</b>	<1	<1	<1	63	7	<1	2	<1	<1	368
<b>SKV402, HP Steam</b>	<1	<1	<1	71	10	<1	<1	<1	<1	327

- Extremely high value of TOC in the Makeup Water
- High values of Acetate in the water steam circuit, and also high TOC values
- Future investigation - Performance of the demin water plant – Does it retain organics???

# Questions??

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