E_{OP} Stage control

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E_{OP} stage pH control: why do it?

- Significant savings in NaOH if end pH can be lowered without affecting brightness
  - Target reduction from 10.8 to 10.3 results in ~2.0-2.5kg/ton NaOH saving
  - At ~0.50$/kg NaOH, this represents ~330,000-410,000$/yr for a 1000 bdmt/d.

E_{OP} stage pH control: other incentives?

- Temperature affects how pH of E_{OP} filtrate behave
  - This is not temperature correction for the pH probe electronics
  - This is temperature compensation of solution

- Safety issue
  - Insertion/retraction of pH probe
  - Hot process media
  - High pH

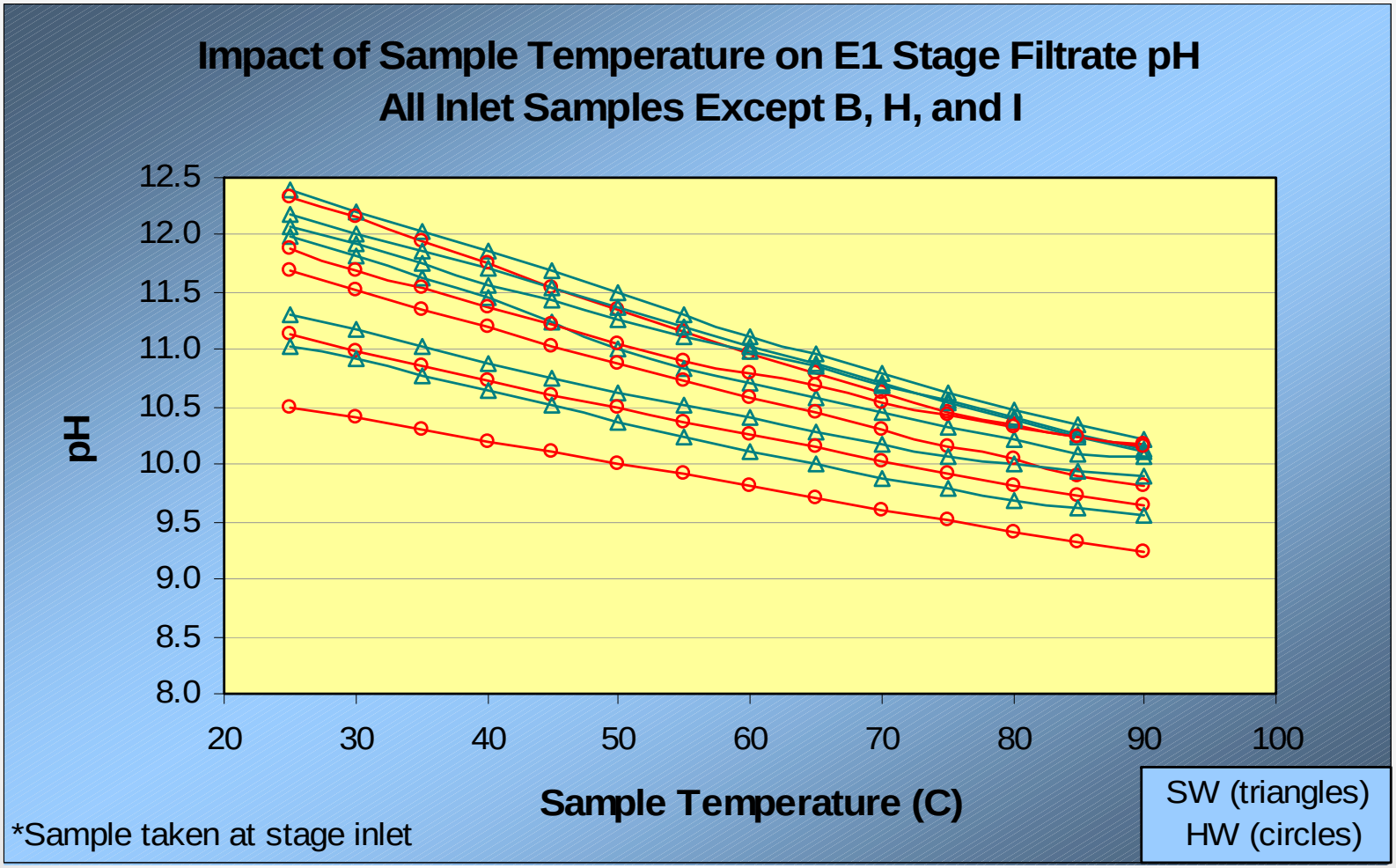
E_{OP} stage pH control: other incentives?

- Simplify and speed up preventive maintenance
  - Typically a long process for calibration
  - Insertion pH probe tends to have short life span (due to high temp, high pH, scaling)
  - Become insensitive with time (due to high temp, high pH, scaling)
  - Calibration accuracy
    - Measure in medium consistency pulp, calibrate in liquid

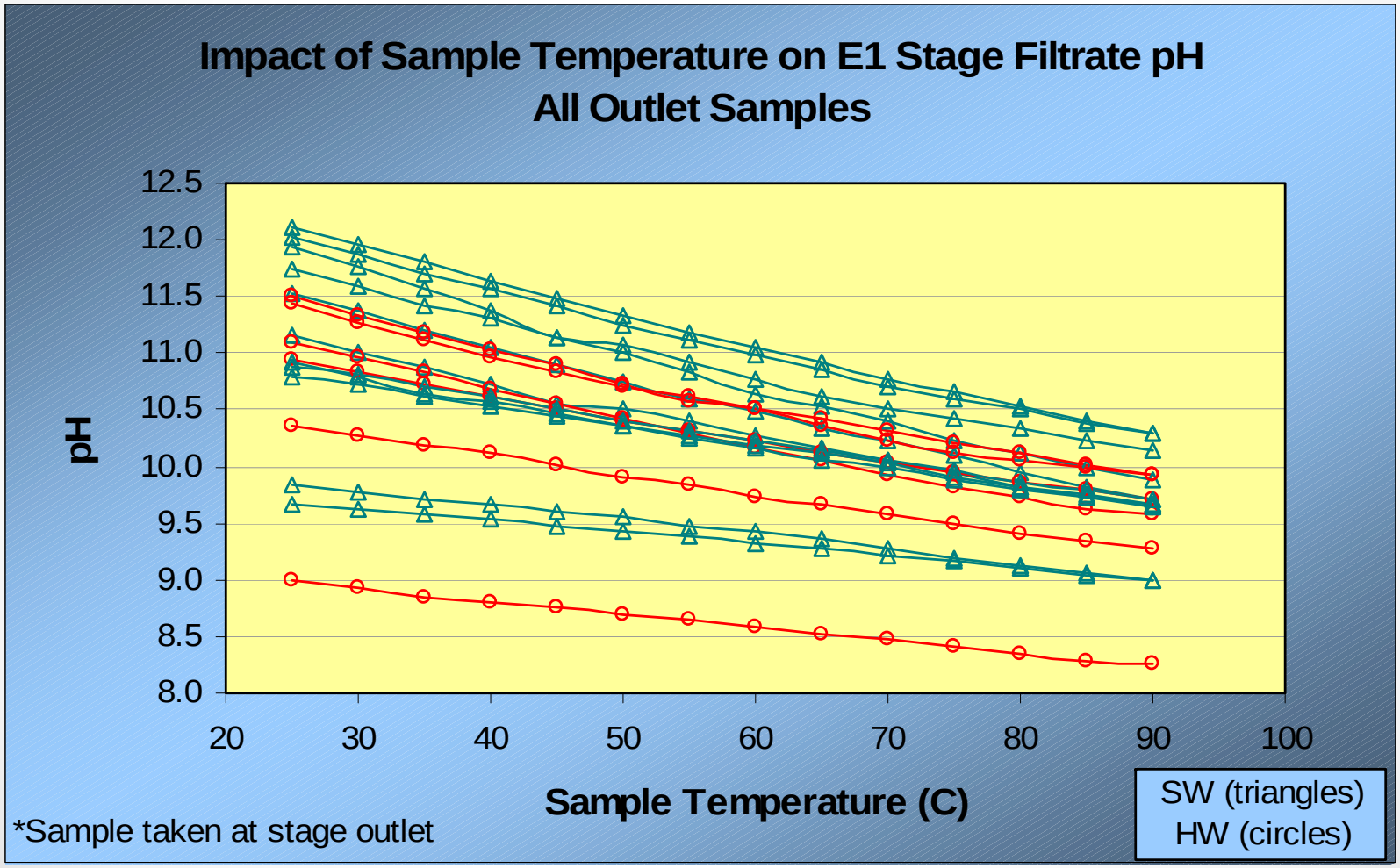
E_{OP} stage pH control: correction at 25°C

- Standardization at 25°C:
  - Report pH meter at 25°C at operator level
  - Report lab test at 25°C to the operator
    - Recommended to enter test results for pH & temperature in DCS for computation using same DCS compensation
  - Recommended 25°C because this is how pH are reported in technical papers by research facilities such as FPInnovations
  - Allow comparisons from mill to mill
    - *However, any fixed temperature standardization would work…*
- Works for O_2 stages & E_{OP} stages of hardwood and softwood

E_{OP} stage pH control: correction at 25ºC



E_{OP} stage pH control: correction at 25ºC



E_{OP} stage pH control:

correction at 25°C

Correction Table for E1 Stage Inlet pH

Sample Temperature (C)										pH Corrected to 25 C
90	80	70	60	55	50	45	40	35	30	
6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	**6.00**
7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	**7.00**
					8.00	8.00	8.00	8.00	8.00	**8.00**
					9.00	9.00	9.00	9.00	9.00	**9.00**
9.02	9.05	9.07	9.09	9.09	9.09	9.10	9.10	9.10	9.10	**9.10**
9.09	9.13	9.16	9.18	9.19	9.19	9.19	9.20	9.20	9.20	**9.20**
9.15	9.20	9.24	9.27	9.28	9.29	9.29	9.30	9.30	9.30	**9.30**
9.20	9.26	9.32	9.36	9.37	9.38	9.39	9.39	9.40	9.40	**9.40**
9.25	9.32	9.38	9.44	9.45	9.47	9.48	9.49	9.49	9.50	**9.50**
9.28	9.36	9.44	9.51	9.53	9.55	9.57	9.58	9.59	9.60	**9.60**
9.31	9.40	9.49	9.57	9.61	9.63	9.66	9.67	9.69	9.69	**9.70**
9.33	9.43	9.54	9.63	9.67	9.70	9.74	9.76	9.78	9.79	**9.80**
9.35	9.45	9.57	9.68	9.73	9.77	9.81	9.84	9.87	9.89	**9.90**
9.37	9.48	9.60	9.72	9.77	9.83	9.88	9.92	9.95	9.98	**10.00**
9.38	9.49	9.63	9.76	9.82	9.88	9.94	9.99	10.03	10.07	**10.10**
9.39	9.51	9.65	9.79	9.85	9.92	9.99	10.05	10.11	10.16	**10.20**
9.40	9.52	9.67	9.82	9.89	9.96	10.04	10.11	10.18	10.24	**10.30**
9.41	9.54	9.68	9.84	9.92	10.00	10.09	10.17	10.25	10.33	**10.40**
9.42	9.55	9.70	9.87	9.95	10.04	10.13	10.22	10.32	10.41	**10.50**
9.43	9.56	9.72	9.89	9.98	10.08	10.18	10.28	10.39	10.49	**10.60**
9.44	9.57	9.74	9.92	10.01	10.12	10.23	10.34	10.46	10.58	**10.70**
9.46	9.59	9.76	9.95	10.05	10.16	10.28	10.41	10.54	10.67	**10.80**
9.4				10.09	10.21	10.34	10.48	10.62	10.76	**10.90**
9.4				10.14	10.27	10.				**11.00**
9.51	9.66	9.85	10.08	10.20	10.33	10.				**11.10**
9.53	9.69	9.90	10.14	10.26	10.41	10.57	10.72	10.88	11.04	**11.20**
9.56	9.73	9.95	10.20	10.34	10.49	10.65	10.81	10.98	11.14	**11.30**
9.60	9.77	10.01	10.28	10.42	10.57	10.74	10.91	11.08	11.24	**11.40**
9.64	9.83	10.07	10.36	10.50	10.66	10.84	11.00	11.17	11.34	**11.50**
9.69	9.89	10.15	10.44	10.59	10.76	10.93	11.10	11.27	11.44	**11.60**
9.75	9.96	10.23	10.53	10.69	10.85	11.03	11.20	11.37	11.54	**11.70**
9.82	10.04	10.32	10.63	10.78	10.95	11.13	11.30	11.47	11.64	**11.80**
9.90	10.12	10.41	10.72	10.88	11.05	11.23	11.40	11.57	11.74	**11.90**
9.98	10.21	10.50	10.82	10.98	11.14	11.33	11.50	11.67	11.84	**12.00**
10.07	10.30	10.60	10.92	11.08	11.24	11.43	11.60	11.77	11.94	**12.10**
10.16	10.40	10.70	11.02	11.17	11.34	11.52	11.70	11.87	12.04	**12.20**
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10.75	10.99	11.29	11.62	11.77	11.94	12.12	12.30	12.47	12.64	**12.80**
10.85	11.09	11.39	11.72	11.87	12.04	12.22	12.40	12.57	12.74	**12.90**
10.95	11.19	11.49	11.82	11.97	12.14	12.32	12.50	12.67	12.84	**13.00**

1. Temperature of Sample

2. pH of Sample

3. pH corrected to 25 C

E_{OP} stage pH control: How to do it?

- Safety issue
  - Recommend the use of filtrate extractor
    - Static type with filter screen
    - Piston type with squeeze mat
- Simplify and speed up preventive maintenance
  - Scarcier E&I resources
  - Calibration liquid-liquid

E_{OP} stage pH control: How to do it?

- Filtrate extractor
  - Allow the use of cheaper pH probe
  - Safe handling of hot filtrate media
  - Faster calibration check
  - Use temperature measurement at pH probe location
    - Beware of built-in temperature measurement, here is it located on the probe
    - Use RTD on filtrate pot
  - Minimize deadtime with location close to pump/mixer
    - Also minimize piping diameter and pipe length to pH pot
  - Look for minimum 200-250ml/min filtrate flow
  - Flush back with combination of steam/hot water/air to avoid scaling deposit of filter screen and temperature shock of pH probe

E_{OP} stage pH control: How to do it?

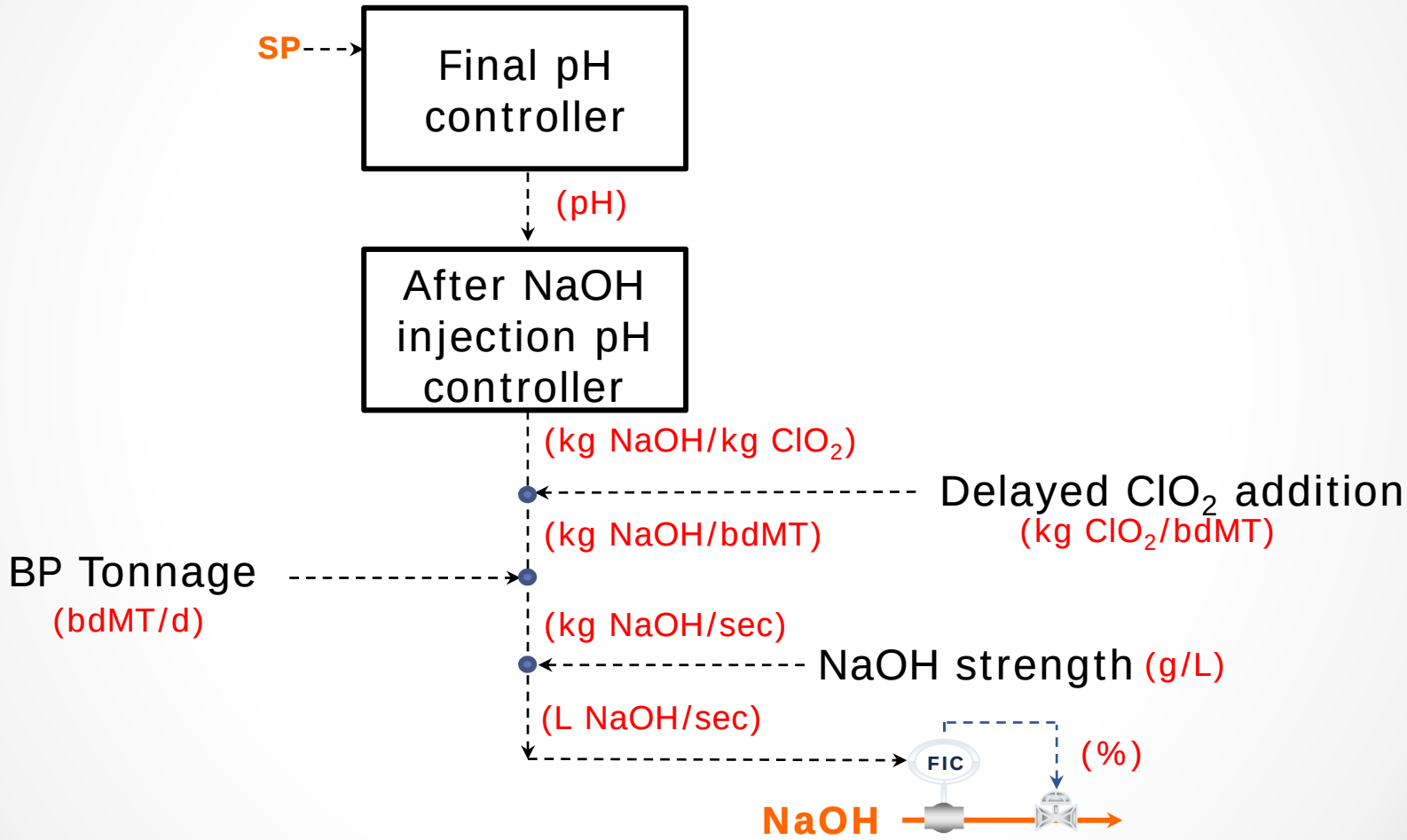
- pH probe preventive maintenance
  - Weekly
  - Use pH buffer 7 and 10, higher if available
  - Replace probe at fixed date
    - Have a historical tracking of pH probe
    - You may loose your accumulated savings by trying to extend probe life to failure.
  - When replacing a pH probe, always double check the next day. Somehow it needs to “cure in process media”

E_{OP} stage pH control:

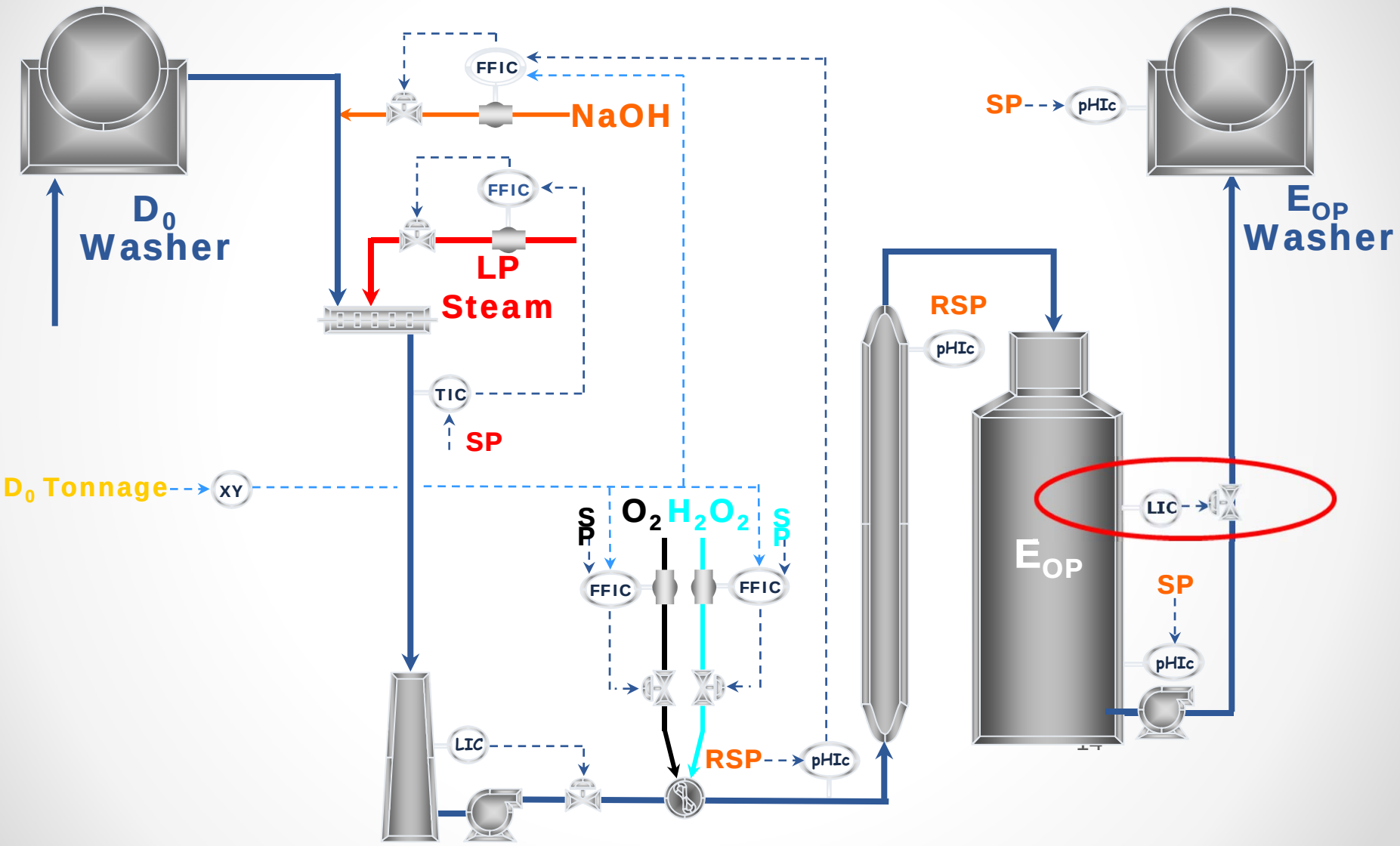
- NaOH dosage is added as kg/ton, lb/ton or % applied
- Monitor/use NaOH/ClO_2 ratio – back up control
  - Indication of potential issues
  - Also used as limiter
- PID controller to be Lambda tune
  - with possible gain schedule on tonnage

- Multiple cascades loop possible
  - End pH is what we're after
    - Achieved by better control of pH early on
  - End pH
    - ph at top of upflow pipe or tube
      - before pressure control valve if present
    - at the botton of downflow tower some 5 ft above dilution ring
    - in the vat…(because this is where testing is done)

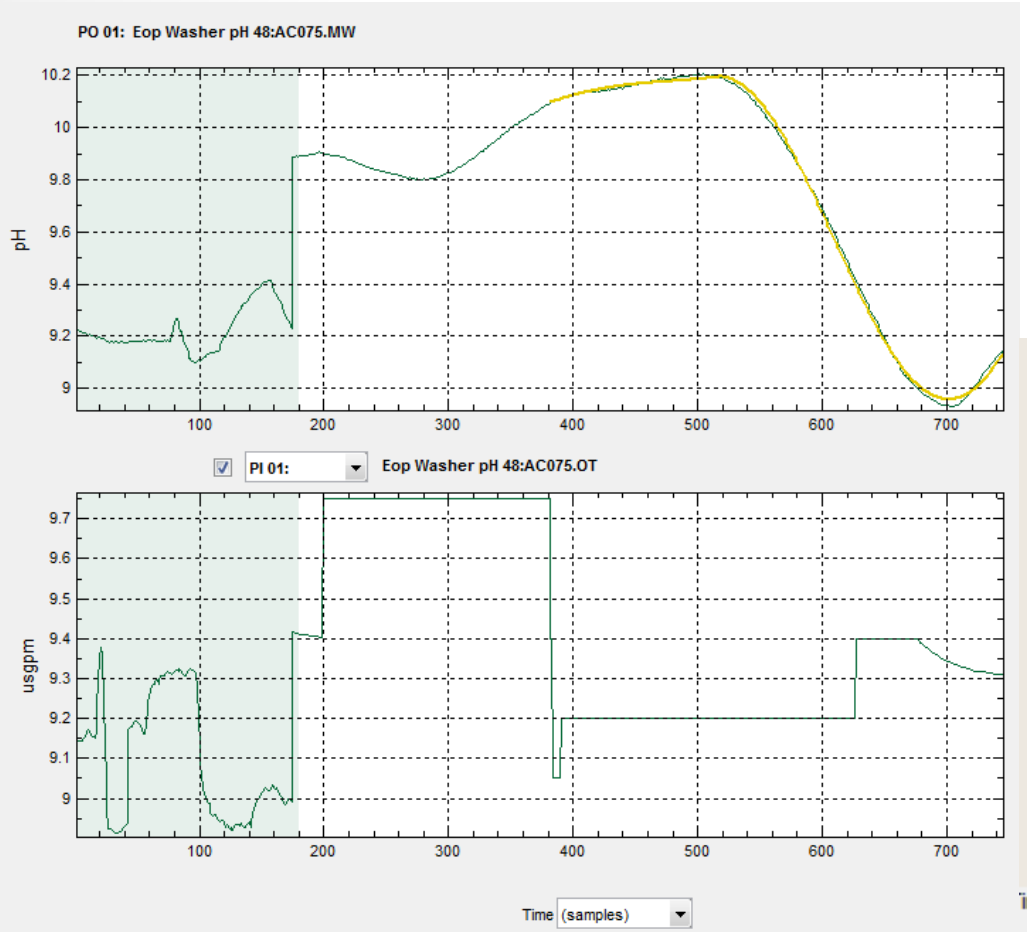
E_{OP} stage pH control:



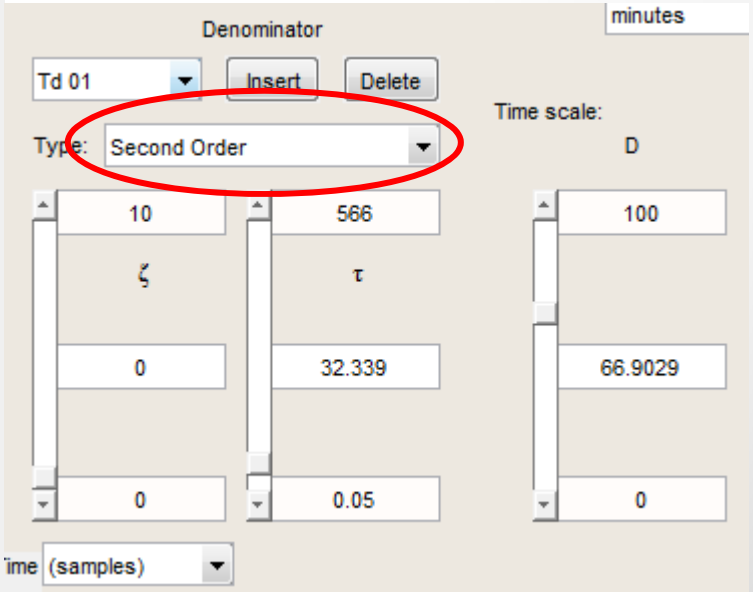
E_{OP} stage pH control:



E_{OP} stage pH control: in the vat...



- Deadtime is longer than the residence time(!)
  - Filter tank filters response
- Behave like a second order loop



E_{OP} stage pH control:

- Multiple cascades loop possible
  - Permissive: time delay for PID on top of upflow tube
  - Permissive: time delay for PID at end of tower
  - Lambda tuned with gain schedule based upon tonnage

- Troubleshooting: when pH loop starts cycling, this is a strong indication pH probe has become insensitive
  - Don’t retune the loop!!!
  - Change pH probe.
    - log life times and schedule PM for probe replacement
      - pH probe cost not worth running to failure

Acknowledgment:

- Doug Reid & AKZO team for all testing on E_{OP} filtrate, and main author of technical paper: " THE IMPACT OF SAMPLE TEMPERATURE ON pH OF EXTRACTION STAGE FILTRATES "

- Brian LaBrash & team for sharing process data.

- Feedback from the BC participants to make me realize once again that process control engineers need to do a better job at explaining and simplifying control concepts. Too often, process control engineers take basic process control concept for granted.

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