Implementation of the Near-Neutral Chlorine Dioxide Brightening Technology at Domtar Johnsonburg Mill

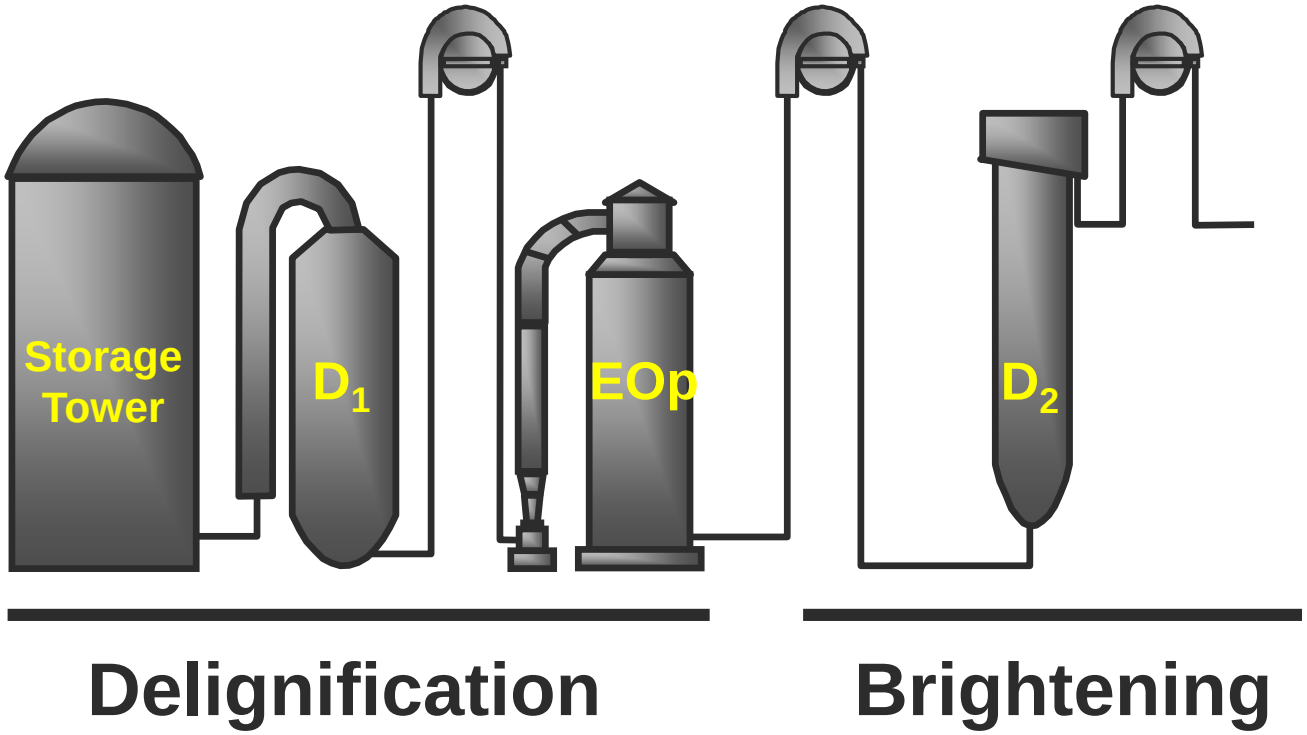
Theodore Radiotis, André Audet, Chung-li Lee, **Michael J. Subilia II**, Jason McCauley, Chris Kreckel, and Bill Hoh

Presented at Spring 2019 BCM by **Shree Praksh Mishra** and **John O'Donnell**

Outline

- Conventional Bleaching
- Near Neutral Brightening (NNB)
- Mill NNB Implementation
  - CO_2 installation
  - Trial results
  - Modified D_2 kappa dosage control
- Summary

Conventional Bleaching



- ClO_2 is used for both delignification as well as brightening
  - Each ClO_2 bleaching stage has a different chemistry and a different optimum pH

Conventional Bleaching:
Brightening stage optimum pH?

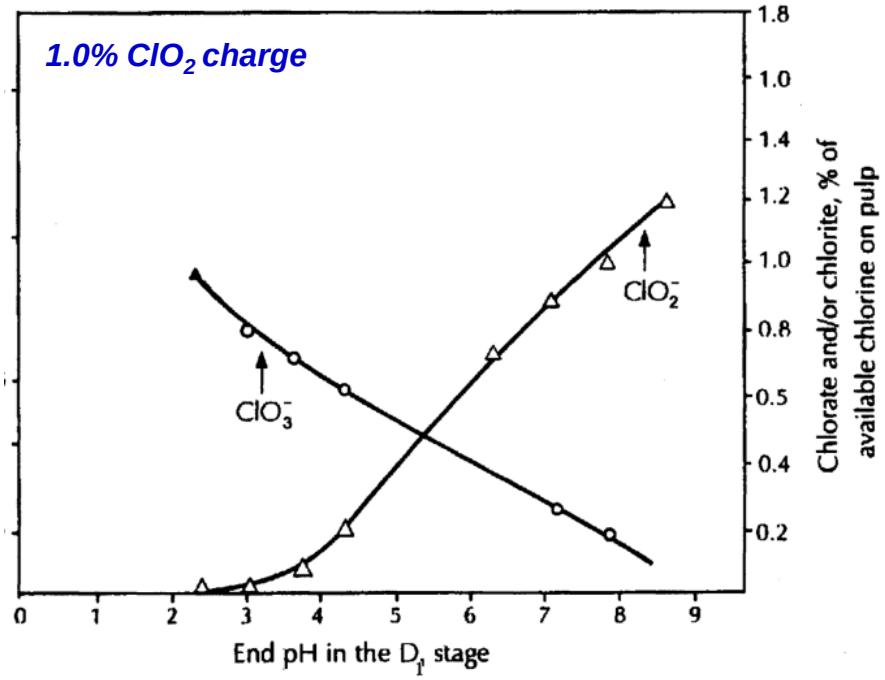
"… early studies showed that *maximum brightness was achieved over a broad pH range centered at pH 6*"

However, in these studies, buffer solutions (*phosphate*) were used so that the pH was constant.

A more appropriate simulation of the falling pH during a chlorine dioxide bleaching stage showed the optimal end pH to be in the range 3.5 to 4…"

"Pulp Bleaching: Principles and Practice", 1996

Change in chlorine-species with pH



Rapson and Anderson, 1977

Conventional Bleaching:
Brightening stage optimum pH?

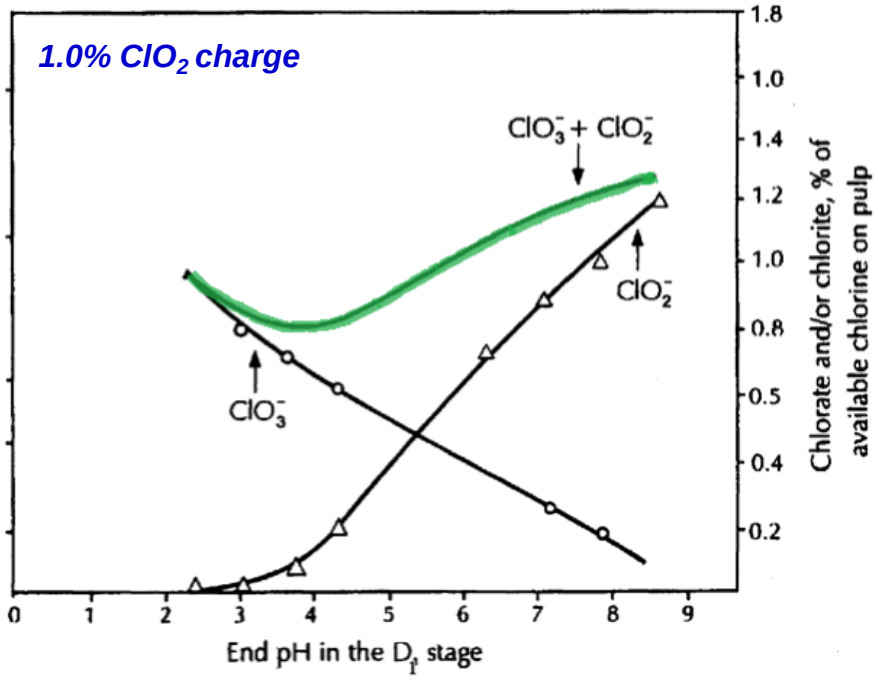
"… early studies showed that *maximum brightness was achieved over a broad pH range centered at pH 6*"

However, in these studies, buffer solutions (*phosphate*) were used so that the pH was constant.

A more appropriate simulation of the falling pH during a chlorine dioxide bleaching stage showed the optimal end pH to be in the range 3.5 to 4…"

"Pulp Bleaching: Principles and Practice", 1996

Change in chlorine-species with pH



Rapson and Anderson, 1977

Conventional Bleaching:
Brightening stage optimum pH?

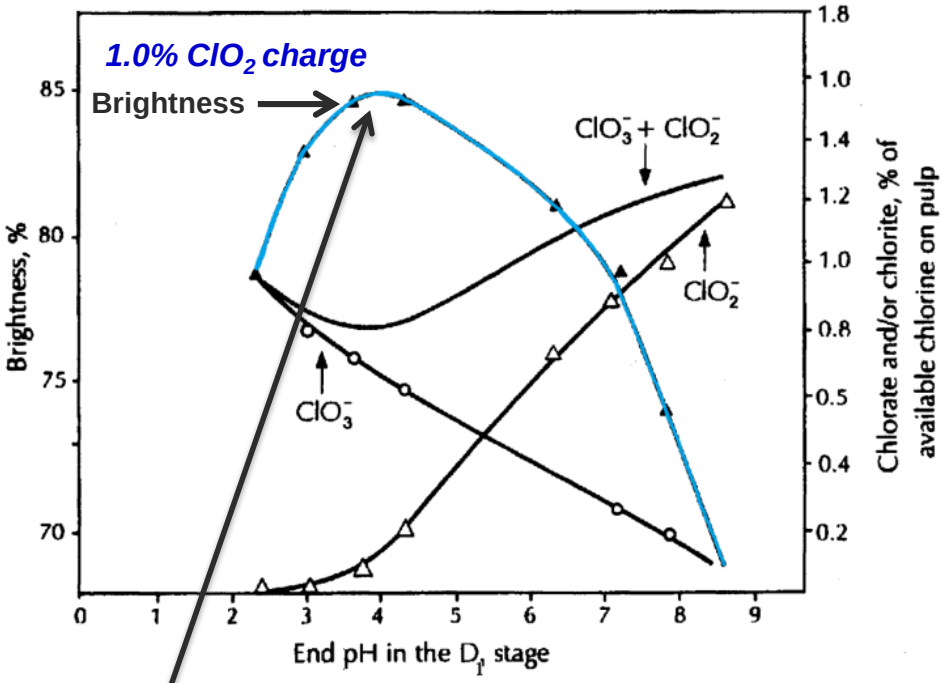
"… early studies showed that *maximum brightness was achieved over a broad pH range centered at pH 6*"

However, in these studies, buffer solutions (*phosphate*) were used so that the pH was constant.

A more appropriate simulation of the falling pH during a chlorine dioxide bleaching stage showed the optimal end pH to be in the range 3.5 to 4…"

"Pulp Bleaching: Principles and Practice", 1996

Change in chlorine-species with pH



Rapson and Anderson, 1977

This optimum pH can shift with ClO_2 Charge

Outline

- Conventional Bleaching
- Near Neutral Brightening (NNB)
- Mill NNB Implementation
  - CO_2 installation
  - Trial results
  - Modified D_2 kappa dosage control
- Summary

Near Neutral Brightening

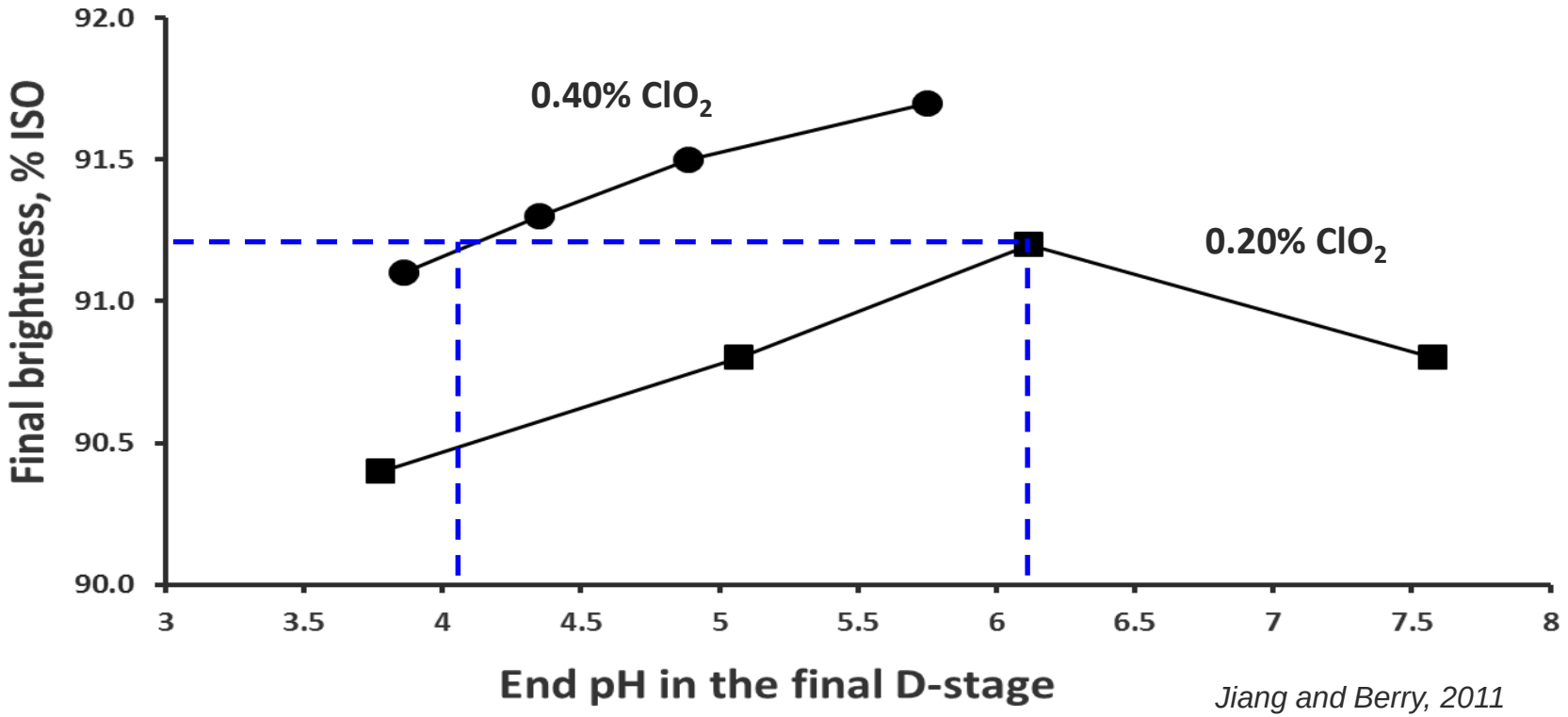
- **“… to obtain maximum brightness with chlorine dioxide the pH should be kept between 6.5 and 5 from beginning to end of the treatment, preferably at pH 6…”**
  (*Rapson, Tappi J., 39(5):285, 1956)*

- **“The optimal pH appears to be furnish and chlorine dioxide charge dependent”**
  (Hart 2006 – TAPPI Fall Conf. Proc., TAPPI press)

- **“…(the last brightening) stage should be operated with a final pH close to neutral when a typical chlorine dioxide charge is applied…”**
  (Jiang and Berry, J-FOR 1(1), 14-20, 2011)

Near Neutral Brightening
Effect of pH on Brightness

ODEopD sequence: Hardwood kraft pulp

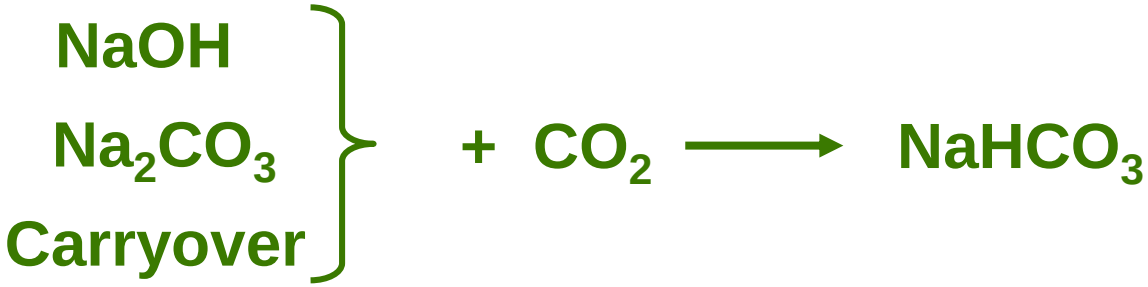


Jiang and Berry, 2011

Increasing the end pH from ~4 to ~6 allows ClO_2 dosage decreased by 0.2% on pulp (2 kg reduction in ClO_2 per ton pulp)

Near Neutral Brightening Buffering (Patented Technology)

- **Phosphate buffer: Costly, introduces NPE's**
- **Sodium bicarbonate: Effective buffer, but low solubility**
- **Solution: *in-situ* generation of sodium bicarbonate**

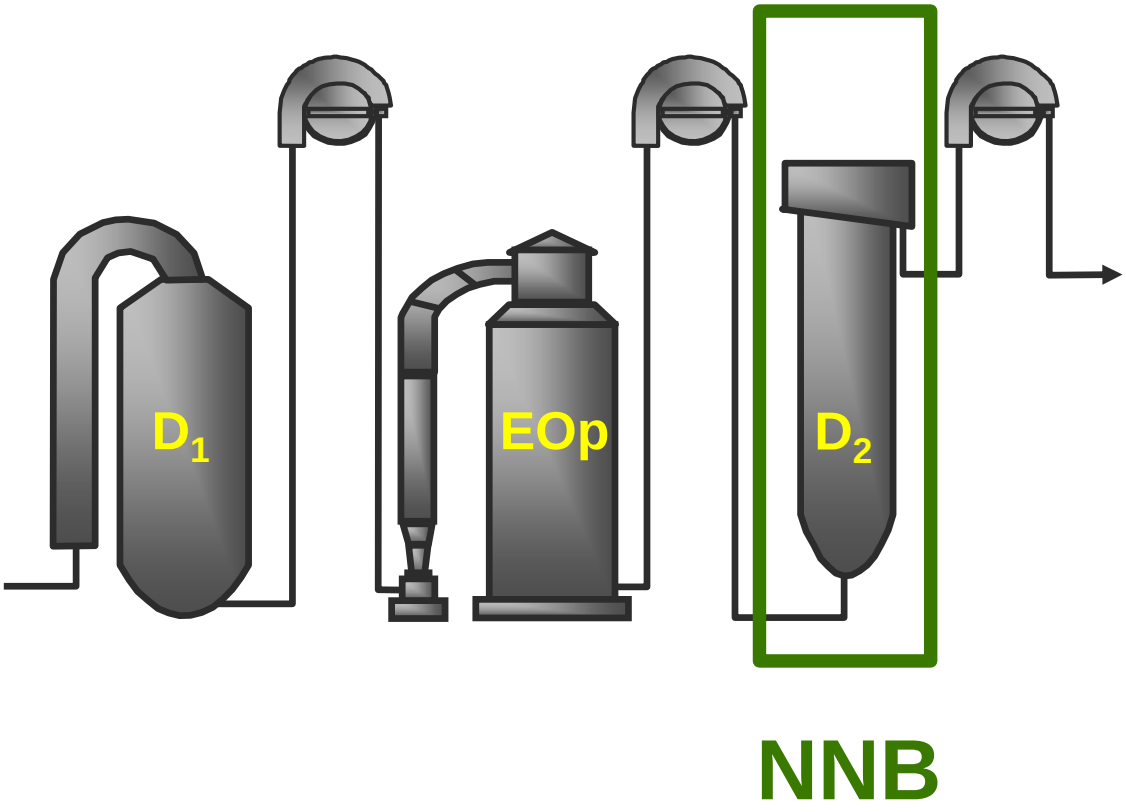


Outline

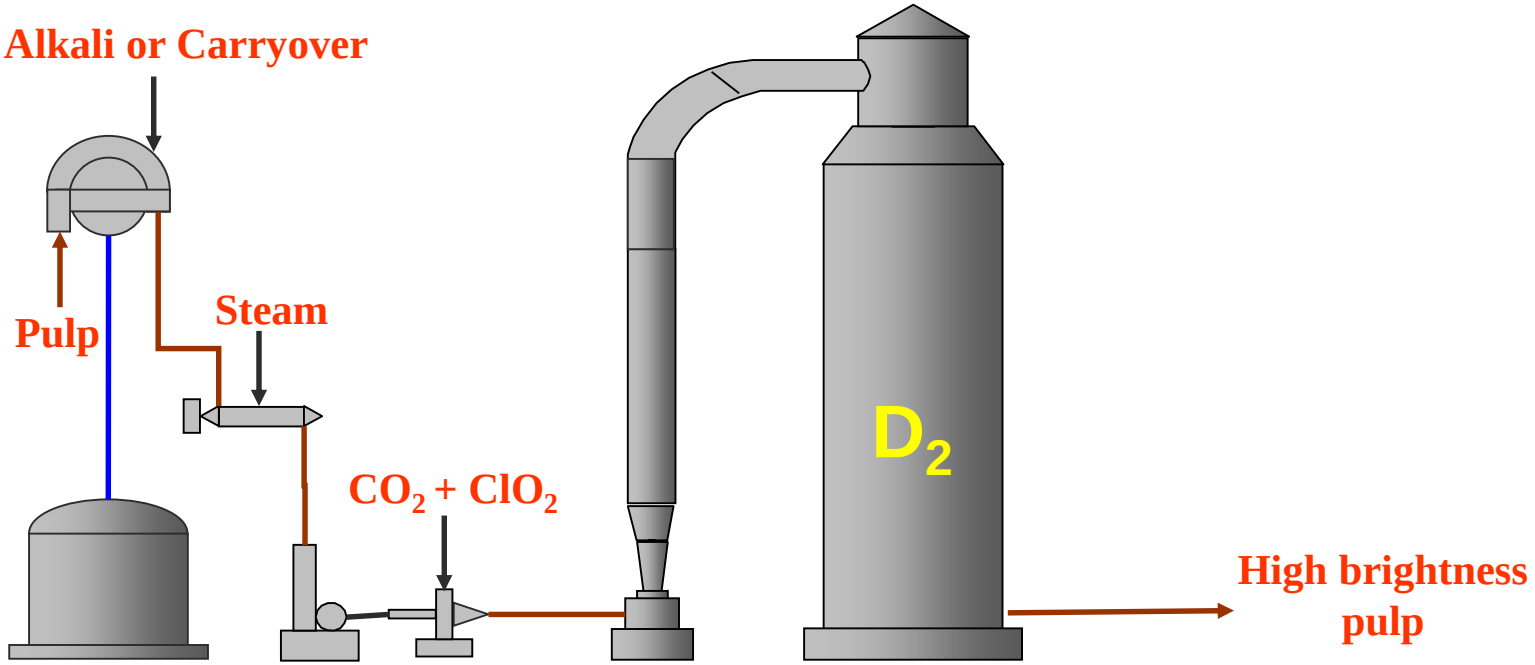
- Conventional Bleaching
- Near Neutral Brightening (NNB)
- Mill NNB Implementation
  - CO_2 installation
  - Trial results
  - Modified D_2 kappa dosage control
- Summary

Mill NNB Implementation

Mill: North American Hardwood Kraft Pulp Mill
Bleaching Sequence: D_1EOpD_2



Mill NNB Implementation

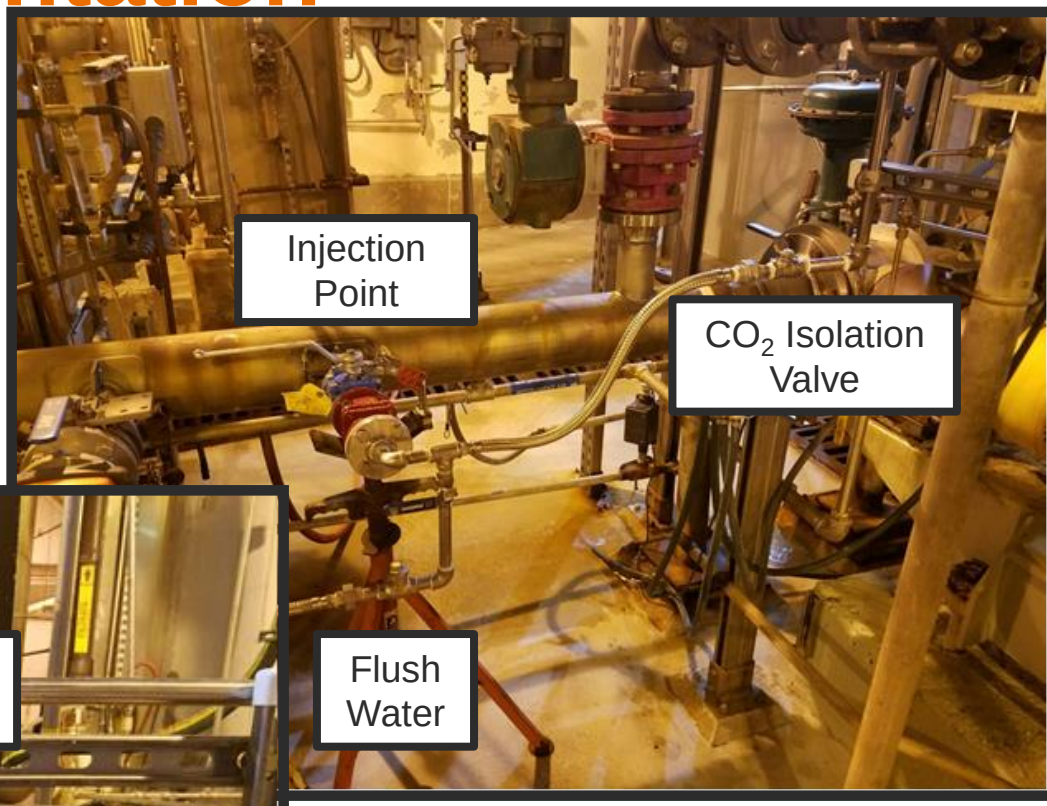


Expected benefits:

- Reduce total ClO_2 dosage by about 3 lb/T
- Eliminate current brightness reversion in the HD tower
- Stabilize brightness to paper machine

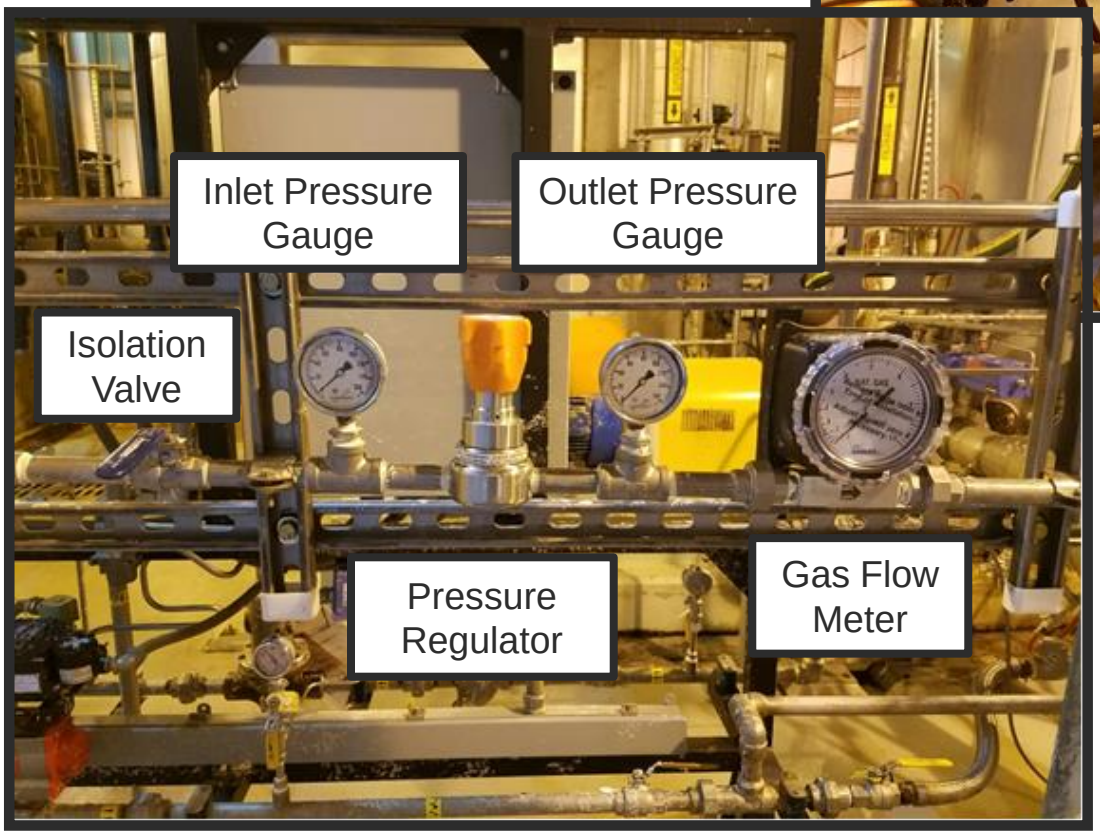
Mill NNB Implementation

CO_2 Installation



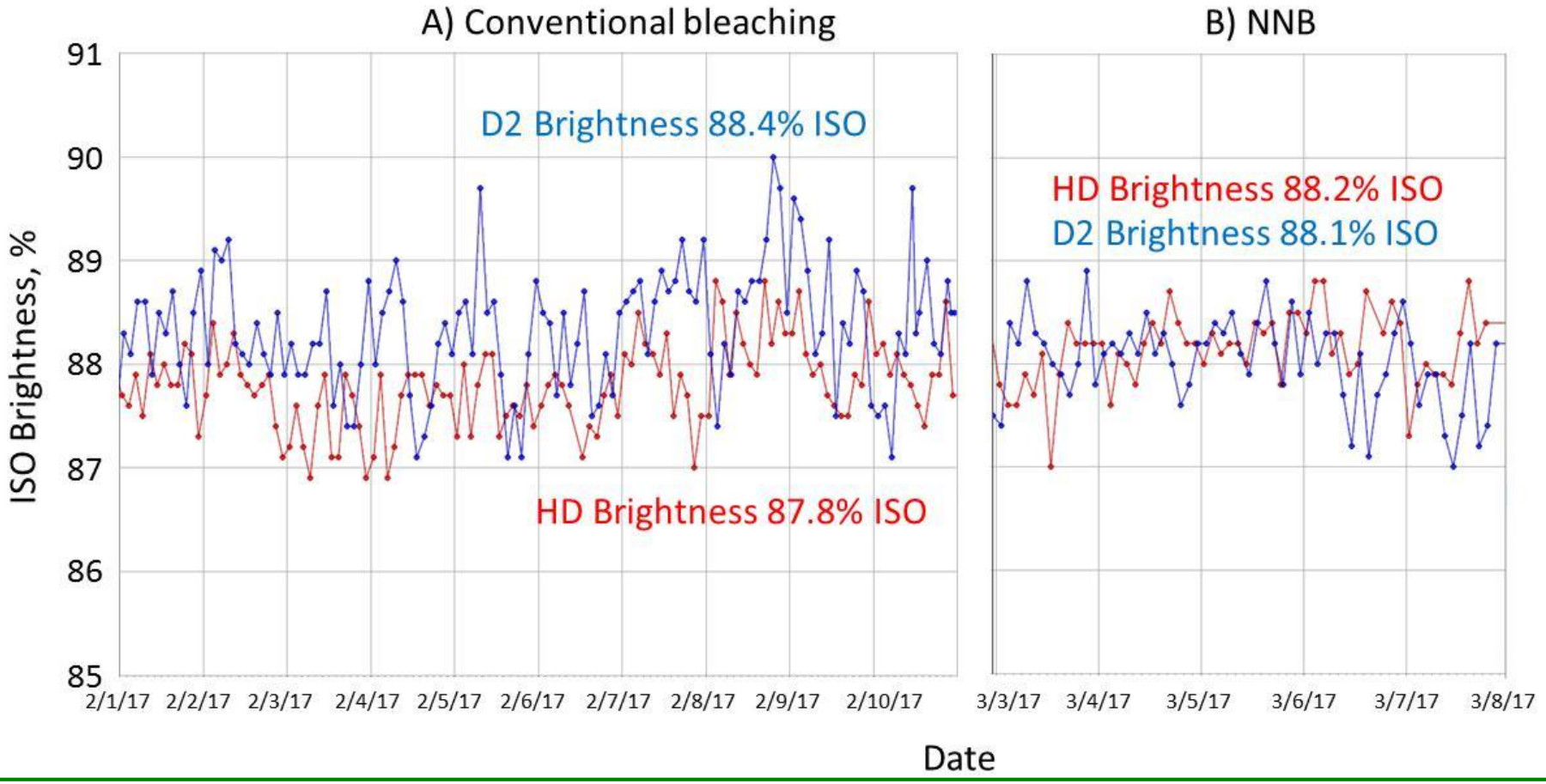
CO_2 injection system

CO_2 flow control system



Mill NNB Implementation

Trial Results: Eliminate brightness reversion

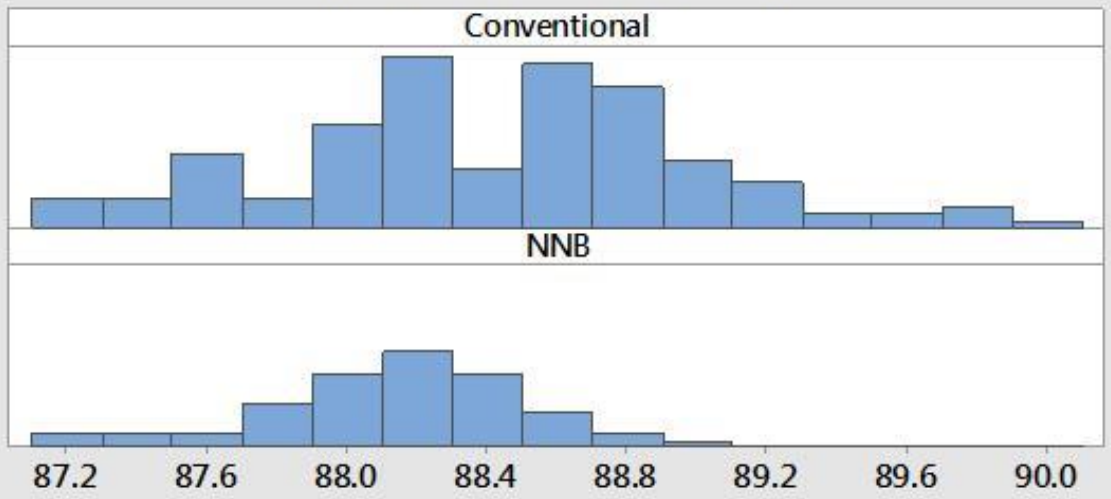


Under conventional bleaching, HD brightness was 0.6 points lower than in D_2, whereas in NNB, HD and D_2 brightness were the same (NO brightness reversion)

Mill NNB Implementation

Trial Results: Stabilize brightness to paper machine

- D_2 brightness standard deviation reduced from 0.59 to 0.38 (35% reduction)



Statistics	Conventional	NNB
Sample size	131	53
Mean	88.371	88.087
Standard deviation	0.59336	0.38433
Individual 80% CI	(0.5507, 0.6456)	(0.3384, 0.4473)

Mill NNB Implementation

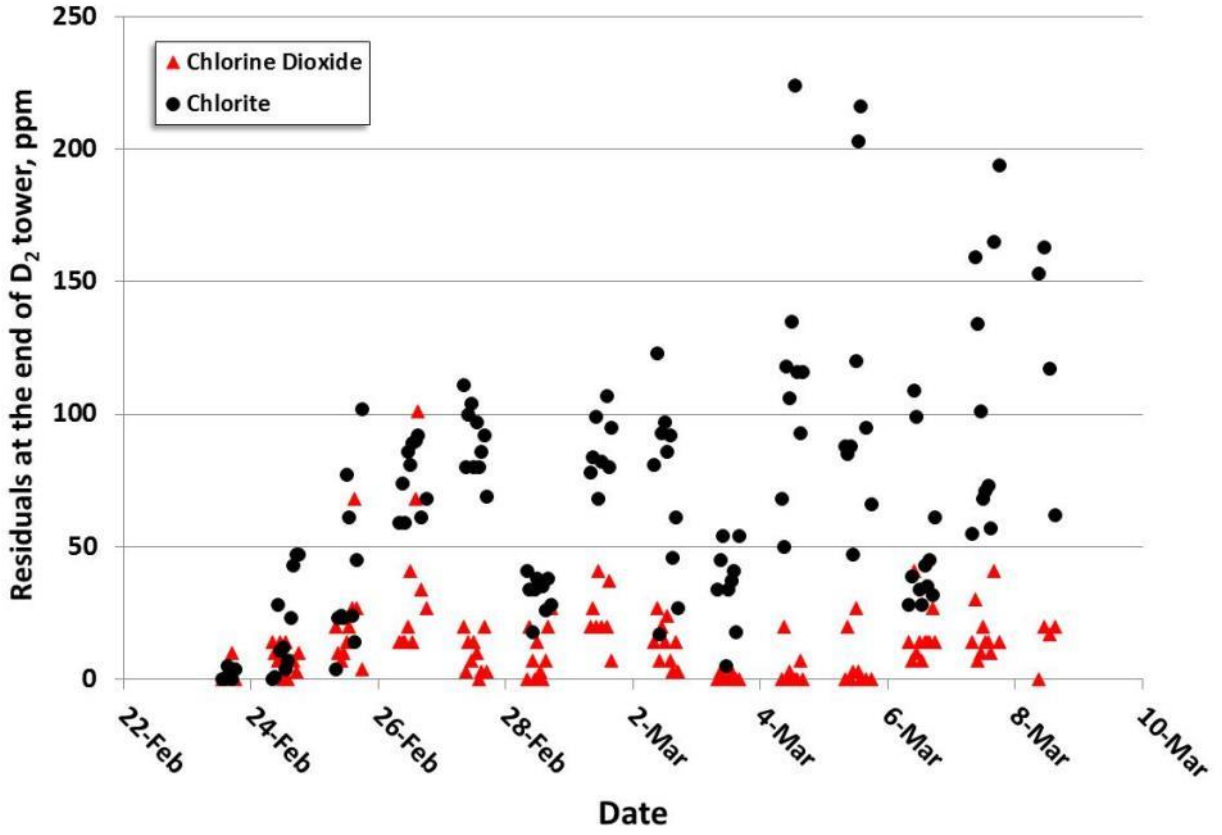
Trial Results: Reduce ClO_2 dosage

	Baseline	NNB trial
Production rate, ton/year	-	-
Bleach inlet kappa number	-	-
D_1 ClO_2 dosage, lb/ton	-	↓ **~3.5**
D_2 ClO_2 dosage, lb/ton	-	-
D_2 washer pH	5.3	6.8
HD brightness to paper machines, % ISO	-	↑ **0.3**
Total ClO_2, lb/ton	-	↓ **3-4**

Total ClO2 dosage reduced by ~3-4 Lbs./Ton

Mill NNB Implementation

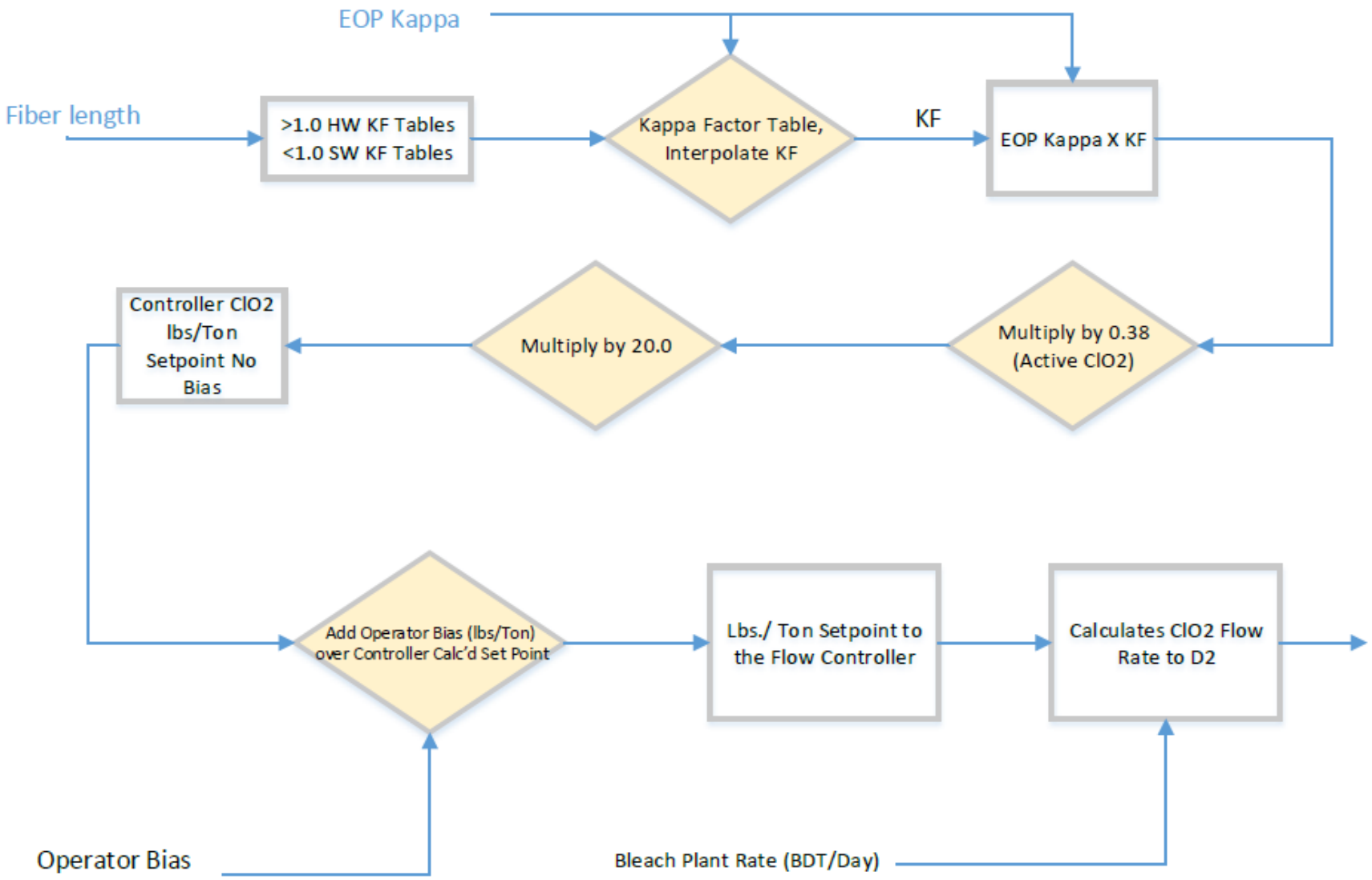
Additional benefit was reduced gas off issues at D2 washer because of lower residual ClO_2 vs ClO_2^-



Under NNB conditions more than 80% of the total residual is in the form of the non-volatile salt of the chemical, chlorite ($NaClO_2$), with the balance as ClO_2.

Mill NNB Implementation

Flowchart of the original D_2 kappa dosage



Mill NNB Implementation

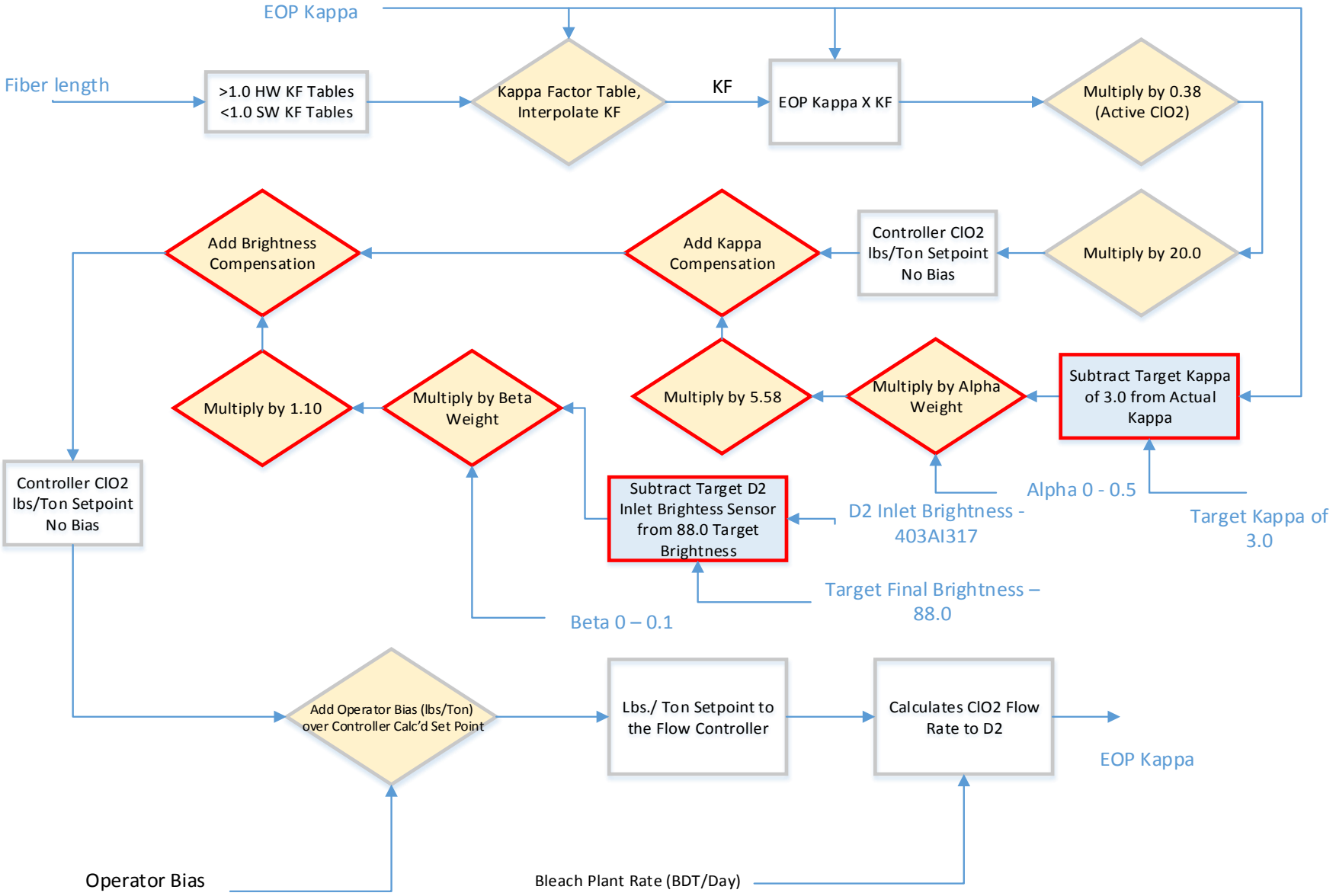
Proposed D_2 composite control equation

Dosage = Eop Kappa x KF x 0.38 x 20
+ α (Eop Kappa – Target Eop Kappa) x A
+ β (88.5 – Eop Brite) x B

Note: KF, α, β, A, B and 88.5 are mill-specific

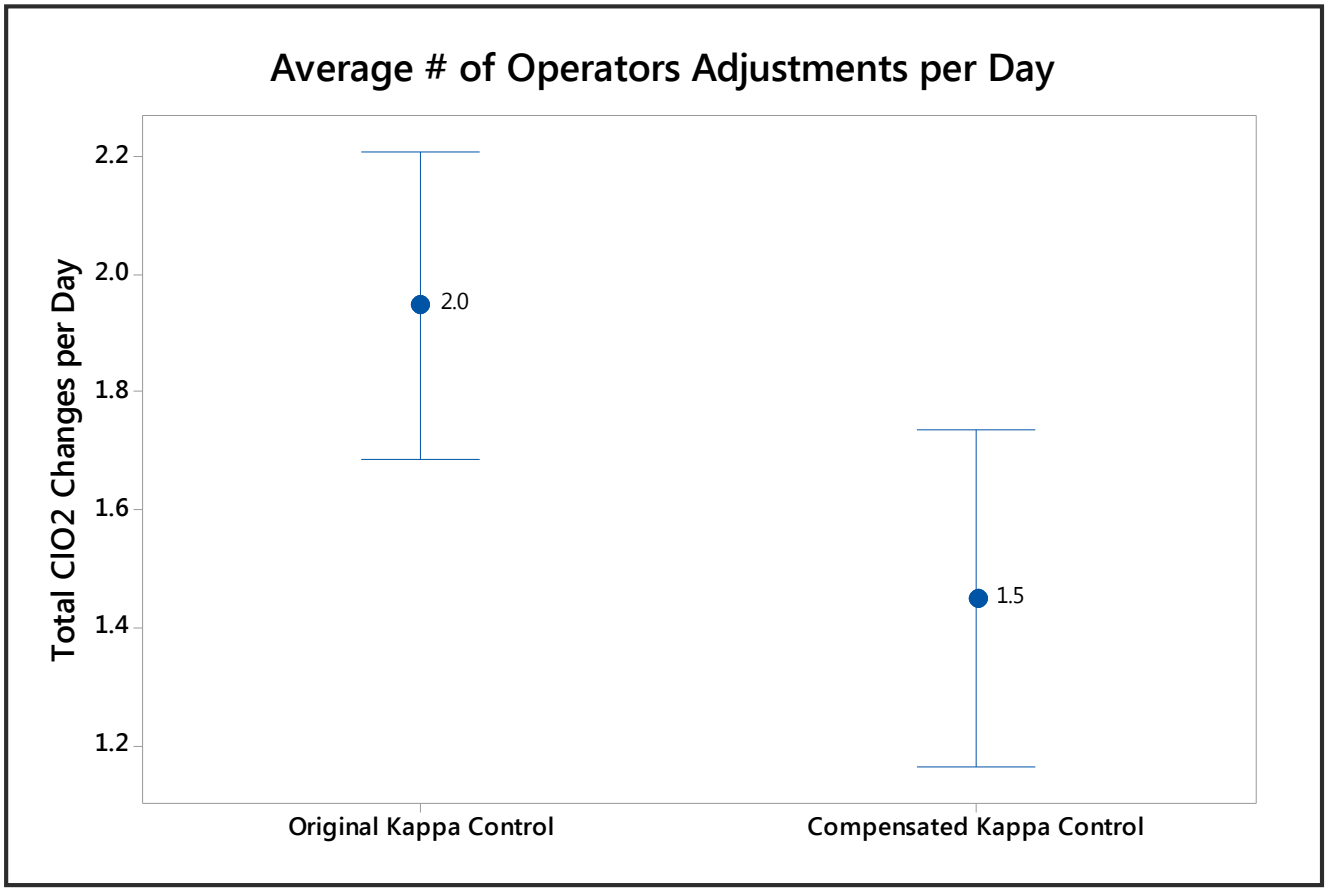
Mill NNB Implementation

Modified D_2 kappa dosage control



Mill NNB Implementation

D_2 composite control implemented



Since the implementation of the D2 composite control equation a more stable D_2 and HD brightness was recorded, resulting in fewer adjustments by the bleach plant operator

Summary of NNB Mill Implementation

Benefits Realized:

- Decreased bleaching chemical demand of ~3-4 lb ClO_2/t
- Pretrial brightness reversion in the HD tower has been eliminated
- Final pulp brightness to the paper machine was stabilized

Additional Benefits:

- ClO_2 gas off incidents have been reduced since NNB was implemented
- Modified D_2 ClO_2 dosage control has since delivered a very stable on target final brightness to the paper machine

Domtar Johnsonburg mill has been operating near neutral brightening (NNB) on a permanent basis after the trial

Acknowledgements

We would like to thank Domtar for their support and permission to share these results, and to FPInnovations and Johnsonburg staff for their technical support

Thank you