Pickle Line Drives Upgrade in Integrated Stages to Minimize Downtime

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Introduction

The existing Pickle Line DC drives were mid-90's vintage and spare parts were becoming difficult and expensive to obtain. The Wet Section DC motors were also getting expensive to maintain and replace due to the corrosive environment. In this paper we will present how the Pickle Line Drives (and also the Wet Section motors) were upgraded and modernized in multiple short outages (using existing short maintenance outages), with as much work done as possible with the Pickle Line running, minimizing down time, and coordinating the new Drives with the yet-to-be upgraded legacy Drives.

History

The Pickle Line was originally installed in the mid-1990’s with DC Motors, and DC Drives running on analog references from the PLC. The PLC was upgraded in 2009, followed by the Server-Client HMI system in 2011.

Reasons for Drives Upgrade

Obsolescence

The existing DC Drives were good drives for their time, but they were obsolete and replacement parts were getting increasingly difficult to obtain. The primary reason for the Drives Upgrade was their obsolescence.

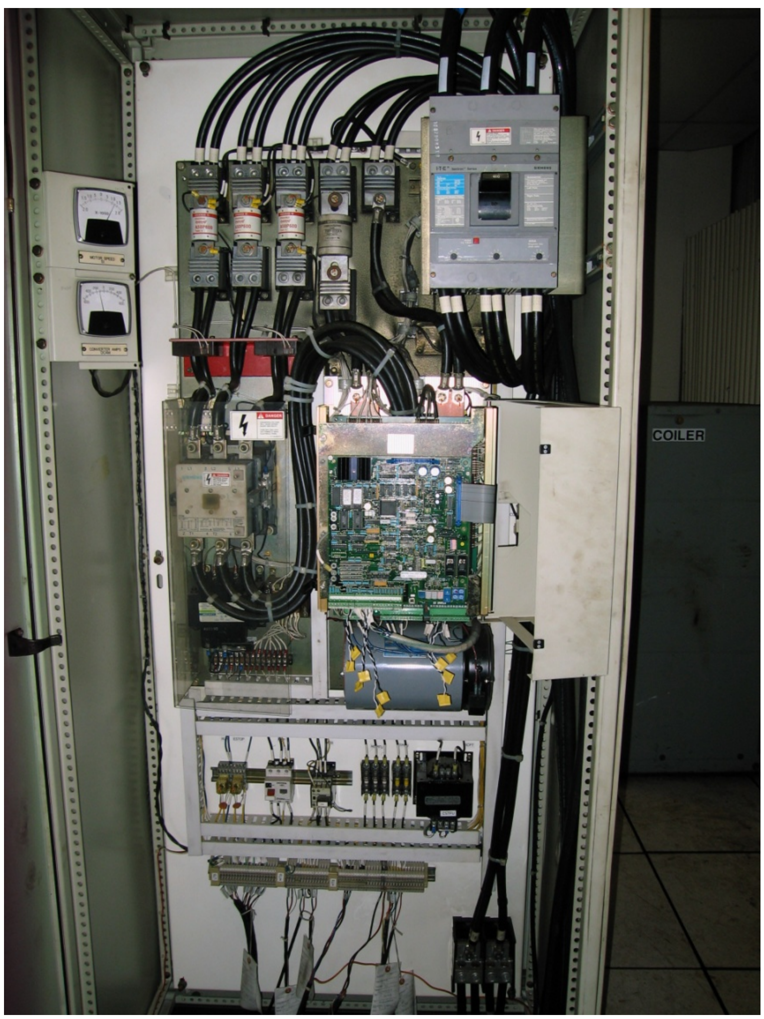


Figure 1. Existing Uncoiler Drive

Wet Section Motors

Environment

15 of the 16 existing Squeegee Motors in the Wet Section were DC Motors. The acid fumes in the Wet Section detrimentally affected the Squeegee Motors' commutator conditions.

Motor Loads

The existing 10hp Squeegee DC Motors were also frequently overloaded.

Multiple Motors on each DC Drive

8 of the 15 Squeegee DC Motors had their armatures in parallel on one DC Drive. The remaining 7 Squeegee DC Motors had their armatures in parallel on another DC Drive. All 15 of them had separate Field Controllers, but no speed feedback devices.

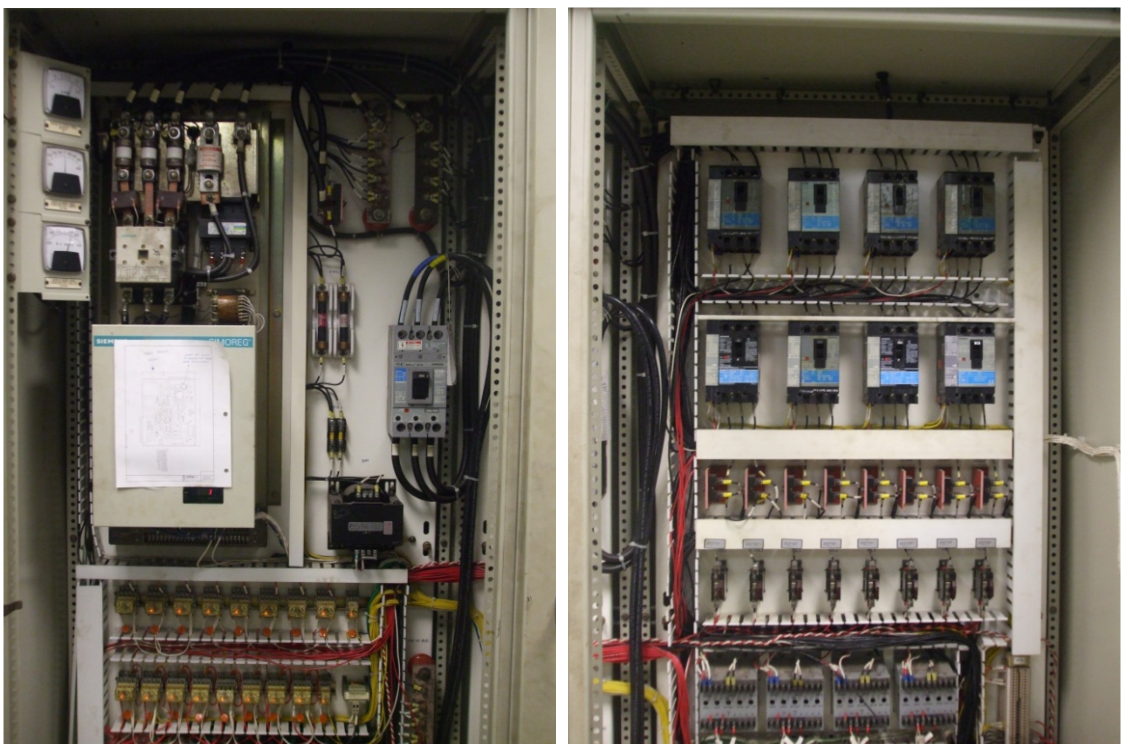


Figure 2. Existing 8-Motor Squeegee DC Drive Cabinet

The decision was made to replace the 15 Squeegee 10hp DC Motors with 20hp AC Motors for decreased maintenance costs, increased motor life, decreased relative motor loads, and better motor control. The 16^{th} Squeegee Motor was already an AC Motor, but was replaced with one of the new 20hp AC Motors.

Upgrade Challenges

Multiple Short Outages

The customer requested that the Drive Upgrade be performed over the course of multiple short outages, versus an extended outage. With some minor rearrangements, there was room in the Control Room for several additional Drive Cabinets.

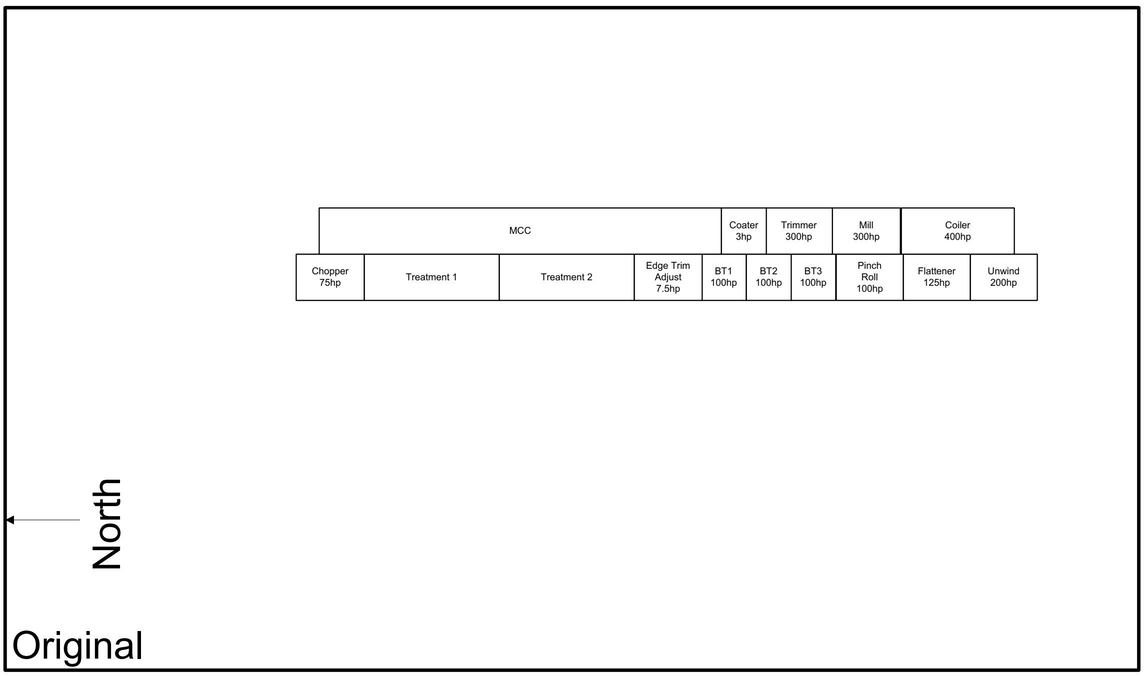


Figure 3. Original Drive Room Layout

Before the first outage, we installed and powered the Rectifier Cabinet, installed and powered the two AC Drive Lineup Cabinets, placed and powered the new AC Motors on the Wet Section Mezzanine, and shadowed the line by running the new AC Motors uncoupled.

Stage 1 commissioned over a 3-day weekend in March 2015.

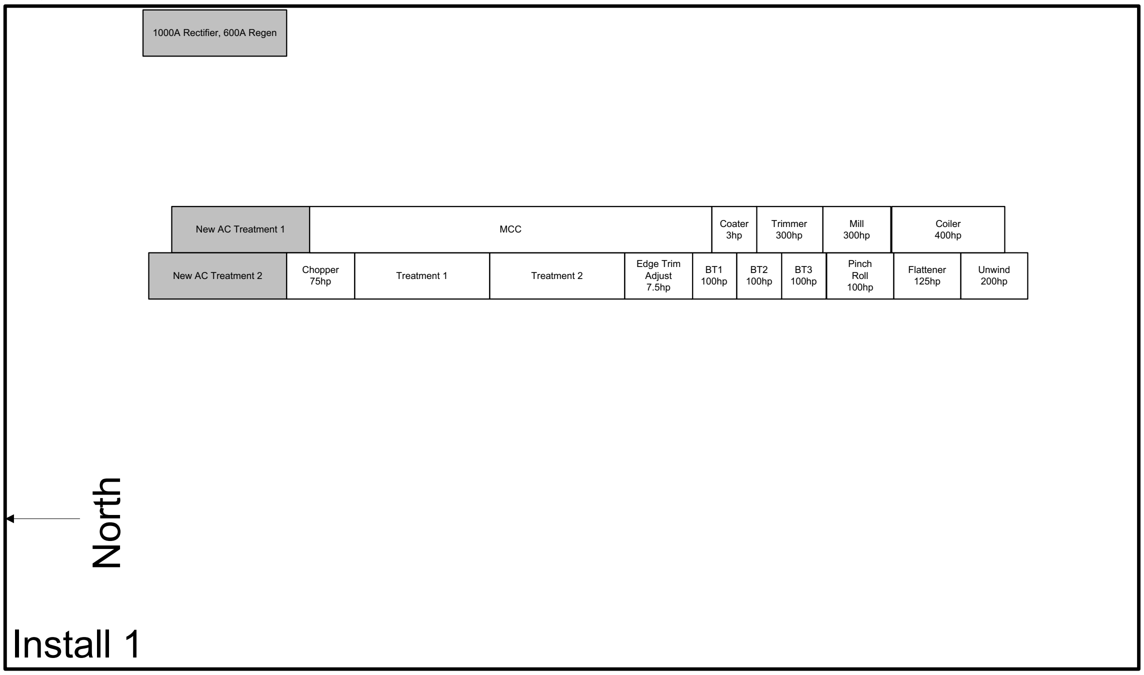
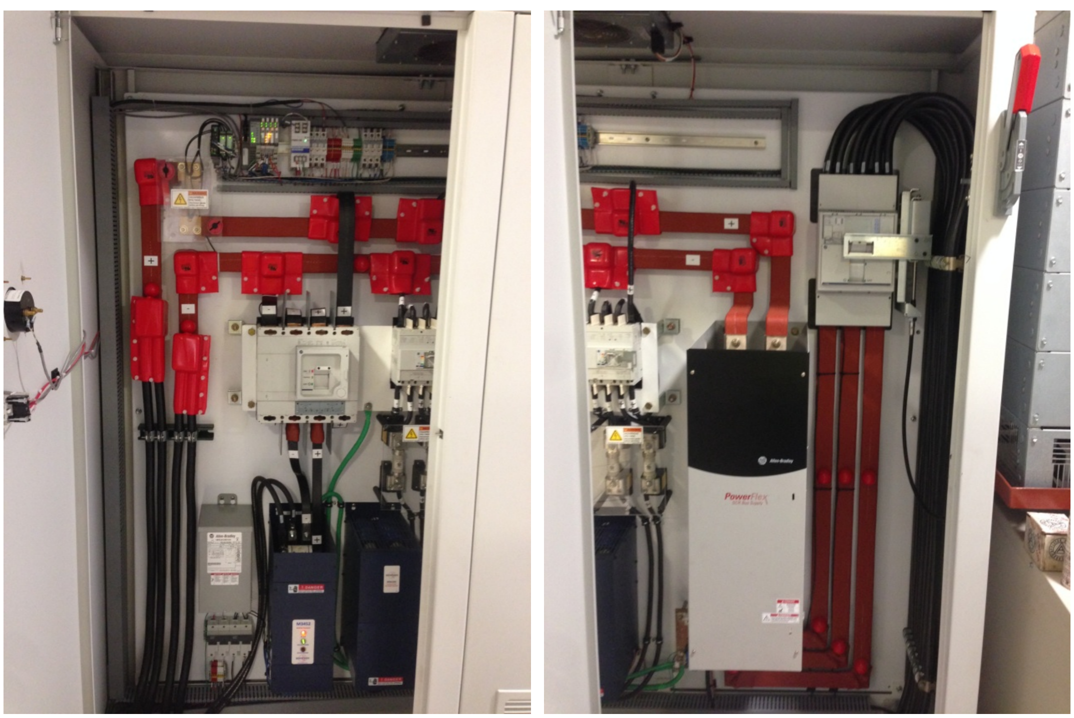
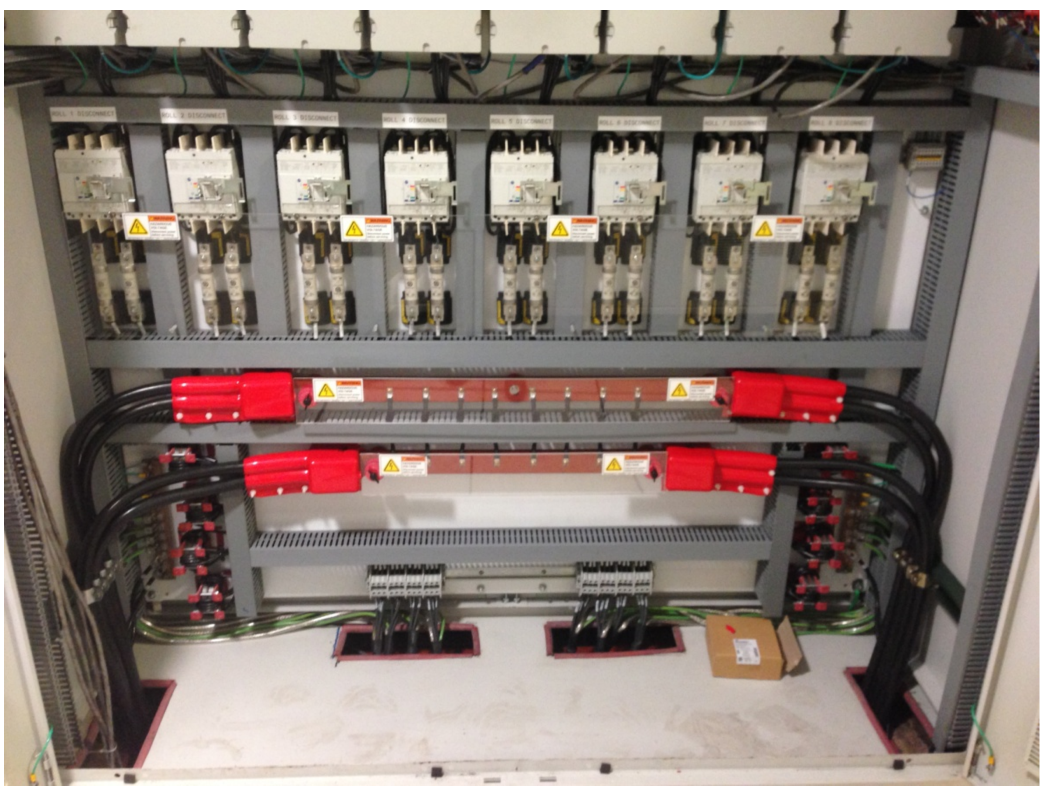


Figure 4. Stage 1 Drive Room Layout – New Drives Installed



Figures 5 & 6. Rectifier Cabinet – Right & Left



Figures 7 & 8. AC Drive Lineup Cabinet – Top & Bottom

After the first outage the no longer used Drive Cabinets were removed with the Pickle Line running.

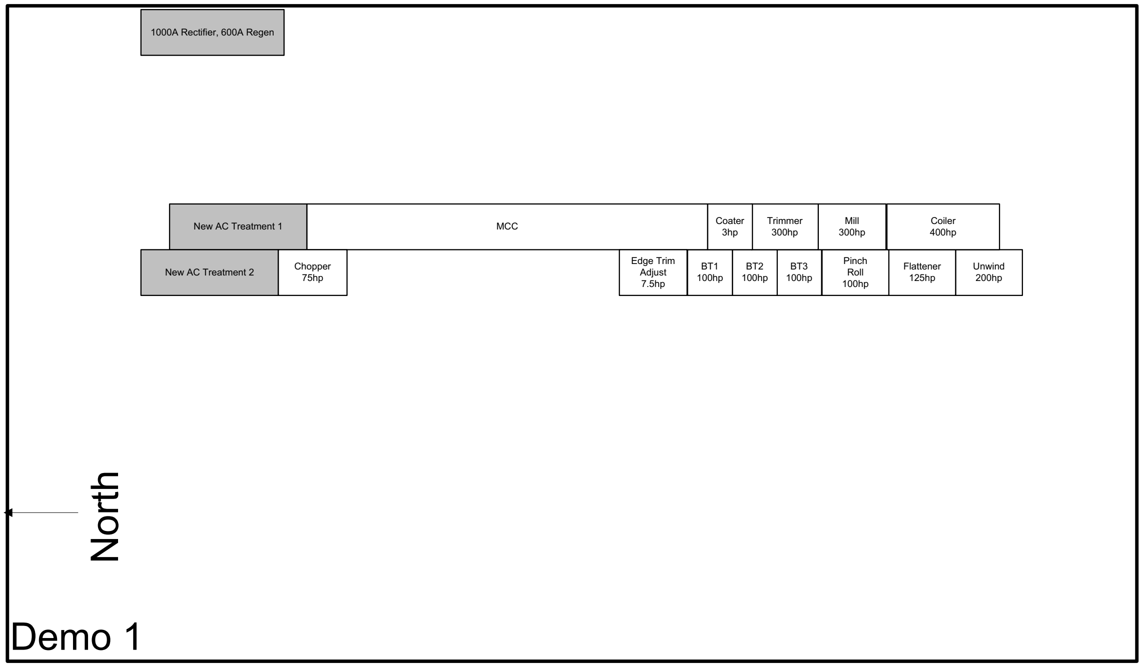


Figure 9. Stage 1 Drive Room Layout – Old Drives Removed

This process continued over the course of 3 more outages, with DC Drive Cabinets being installed with the Pickle Line Running, short outages to swap motor leads, and then the old DC Drive Cabinets being removed in turn. The order in which the drives were upgraded was dictated by Drive Room geography. The total process started in March 2015 and completed in November 2015.

Stage 1.5 commissioned during an 8-hour weekly maintenance shift in April 2015.

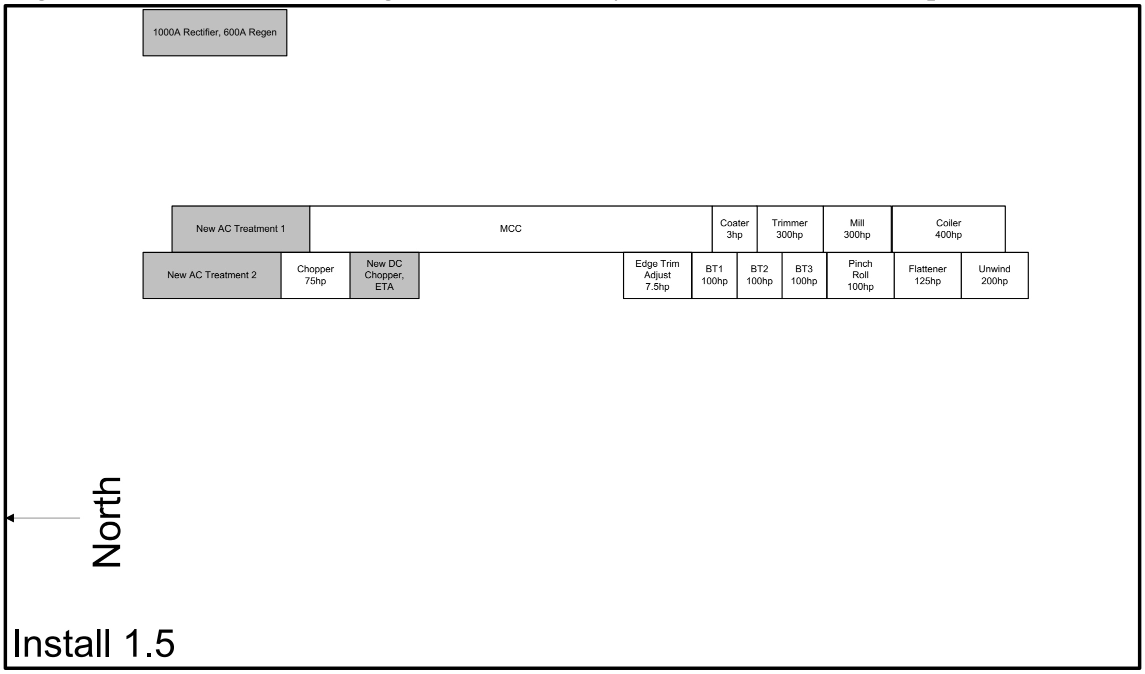


Figure 10. Stage 1.5 Drive Room Layout – New Drives Installed

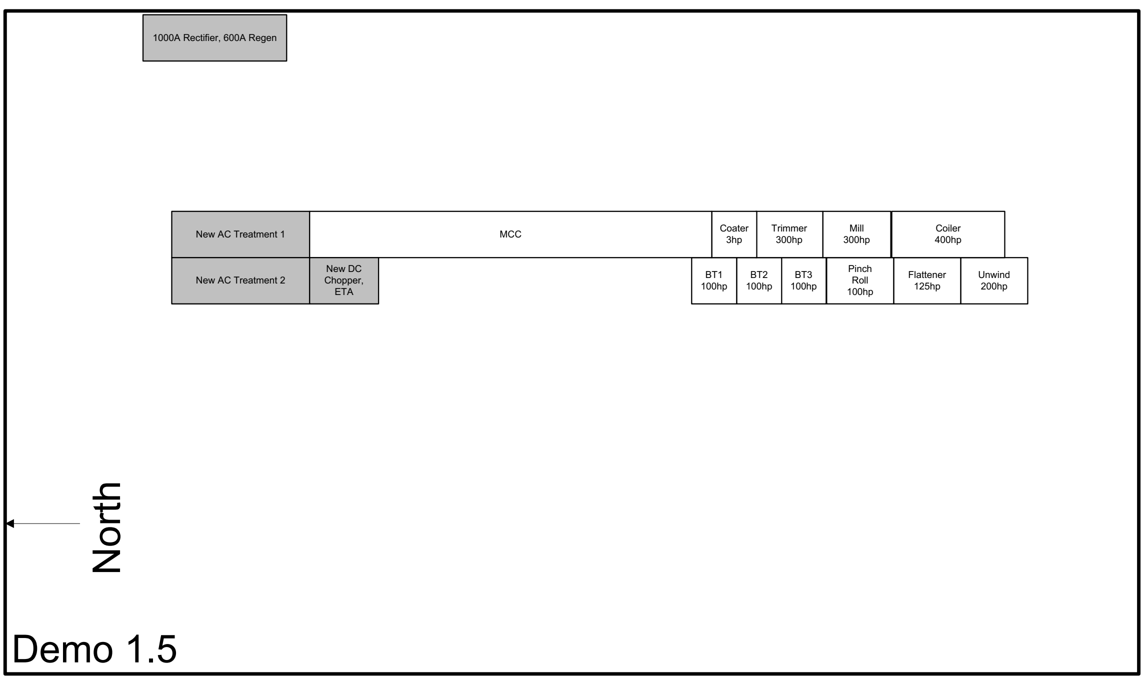


Figure 11. Stage 1.5 Drive Room Layout – Old Drives Removed

Stage 2 commissioned (along with the Temper Mill) during the July 2015 one-week outage.

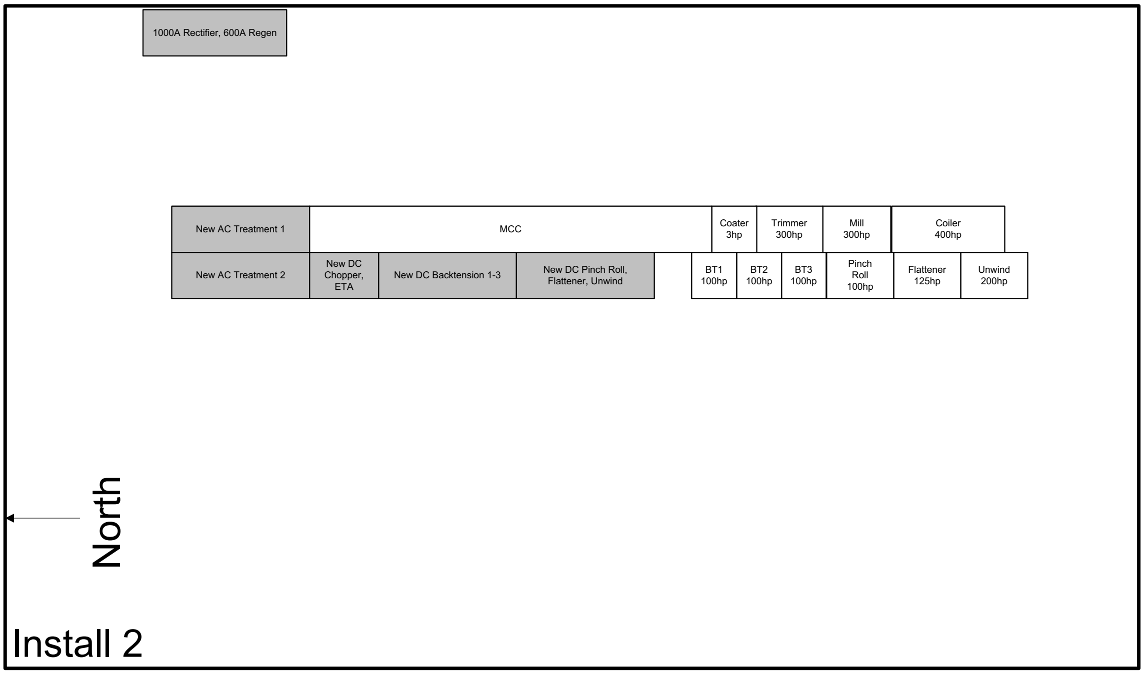


Figure 12. Stage 2 Drive Room Layout – New Drives Installed

Figure 13. Stage 2 Drive Room Layout – New Drives Installed

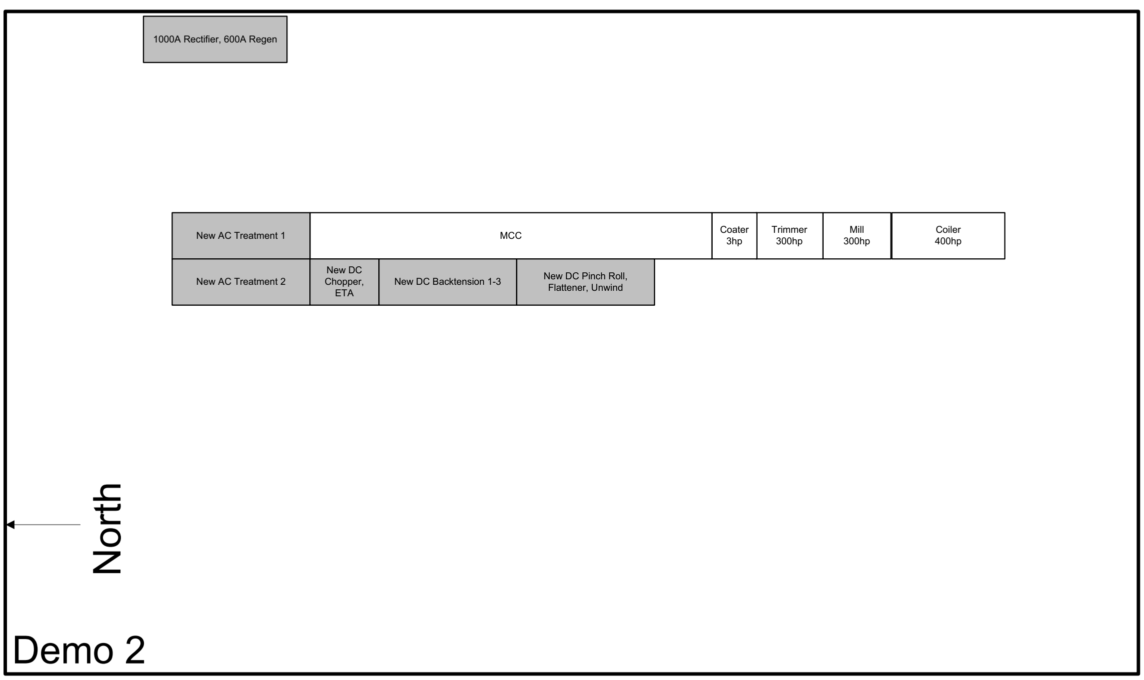


Figure 14. Stage 2 Drive Room Layout – Old Drives Removed

Stage 3 commissioned during a 3-day weekend in November 2015.

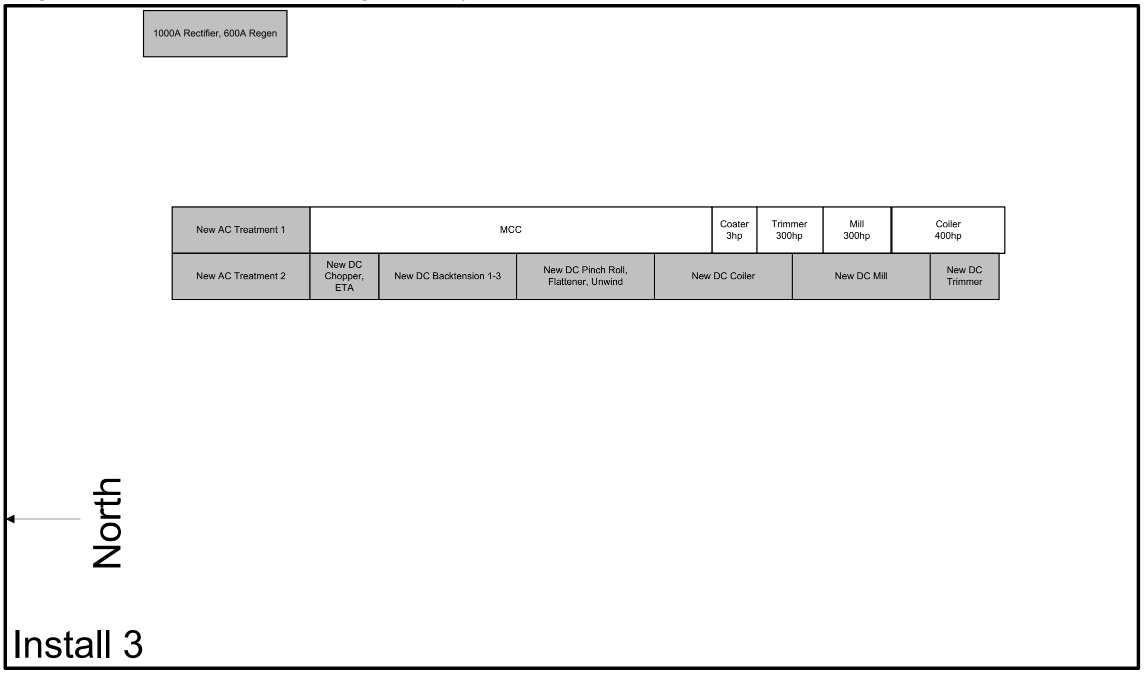


Figure 15. Stage 3 Drive Room Layout – New Drives Installed

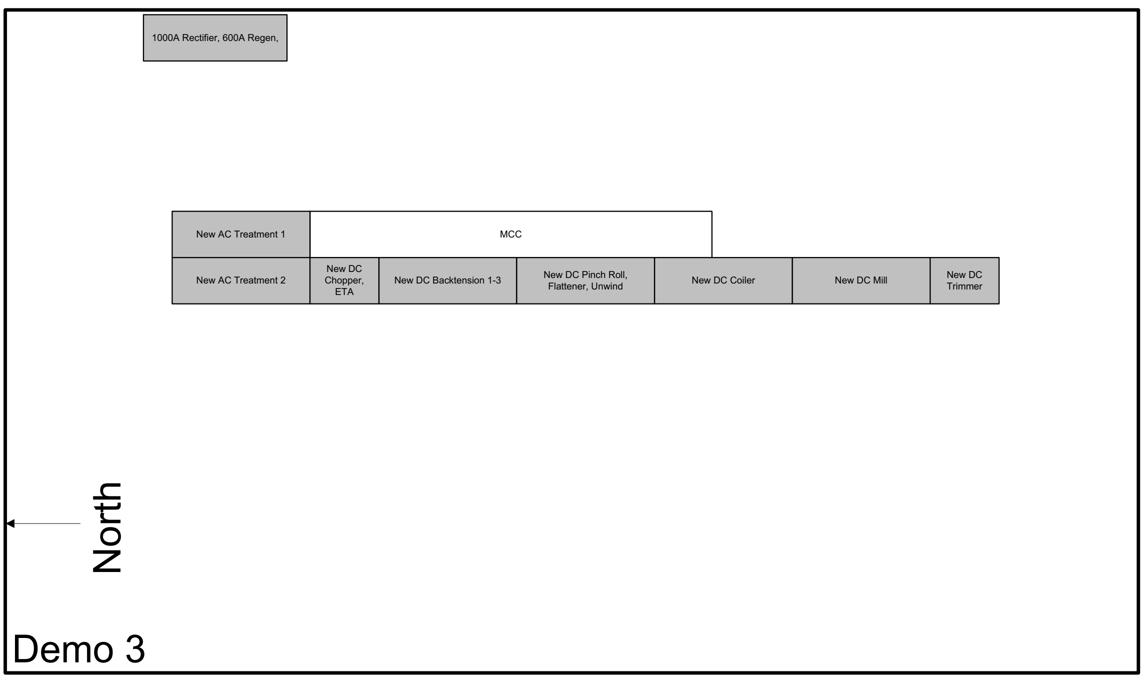


Figure 16. Stage 3 Drive Room Layout – Old Drives Removed

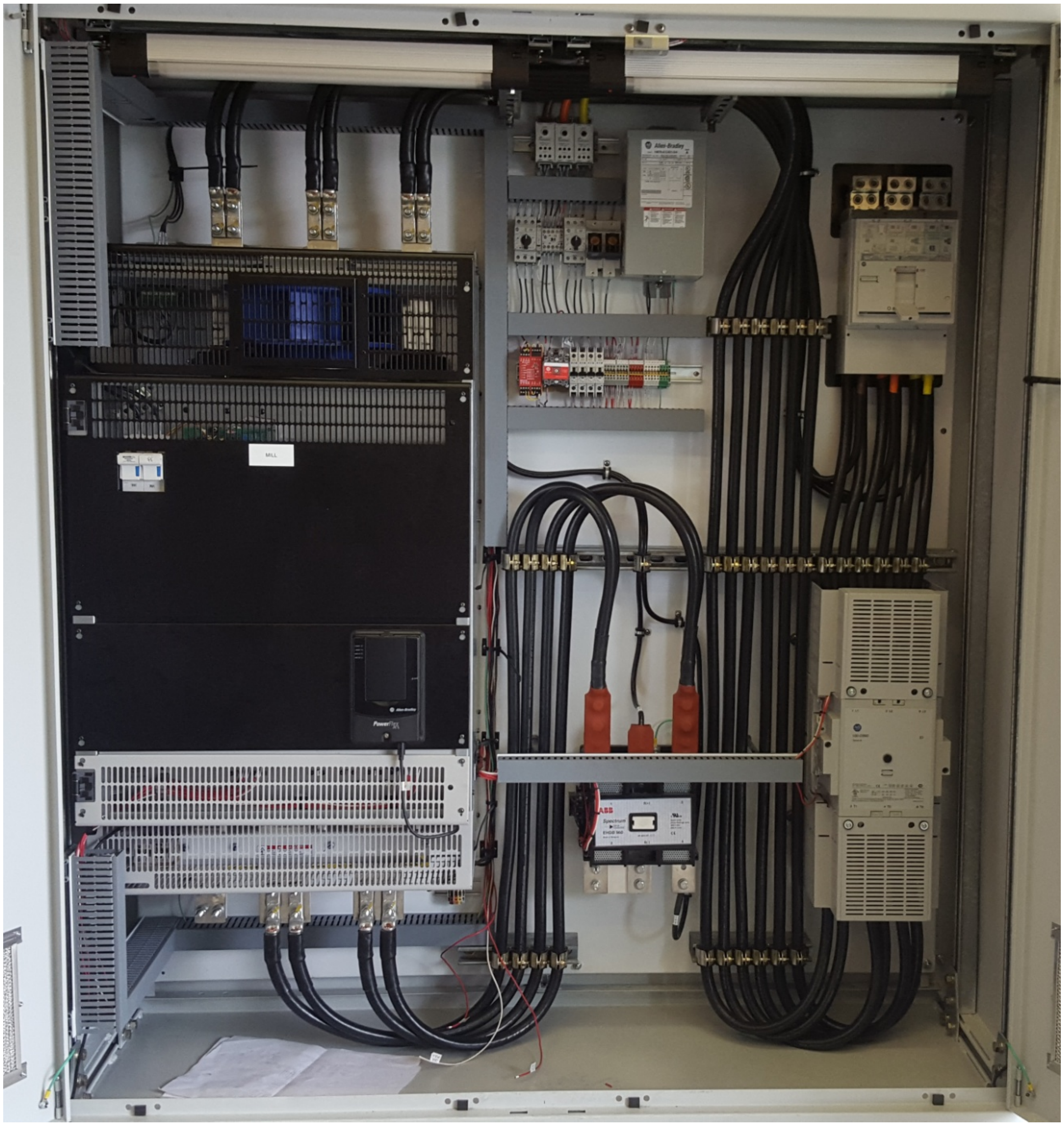


Figure 16. Stage New DC Drive Cabinet (At Shop)

Old DC Drive versus New DC Drive Reference Update Rates

The original PLC system on the line was an Allen-Bradley PLC-5/250 (Pyramid Integrator) for the Line Sequencing and an Allen-Bradley PLC-5/20E for the Drive Coordination. The two PLC's were combined into one Rockwell ControlLogix L61 (it has since become an L72). The original PLC-5/20E Drive Coordination Controller Main Rack became a RIO Rack to the new ControlLogix. This created a lag in update rates that led to a 'surging' on the line during acceleration & deceleration as the various Drive References were updated at the RIO Block Transfer Rates (~250 milliseconds). Since the Drive Upgrade was in the near future (it was delayed), this ended up being masked by putting in a small ramp in the Drive Parameters versus putting in ControlLogix analog outputs for the Drive References.

Once the Drive Upgrade started, the new AC and DC Drives updated at a much faster rate via Ethernet References. This created 'surging' during acceleration and deceleration, but worse than before. The RIO Block Transfer Writes used to update the Analog Reference to the Old DC Drives give a 'Done' bit once the update is completed. We used the 'Done' bit from the Old Uncoiler Drive on the Entry, and either the Old Mill Drive (when in service) or the Old Recoiler Drive on the Exit to trigger a pulsed update of the Speed Reference to the New Drives in question. This allowed the New Drives to stay coordinated with the Old Drives during the multiple upgrade stages. Once the Drive Upgrade was complete this was removed and the 'Done' bit Reference Update and allowed the New Drives to update with the code execution scans.

Recoiler Tension

The original system scaled the Recoiler Tension Reference in PSI from the HMI to an Armature Current Reference. This made the 'Tension Reference in PSI' more of a 'Tension Reference in Pounds' under most circumstances. The Exit Strip Tension would remain somewhat constant due to the Recoiler Field Weakening curve coinciding with the Coil Diameter build-up. However changes in speed or running at a lower speed could result in changes in Exit Strip Tension, since the Field Weakening curve would no longer coincide with the Coil Diameter build-up. I changed this to be a true Tension Reference in PSI, regulating itself via the appropriate Motor Torque based on Coil Diameter and Material Cross-Sectional Area. This change resulted in the Pickle Line running differently than what the operators were used to and unnecessarily created a learning curve. In hindsight it would have been better to have let the Pickle Line run in a manner the operators were used to, and approach the customer about changes to the Drive Coordination and Tensions after the fact.

Conclusions

Stage 1, Stage 1.5, Stage 2, and the Temper Mill went very smoothly with very little down time. Stage 3 had more challenges, but that was self-induced by changing the manner in which a high-horsepower motor ran on the line. In total, the Pickle Line Drives were upgraded away from obsolete DC Drives, problem motors were replaced with higher horsepower & lower maintenance motors, and it was achieved using existing short outages to minimize loss of production time.

Acknowledgements

The logistics on this project were challenging and the success was due in large part to The customer's technical personnel who were very much partners in this project, along with IPSI's staff: Billy White, Darrell Hester, Andrew Broadfoot, DeLaura Merritt, and Jack Vincent.