# Medupi Unit 6 ACC hot cleaning: Method and results

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# Overview

- Background
- Medupi ACC hot cleaning - general
- Initial ACC hot cleaning plan
- Revised ACC hot cleaning plan
- Hot cleaning: photos, inspections and observations
- Hot cleaning results
- Conclusion
- Acknowledgements

# Background

- Eskom is South Africa's main electricity provider, with installed capacity of approx. 44 000 MW
- A new coal fired base load power station is currently under construction – called Medupi
- Medupi is a 6 x 794 MW power station
- Construction started from Unit 6
- The power station is dry-cooled and employs Air Cooled Condensers
- A significant milestone during commissioning is the hot commissioning or so called hot cleaning of the ACC
- Hot cleaning of the Unit 6 Medupi ACC was performed during the last days of Jan 2015 and first days of Feb 2015

# Background

- Lateral exhaust turbines supplied by Alstom
- Medupi's ACC is supplied by GEA
- 8 rows (streets) per Unit
- GEA's 2-row galvanized steel heat exchanger tubes employed
- 64 x 34' Howden ELF8 fans per Unit
- 225 kW Alstom motors & Hansen gearboxes
- 2 x 6m diameter exhaust steam ducts, 50m gap between turbine hall and ACC
- Wind-cross incorporated into design

# Background

- ACC auxiliary building underneath the ACC, containing the main condensate extraction pumps, ACC condensate tank and steam jet air ejectors (2 x 100% hogging ejectors, 2 x 100% holding ejectors)
- 200 $m^3$ ACC condensate tank, located within ACC auxiliary building under the ACC
- 100 $m^3$ Turbine condensate tank (TCT), for collecting miscellaneous turbine and ACC ducting drains, located in the turbine hall
- 1 x 200% (start-up) TCT drain pump
- 2 x 100% (normal operation) TCT drain pump
- (TCT drain pumps return ACC ducting & turbine drains to ACC condensate tank)

# Background

- Medupi Unit 1-6 Air Cooled Condensers (Feb 2015)

# Background

- Medupi Unit 6 Air Cooled Condenser (Feb 2015)

# Background

- Medupi ACC fan bridges under construction

# Background

- Medupi exhaust steam ducting and ACC auxiliary building under the ACC

# Background

- Medupi ACC wind-cross panel with door

# Medupi ACC hot cleaning - general

- In general, the following methodology was followed for hot cleaning:
  - ACC cleaned mechanically (brushing / sweeping) prior to steam admission to ACC
  - Steam from LP bypass flows into ACC to remove impurities and debris
  - Two phases employed – dump phase, where condensate is dumped and bypass phase, where condensate is returned to cycle for circulation as per normal operation
  - During dump phase – condensate is re-routed prior to reaching the ACC condensate tank to a dump line. Dump line routes dirty condensate to a dump tank, located next to the ACC auxiliary building under the ACC. Dumped condensate is routed from dump tank via discharge line to station drains for disposal
  - During bypass phase, condensate is routed to the CPP before returning condensate to the rest of the water-steam cycle

# Medupi ACC hot cleaning - general

- In general, the following methodology was followed for hot cleaning:
  - During bypass phase, CPP to remove remaining impurities with pre-filters as well as resin beds if required
  - When operating fans in specific rows, ensure mirror operation on both sides (LP turbine A and B side) of ACC, i.e. one row operating on left side and one row on right side of ACC
  - Dephlegmator fans should always be running when operating fans in a particular row
  - Hot cleaning steam flow approx. 25% (380 t/h) of MCR steam flow
  - Dirt / debris collected in TCT from ACC ducting pumped to water treatment plant to avoid fouling the ACC condensate tank

# Medupi ACC hot cleaning - general

- In general, the following methodology was followed for hot cleaning:
  - Online TSS sensor in dump line prior to dump tank, for measuring TSS during dump phase
  - Samples taken at CPP for measuring TSS during bypass phase
  - Criteria to stop dump phase TSS = 150 ppm
  - Criteria to stop bypass phase TSS = 10 ppm
  - CPP includes pre-filters, 20 micron commissioning filters and 5 micron operational filters
  - Temperature limitations on CPP pre-filters and resins taken into account

# Medupi ACC hot cleaning - general

- ACC auxiliary building, with dump line routed to ground level (on the right)

# Medupi ACC hot cleaning - general

- ACC hot cleaning dump tank (container), with dump line entering the tank, and discharge line routed to station drains

# Initial hot cleaning plan

- The initial hot cleaning plan included the following aspects:
  - 6 of 8 ACC steam distribution ducts (rows) blanked internally per cleaning cycle. Therefore 4 cleaning cycles (2 rows at a time) to clean one Unit
  - Intention to sustain high steam / condensate temperature (approx. 80°C) within ACC throughout the process, by reducing ACC area with blanked rows and only operating limited fans within those rows at a time (depending on ambient air temperature)
  - Change-over of blanking plates after each cleaning cycle (2 rows); shut-down (3 hours), cool down (9 hours) and change-over time (6 hours) required
- Disadvantage of the initial method is the time required for blanking plate change-over

# Revised hot cleaning plan

- Due to pressure to synchronize Medupi Unit 6, Eskom Engineering requested to investigate methods to accelerate the ACC hot cleaning duration
- Eskom Engineering recommended the removal of the requirement for blanking plates, in order to save time on Unit shut-downs and change-overs
- The above is the same as method followed on Eskom's previous power stations with ACC's – Matimba and Majuba, as well as similar to the method proposed on Eskom's Kusile power station ACC (SPX)
- (Kusile power station is currently being constructed. It is a sister station to Medupi and is a 6 x 798 MW coal-fired base load power station. The Contract for Kusile was placed somewhat behind Medupi).

# Revised hot cleaning plan

- The revised hot cleaning plan included the following aspects:
  - Steam admitted to all 8 rows simultaneously
  - Generally cleaning of ACC in row pairs, fans operated in those rows only in order to concentrate steam flow to the specific fans operated. Switching to the next row pair after a certain time period.
  - Intention to use a combination of high steam / condensate temperature (high backpressure) and high steam velocity (low backpressure) during alternate periods in order to aim to achieve best cleaning effect
  - High backpressures achieved by running small number of fans during higher ambient temperatures.
  - During times of low backpressures (low ambient temperatures), alternate between running a small number of fans – to obtain high steam velocities at heat exchanger tubes or all 64 fans – to obtain high steam velocities in main ducting

# Revised hot cleaning plan

- The revised hot cleaning plan included the following aspects:
  - Calculations performed with Eskom in-house software to determine approx. temperatures and velocities in different areas of the ACC which could be expected during ACC hot cleaning
  - Typical ambient temperatures taken into account for time of the year and time of day at Medupi site
  - 3 Cases specified, based on calculations (independent on whether in dump or bypass phase)
    - Case 1: Low ambient temperature, run limited number of fans
    - Case 2: Higher ambient temperatures, run limited number of fans
    - Case 3: Low ambient temperatures, run all fans

# Revised hot cleaning plan

Eskom calculations:

- Case 1: achieving high steam velocities at heat exchanger tubes
- Case 2: achieving high steam temperatures
- Case 3: achieving high steam velocities in exhaust ducting
  - (Refer to yellow highlighted cells in reference to above)
  - (Natural convection and wind effects ignored)
  - (Steam flow of approx. 105 kg/s or 380 t/h)

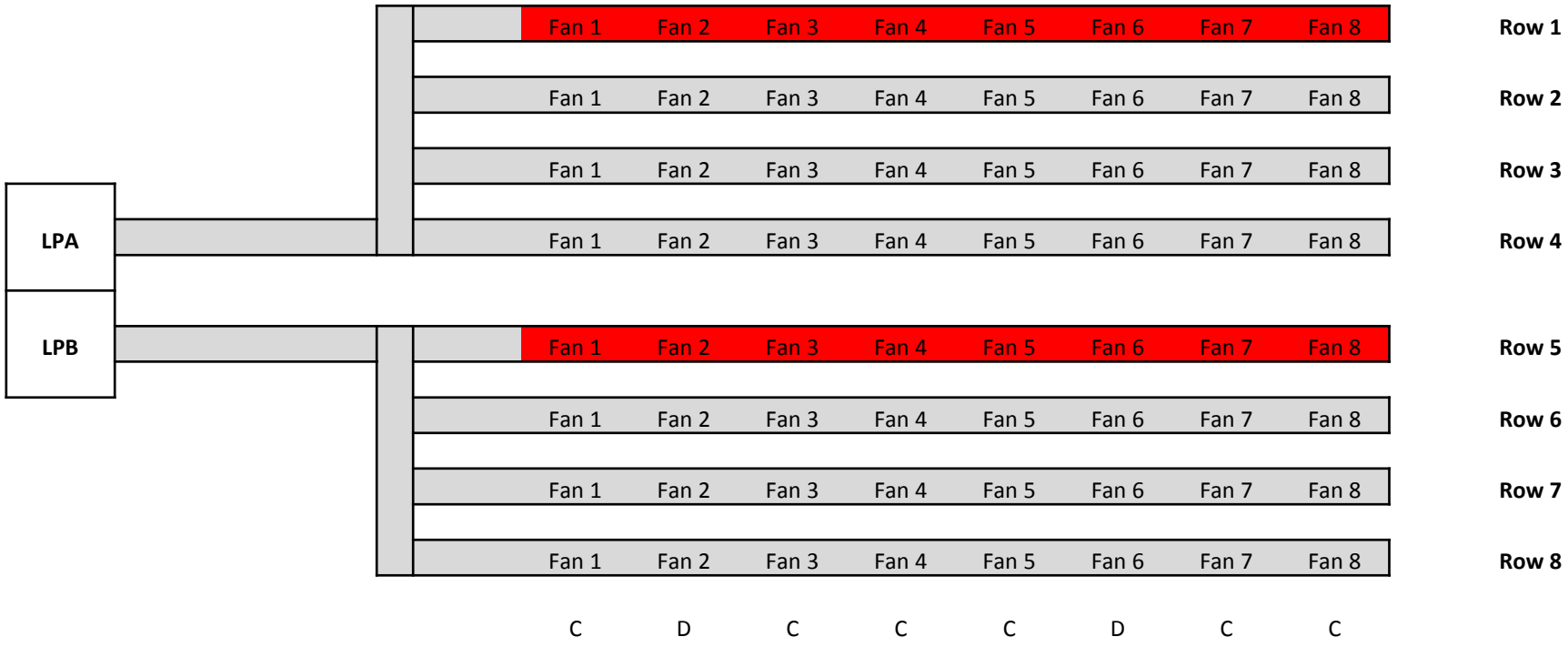
| | Fans in operation | | |
|---|---|---|---|
| | **16** | **10** | **64** |
| **Ambient temperature [°C]** | 23.7 | 35 | 23.7 |
| **Steam mass flow rate (taking part in condensing) [kg/s]** | 103.0 | 106.1 | 100.9 |
| **Heat rejected by ACC to atmosphere [MW]** | 245 | 245 | 245 |
| **Turbine flange backpressure [kPa]** | 13.9 | 47.6 | 4.8 |
| **Turbine flange saturated steam temperature [°C]** | 52.4 | 80 | 32.1 |
| **Steam velocity in exhaust steam ducts [m/s]** | 18.4 | 6.0 | 48.6 |
| **Steam velocity at row 1 heat exchanger tubes [m/s]** | 53.5 | 28.1 | 35.6 |
| **Steam velocity at row 2 heat exchanger tubes [m/s]** | 46.3 | 23.5 | 31.5 |

# Revised hot cleaning plan

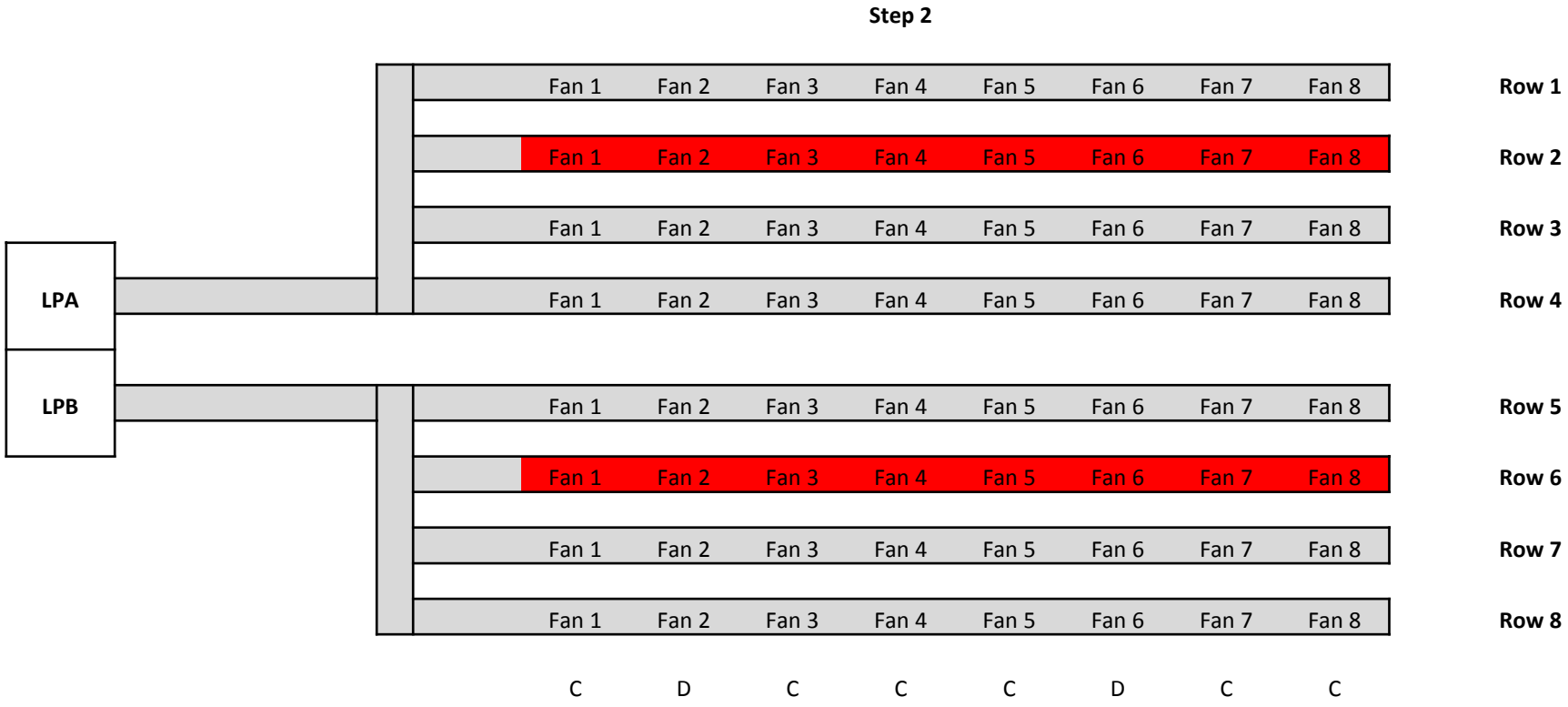
= Running fan

**Case 1: low ambient temperature (23.7°C)**

**Step 1**



# Revised hot cleaning plan



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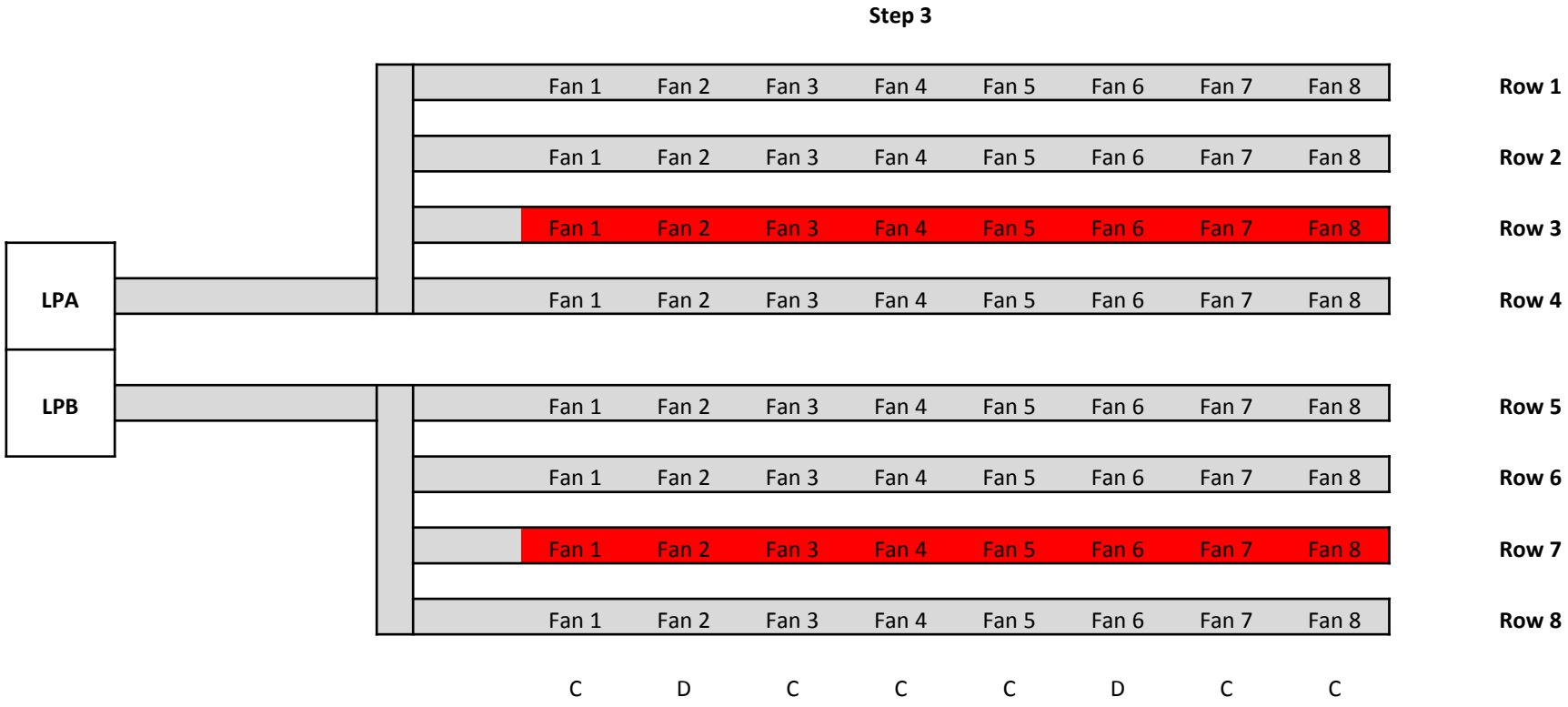

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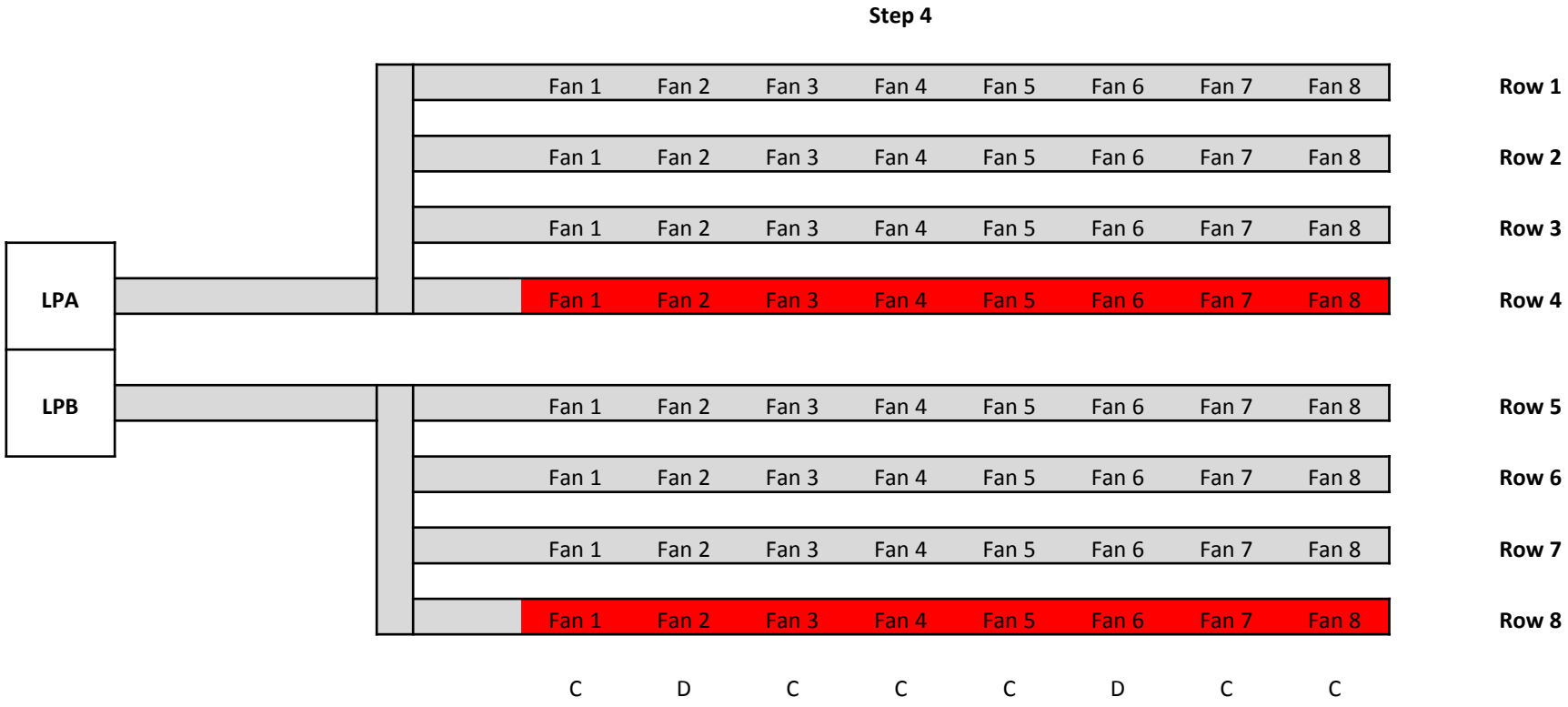
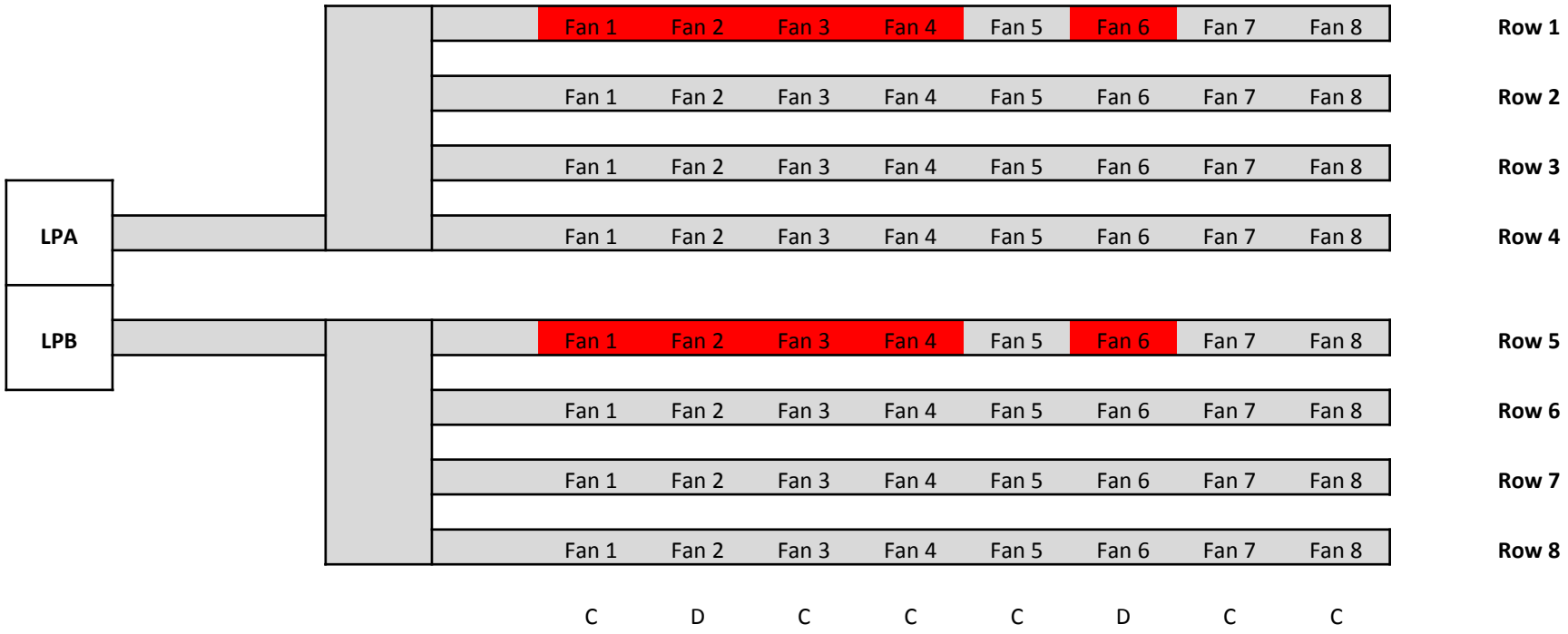


# Revised hot cleaning plan

= Running fan

**Case 2: high ambient temperature (35°C)**

**Step 1**



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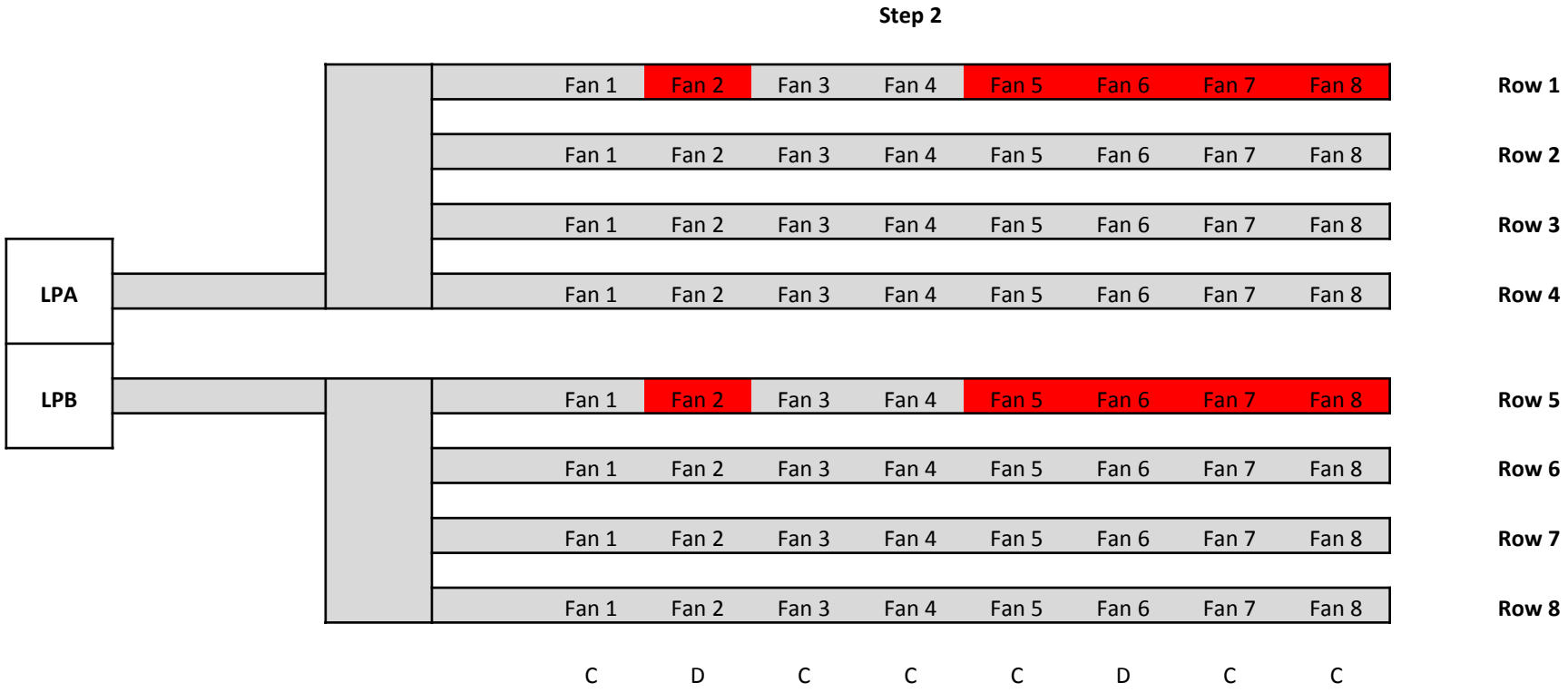

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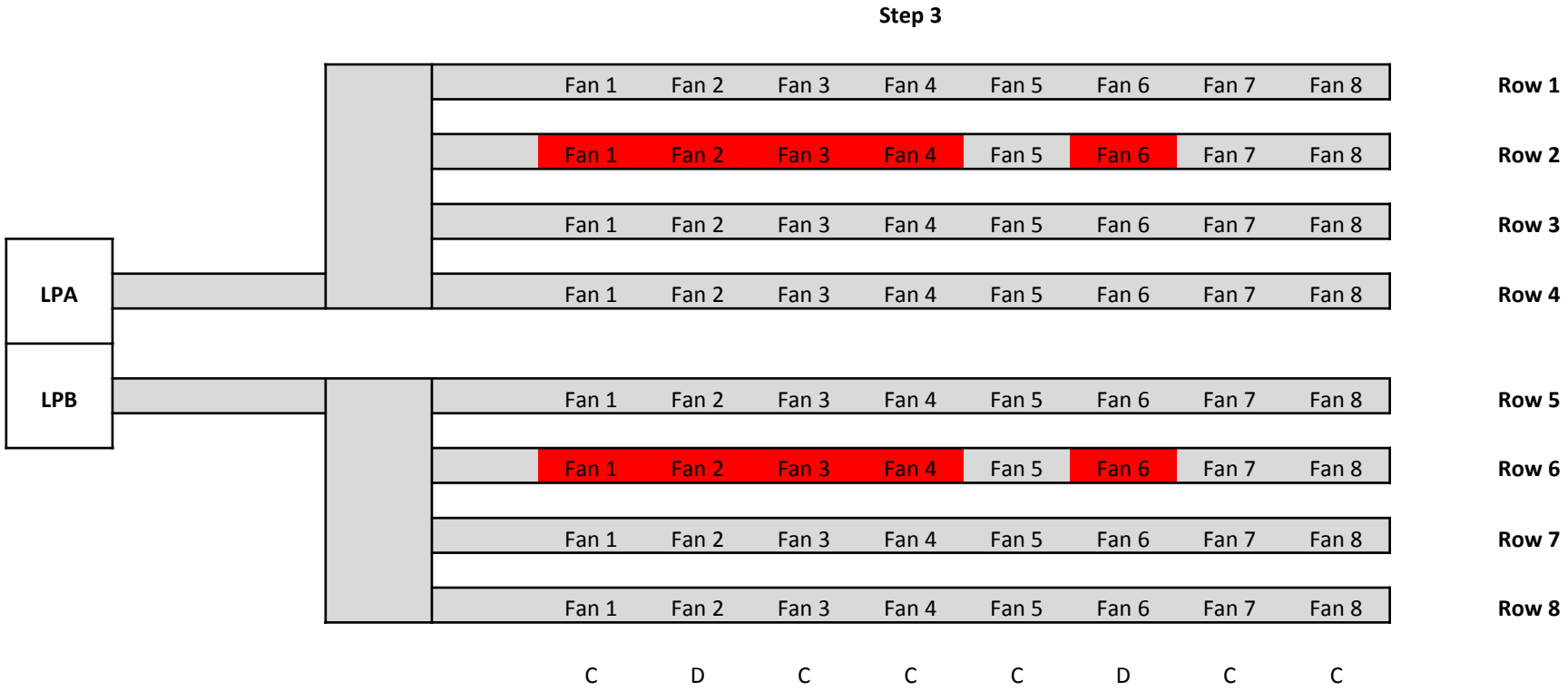
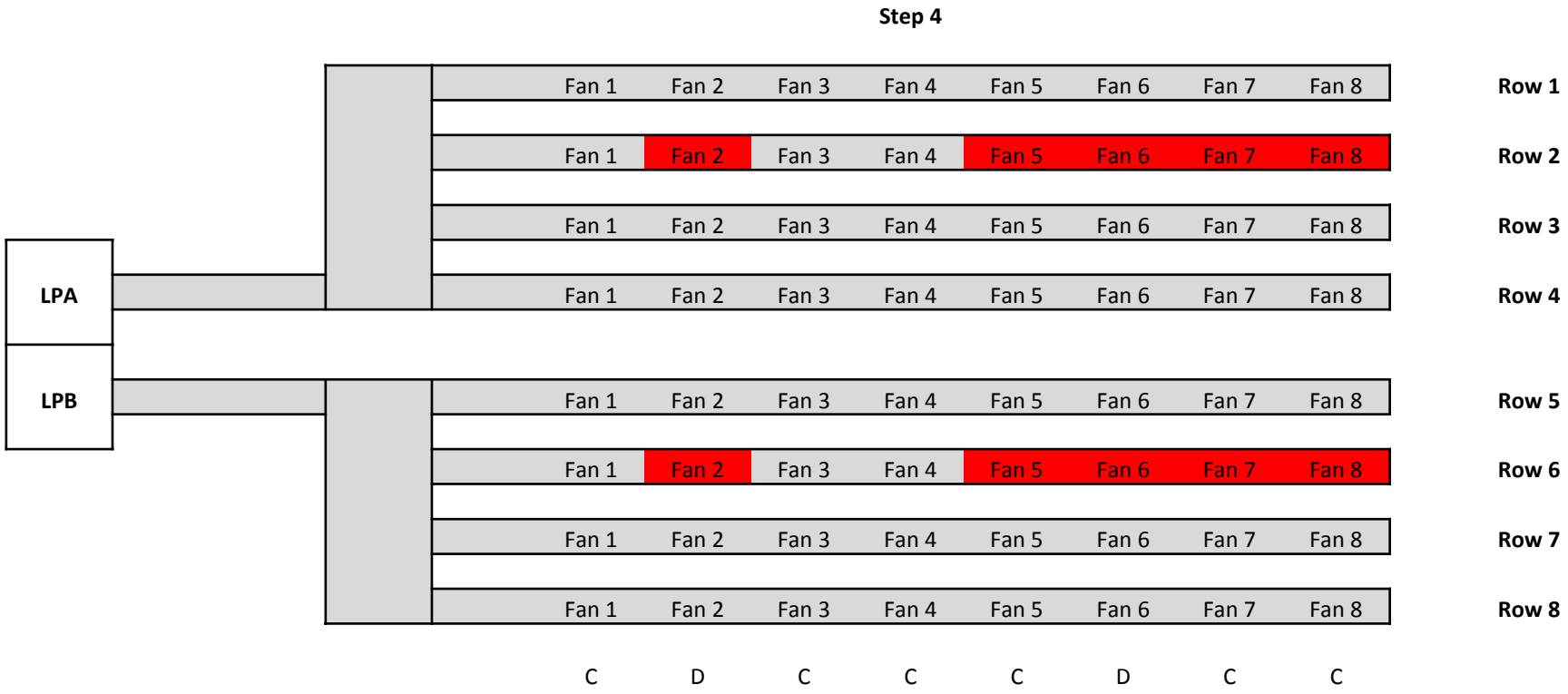
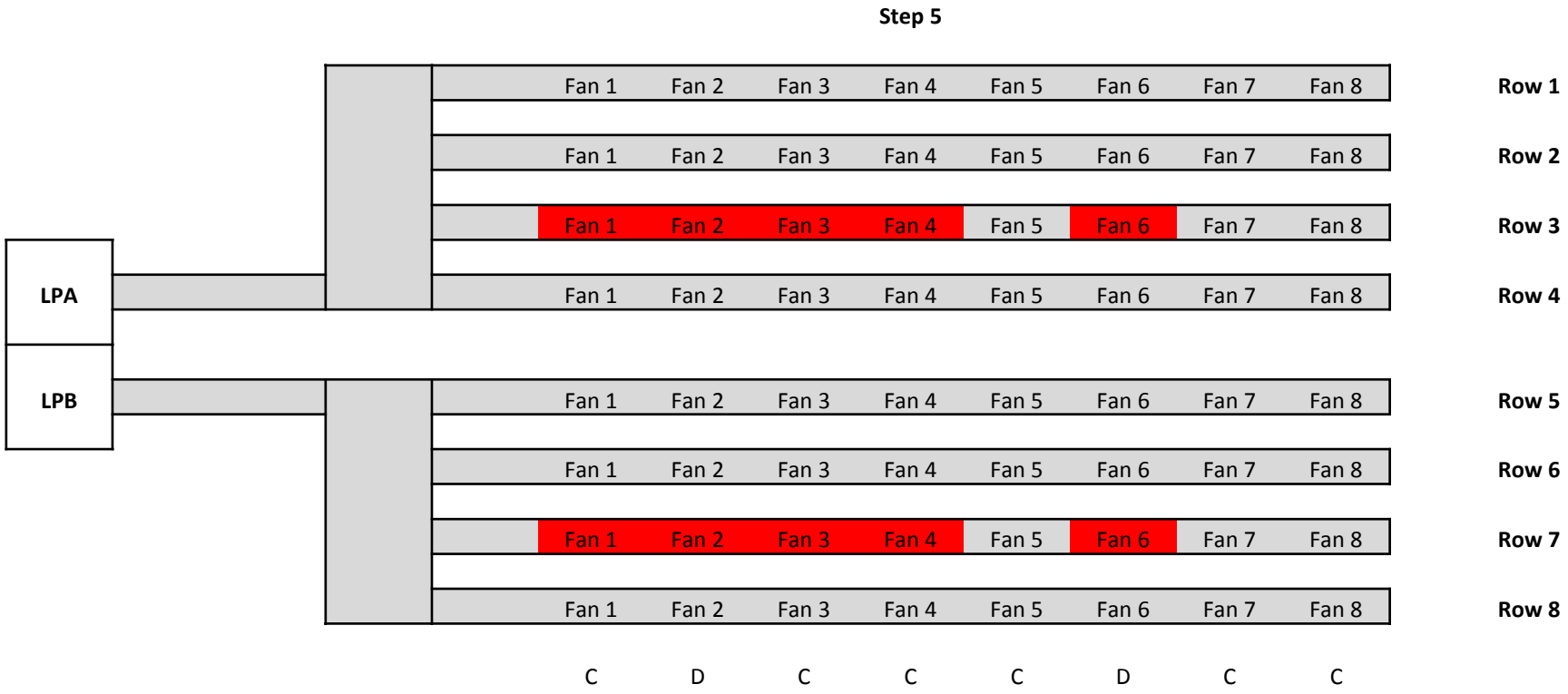


# Revised hot cleaning plan



# Revised hot cleaning plan



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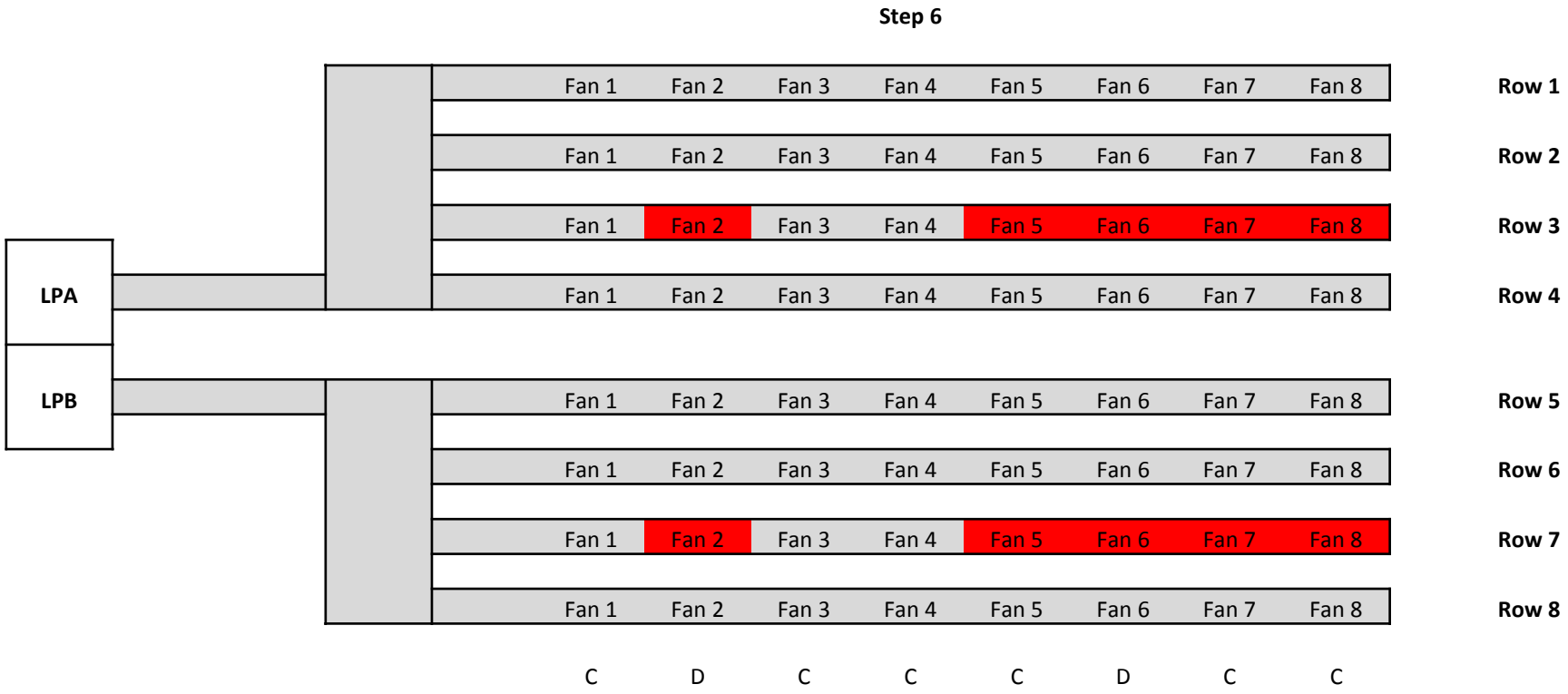

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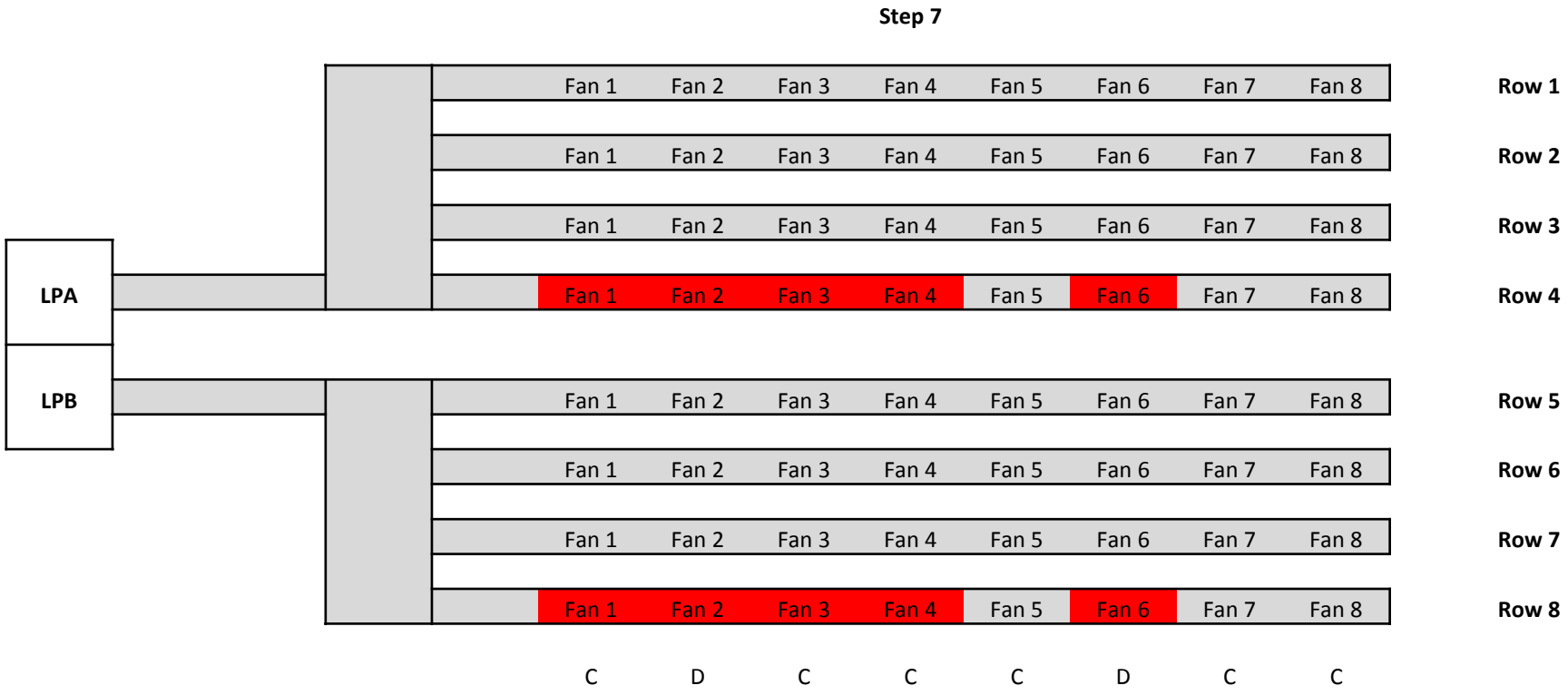

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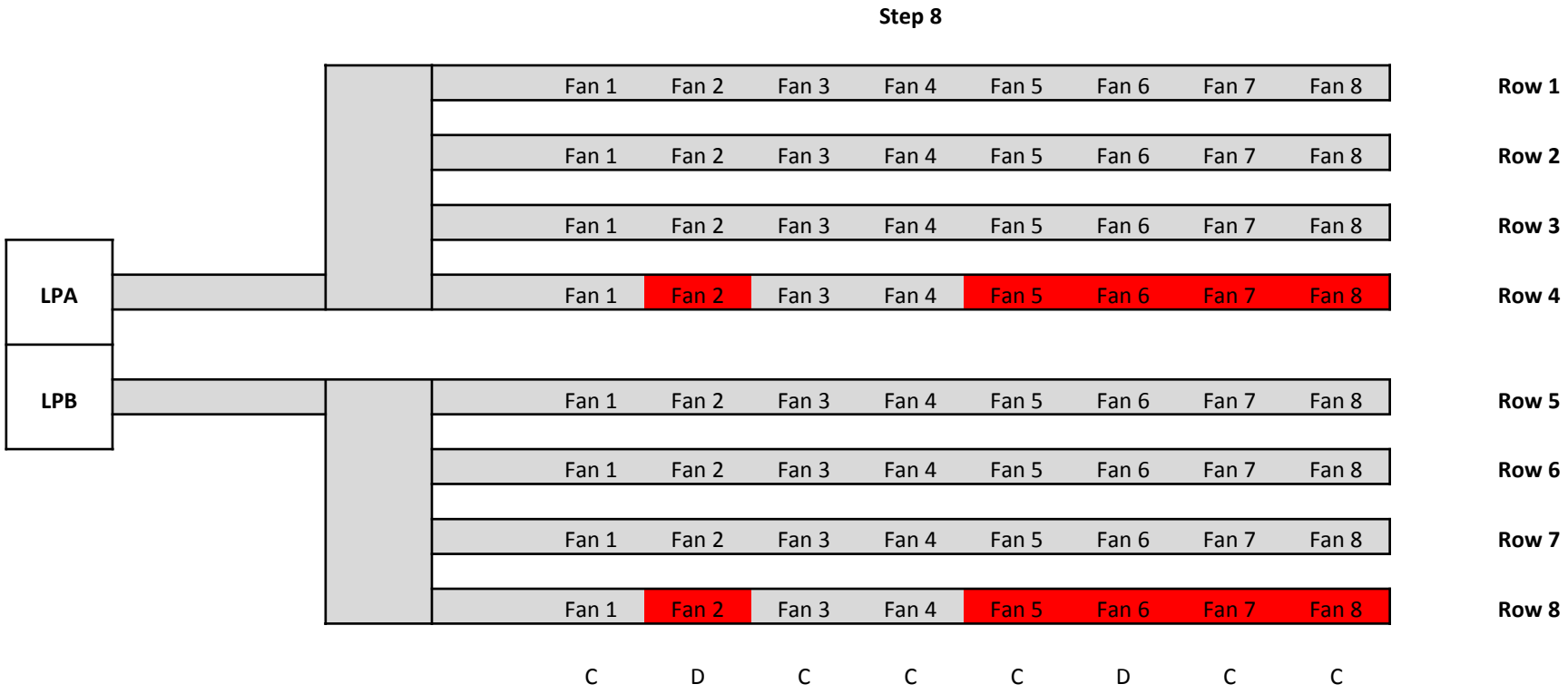
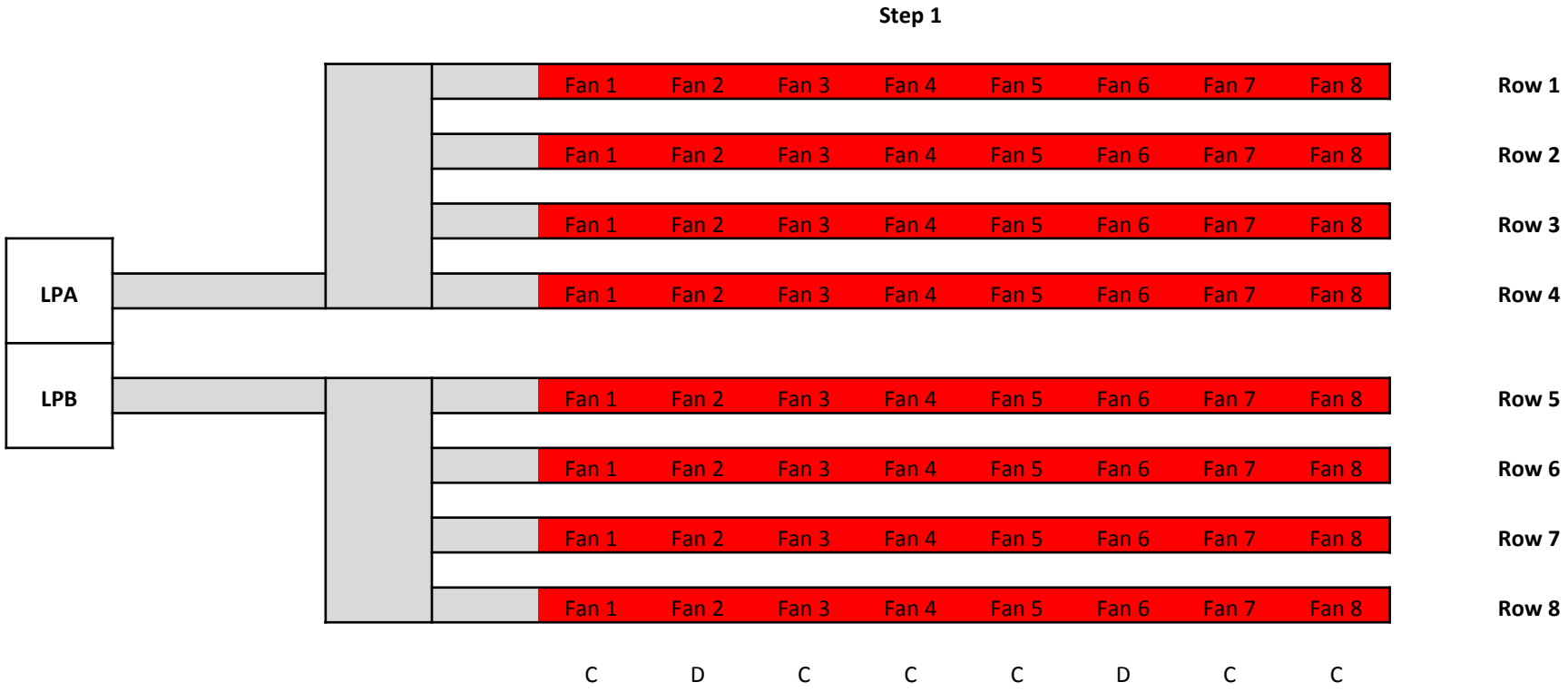


# Revised hot cleaning plan

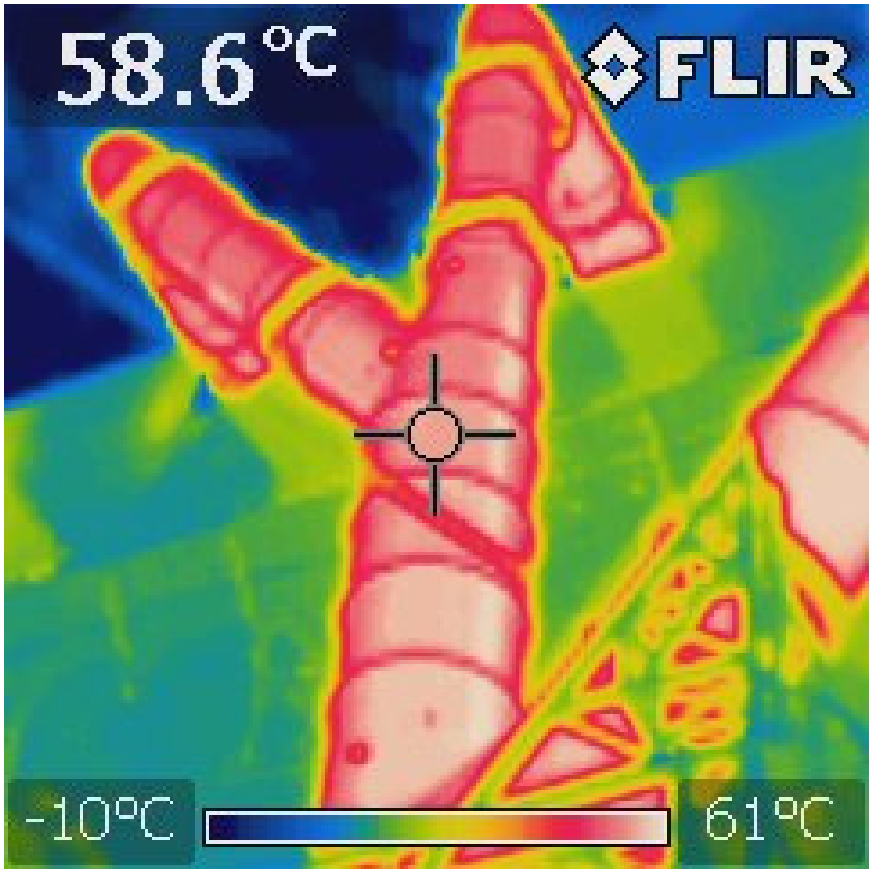
= Running fan

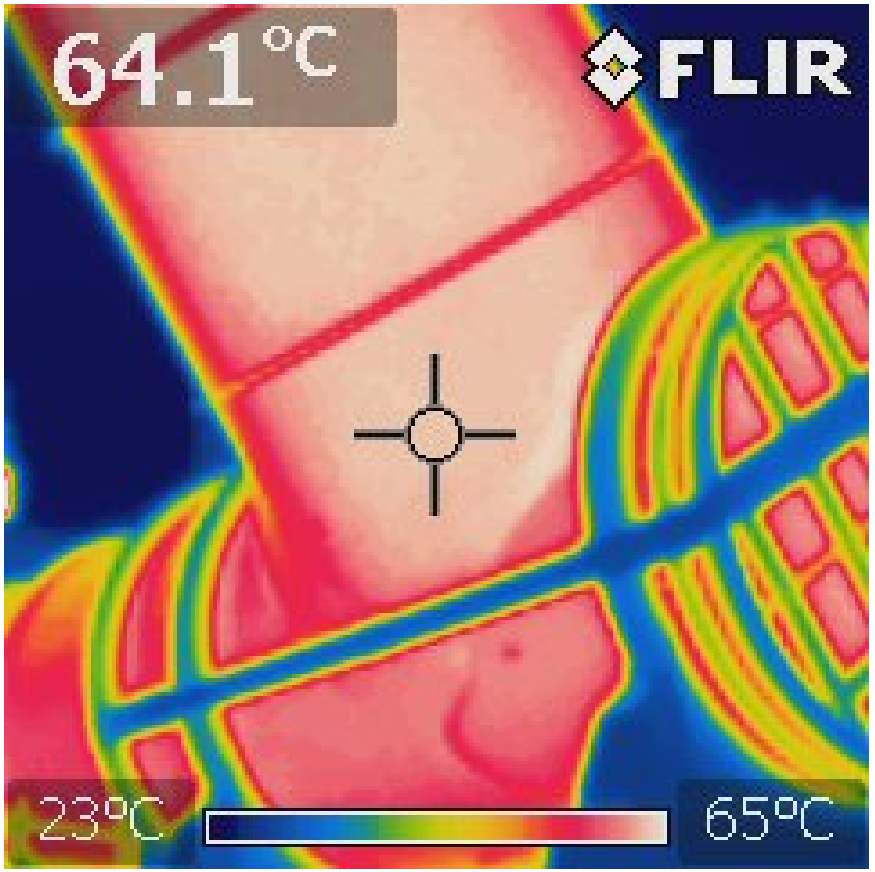
**Case 3: Alternate: low ambient temperature (23.7°C)**



# Hot cleaning: photos, inspections and observations

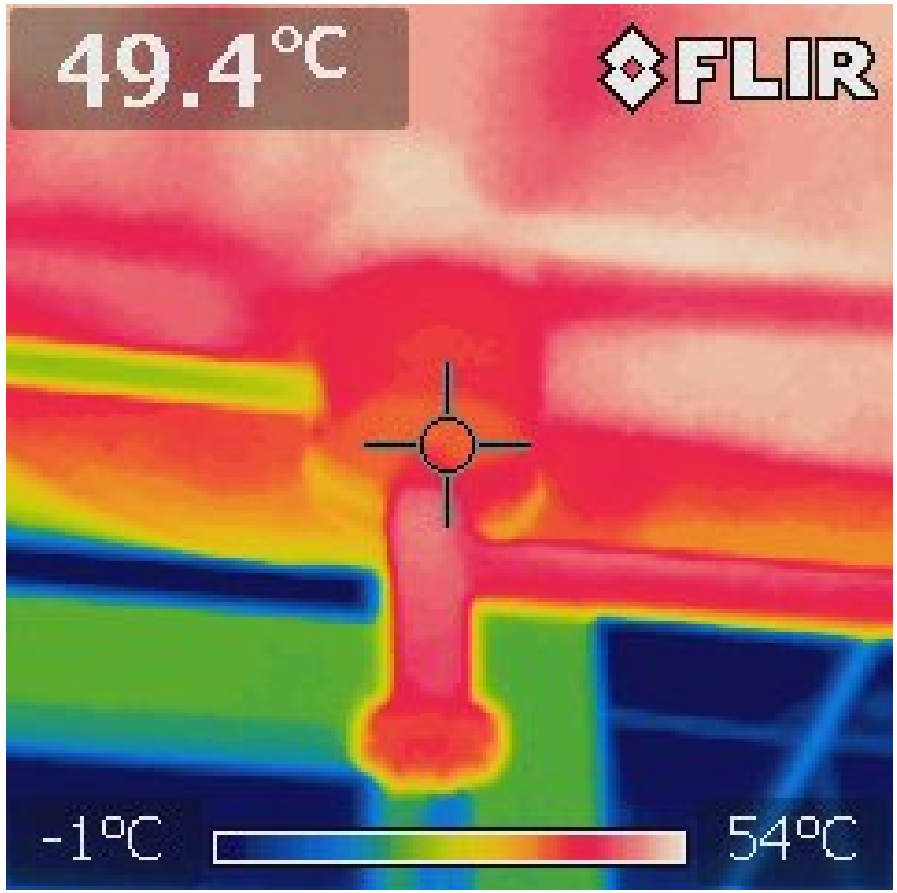
- Thermal photographs during hot cleaning: ducting

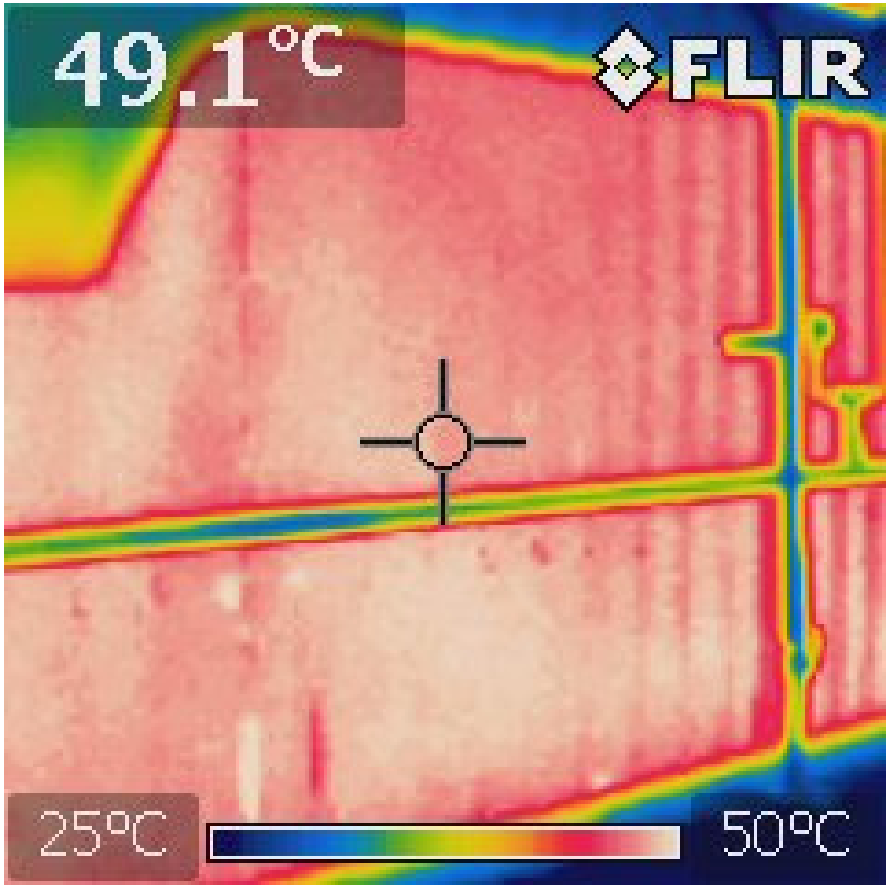


# Hot cleaning: photos, inspections and observations

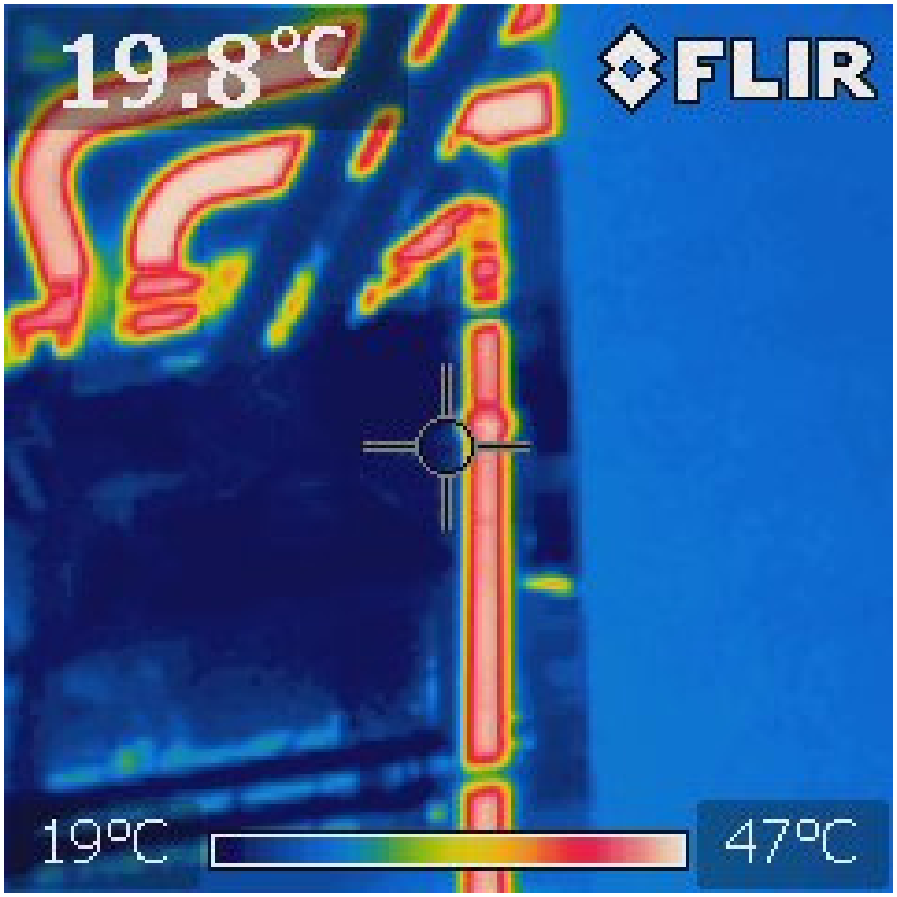
- Thermal photographs during hot cleaning: drain pot and dump tank

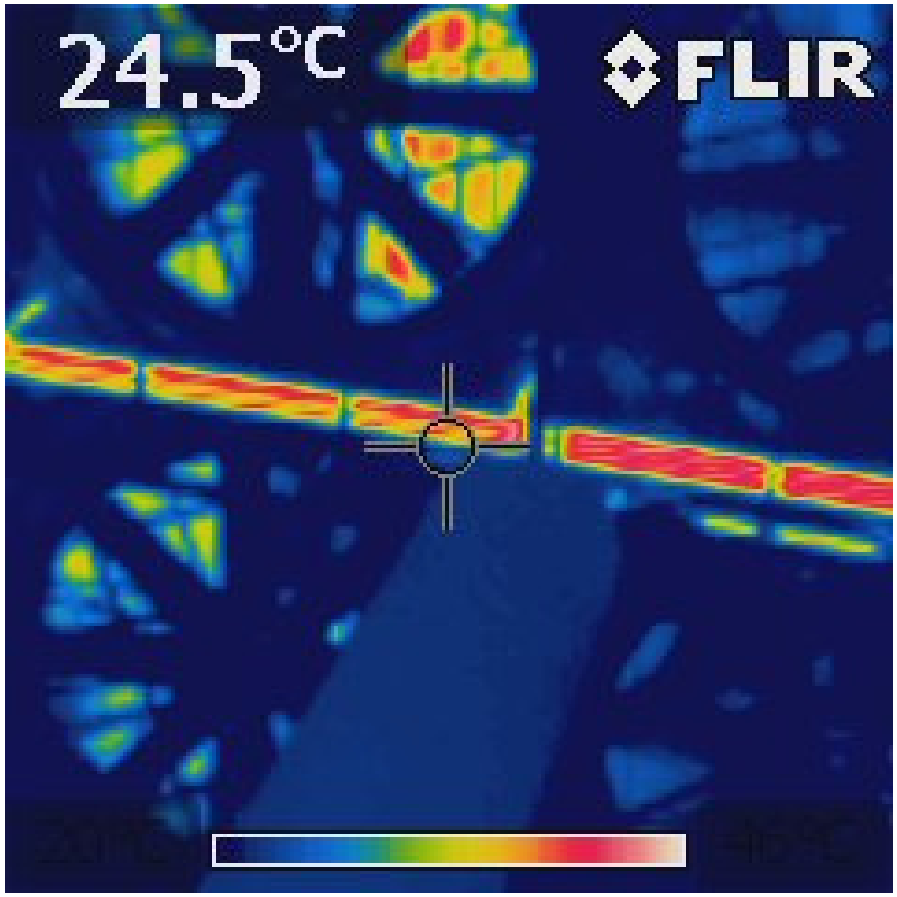


# Hot cleaning: photos, inspections and observations

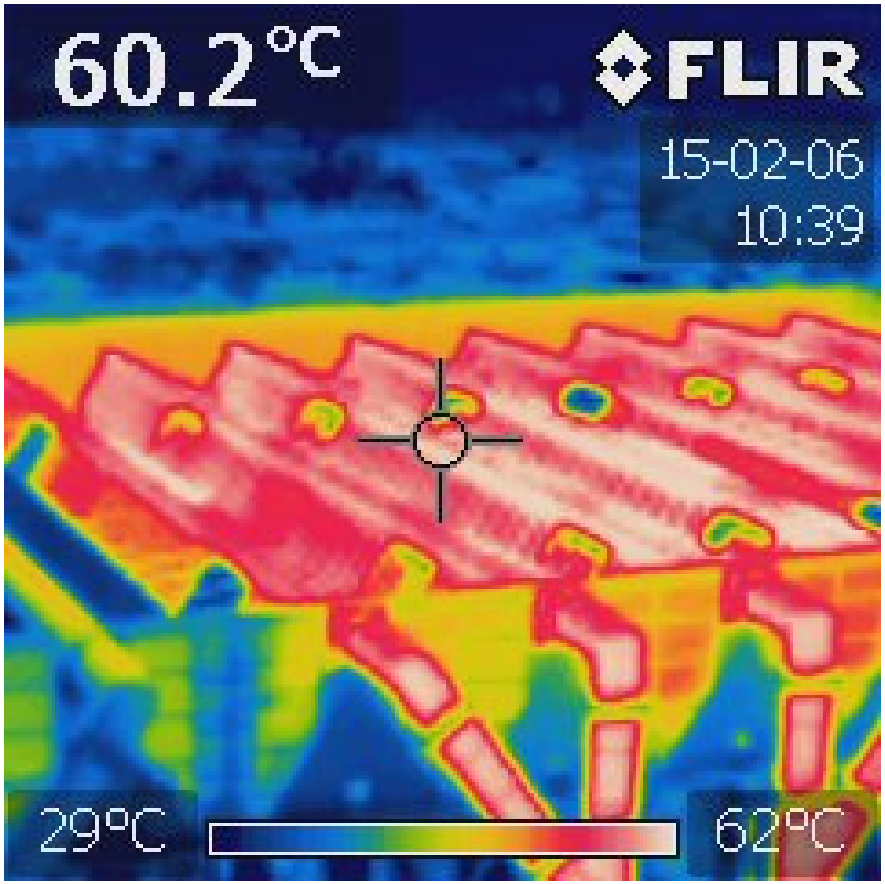
- Thermal photographs during hot cleaning: dump line and condensate drain lines

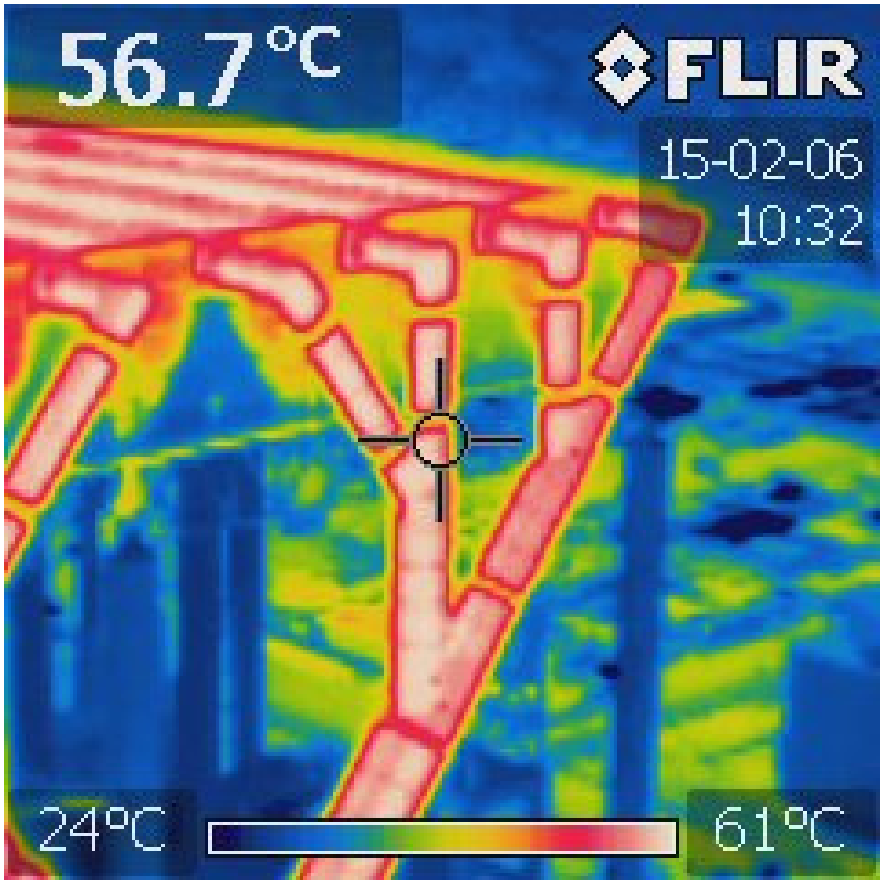


# Hot cleaning: photos, inspections and observations

- Thermal photographs during hot cleaning: bundles and ducting



# Hot cleaning: photos, inspections and observations

- Debris from the ACC found in the dump tank part-way through the process

# Hot cleaning: photos, inspections and observations

- Some of the larger objects found in the dump tank (grinder handles, rocks and desiccant bags)

# Hot cleaning: photos, inspections and observations

- Thermal photographs of various components did not reveal any cold spots, blockages or evident problems
- Initially blocking of TCT drain pump strainers a major problem
  - 150 micron strainers of all 3 TCT drain pumps blocked (pressure differential measurement) within 2 minutes of steam admission to ACC
  - Hot cleaning process has to stop (boiler shut down) to avoid filling ACC exhaust ducting with condensate and over-filling TCT
  - Strainers opened, cleaned and replaced after blocking – taking approx. 30 minutes per strainer
  - Source of major delays to ACC hot cleaning process, exacerbated by instability of the Unit at the time.
  - Problem eventually solved by installing a 1mm strainer on one of the TCT drains pumps to avoid constant blocking

# Hot cleaning: photos, inspections and observations

- Less debris collected in dump tank than expected.  However some large objects found in the dump tank
- Online TSS sensor proved to be inaccurate.  Samples taken to lab for analysis instead
- Samples taken for mostly for each row-pair configuration in operation
- Samples of condensate revealed how quickly ACC was being cleaned
- Other delays during ACC hot cleaning not related to ACC:
  - Boiler trips, turbine barring gear motor trips, demin water supply shortage, tank level controls
  - Due to the above, time required in terms of overall schedule to complete the ACC hot cleaning activity was approx. 3 weeks

# Hot cleaning: photos, inspections and observations

- Blocked TCT drain pump strainer

# Hot cleaning: photos, inspections and observations

- 1st (left) and 2nd (right) condensate samples taken from the dump line during ACC hot cleaning (samples taken a couple of hours from each other)

# Hot cleaning results

- Vacuum raising prior to hot cleaning done successfully on 1st attempt!
- Actual steam flow for hot cleaning kept to approx. 120 kg/s (432 t/h), to ensure stable operation with burners and mills in operation
  - During bypass phase steam flow increased for a short period up to 260 kg/s
- When only taking into account effective ACC hot cleaning time (i.e. steam admission time to ACC), condensate TSS of less than 10 ppm was achieved in **less than 3 days!**
  - Much faster than Eskom or Contractors expected
  - TSS = 150 ppm limit was reached effectively within 1 day of cleaning time

# Hot cleaning results

- TSS results from dump phase

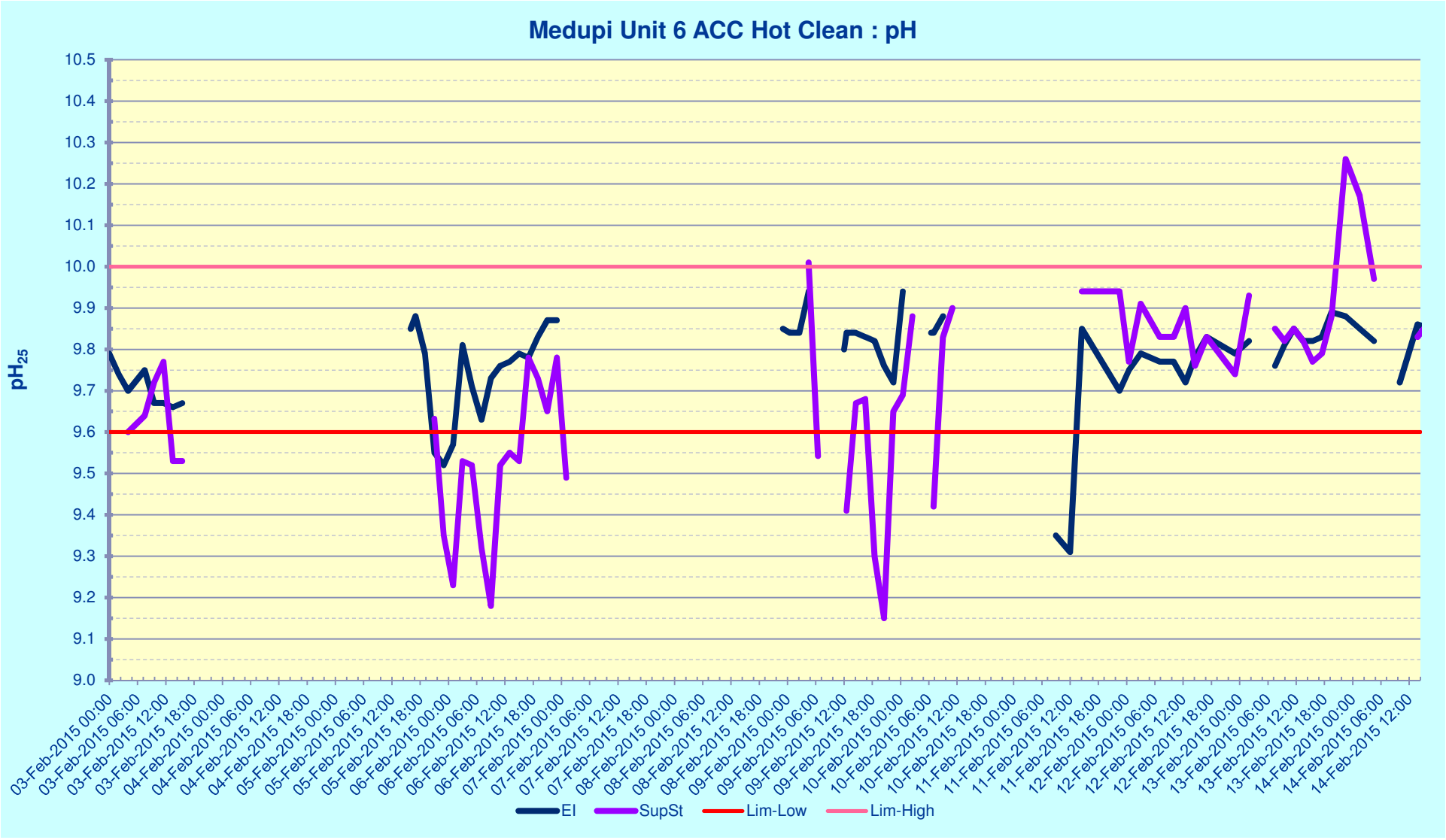
| Date | Time | TSS (ppm) |
|---|---|---|
| 03-Feb-15 | 03:00 | 708 |
| 03-Feb-15 | 05:00 | 1340 |
| 03-Feb-15 | 07:00 | 580 |
| 03-Feb-15 | 17:30 | 432 |
| 06-Feb-15 | 08:00 | 4.1 |
| 06-Feb-15 | 10:00 | 1.05 |
| 06-Feb-15 | 12:00 | 3.05 |
| 06-Feb-15 | 14:00 | 0.8 |
| 06-Feb-15 | 16:00 | 0.85 |
| 06-Feb-15 | 18:00 | 1.3 |
| 06-Feb-15 | 19:30 | 6.05 |
| 06-Feb-15 | 22:30 | 0.35 |
| 06-Feb-15 | 23:30 | 0.8 |
| 07-Feb-15 | 00:30 | 0.3 |
| 07-Feb-15 | 01:30 | 0.4 |
| 07-Feb-15 | 02:30 | 1.2 |
| 07-Feb-15 | 03:00 | 0.2 |
| 09-Feb-15 | 07:30 | 0.1 |
| 09-Feb-15 | 08:30 | 0.05 |

# Hot cleaning results

- Bypass phase started on 10 Feb 2015
- TSS limit to stop ACC hot cleaning had in fact already been reached
- Bypass phase continued for a couple of days to ensure proper functioning of CPP and to ensure acceptable cycle chemistry is obtained in an effort to send steam to set

# Hot cleaning results

- EI = Economiser inlet; SupSt = Superheated steam (main steam)



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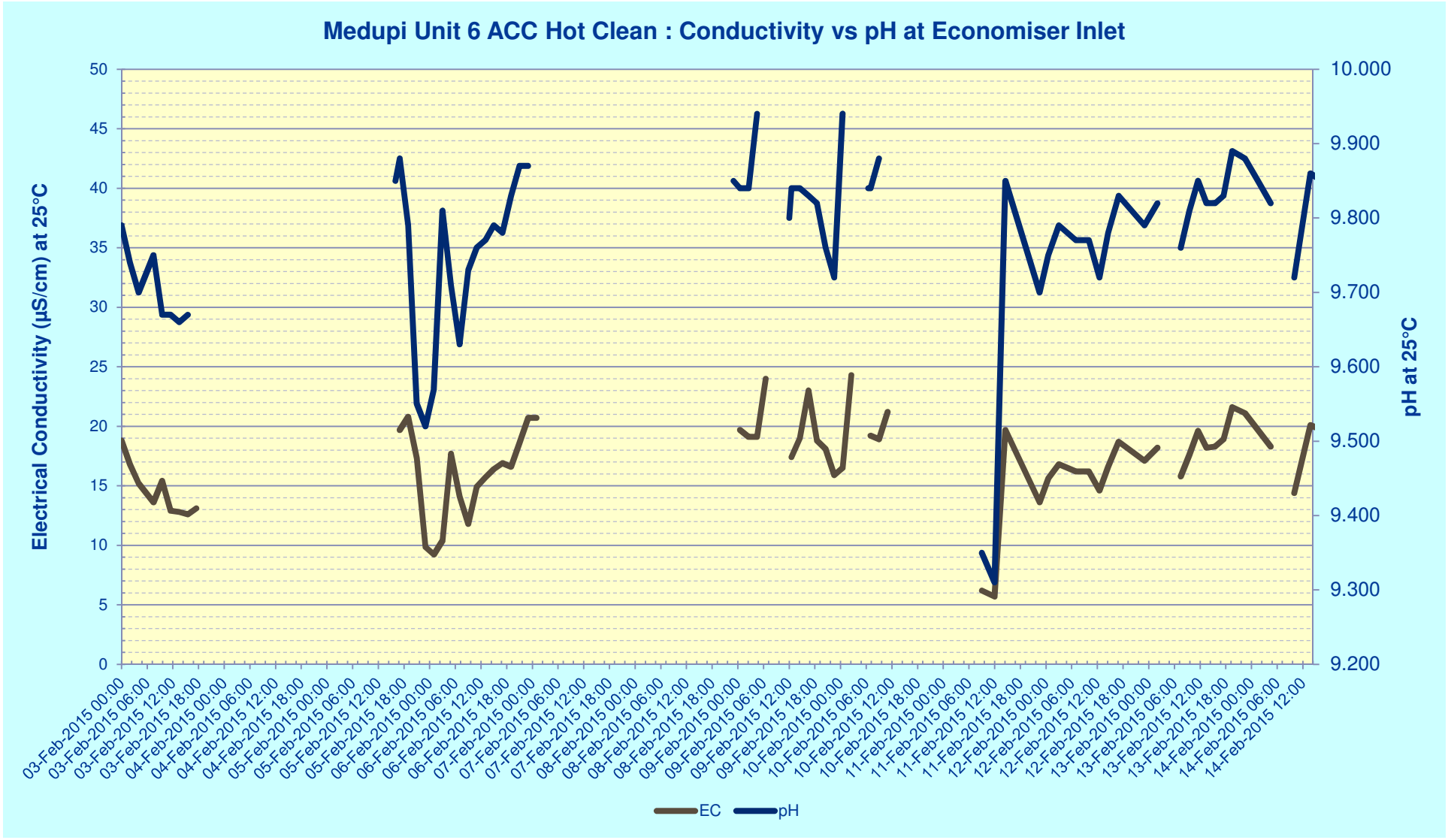
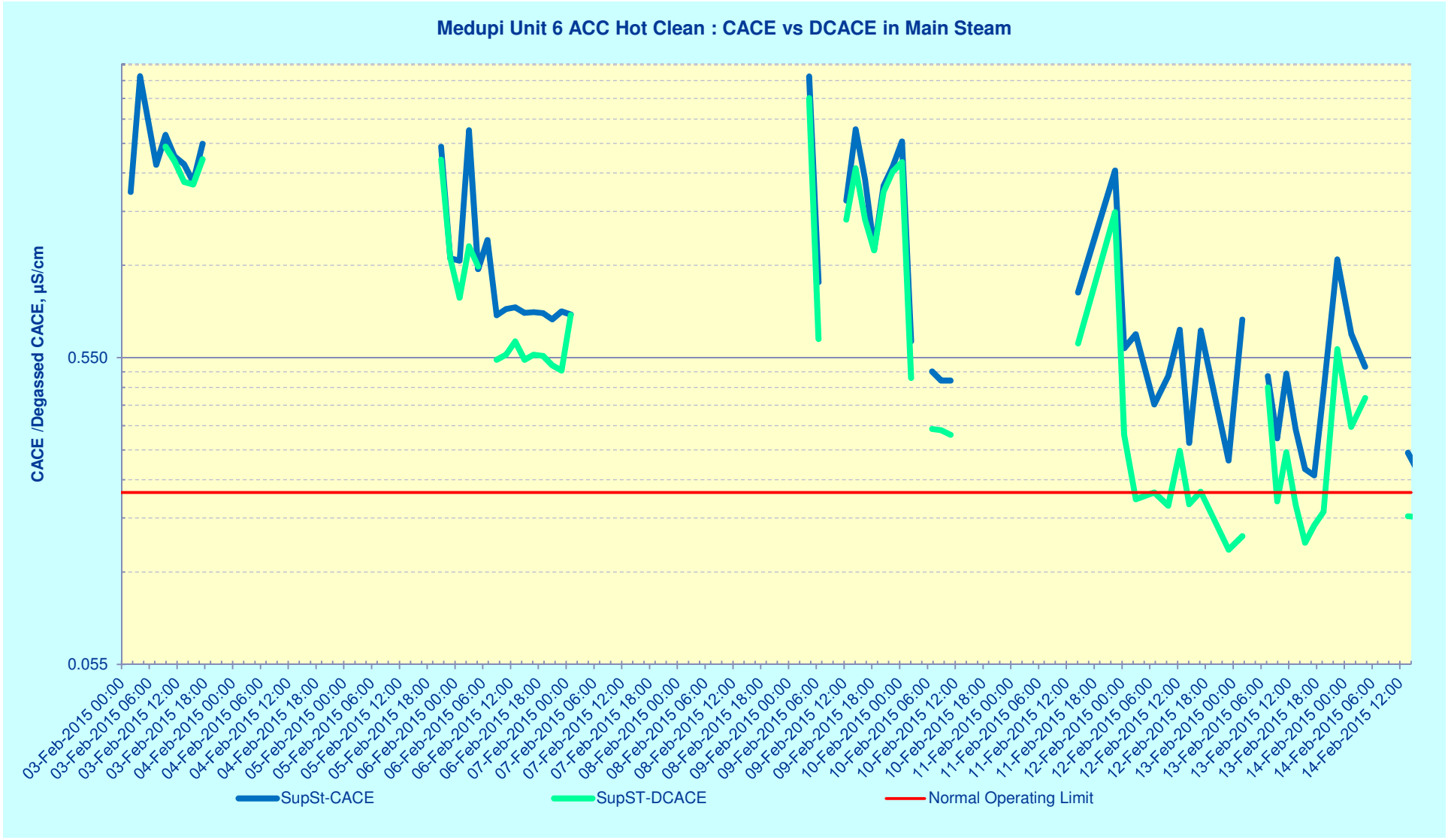


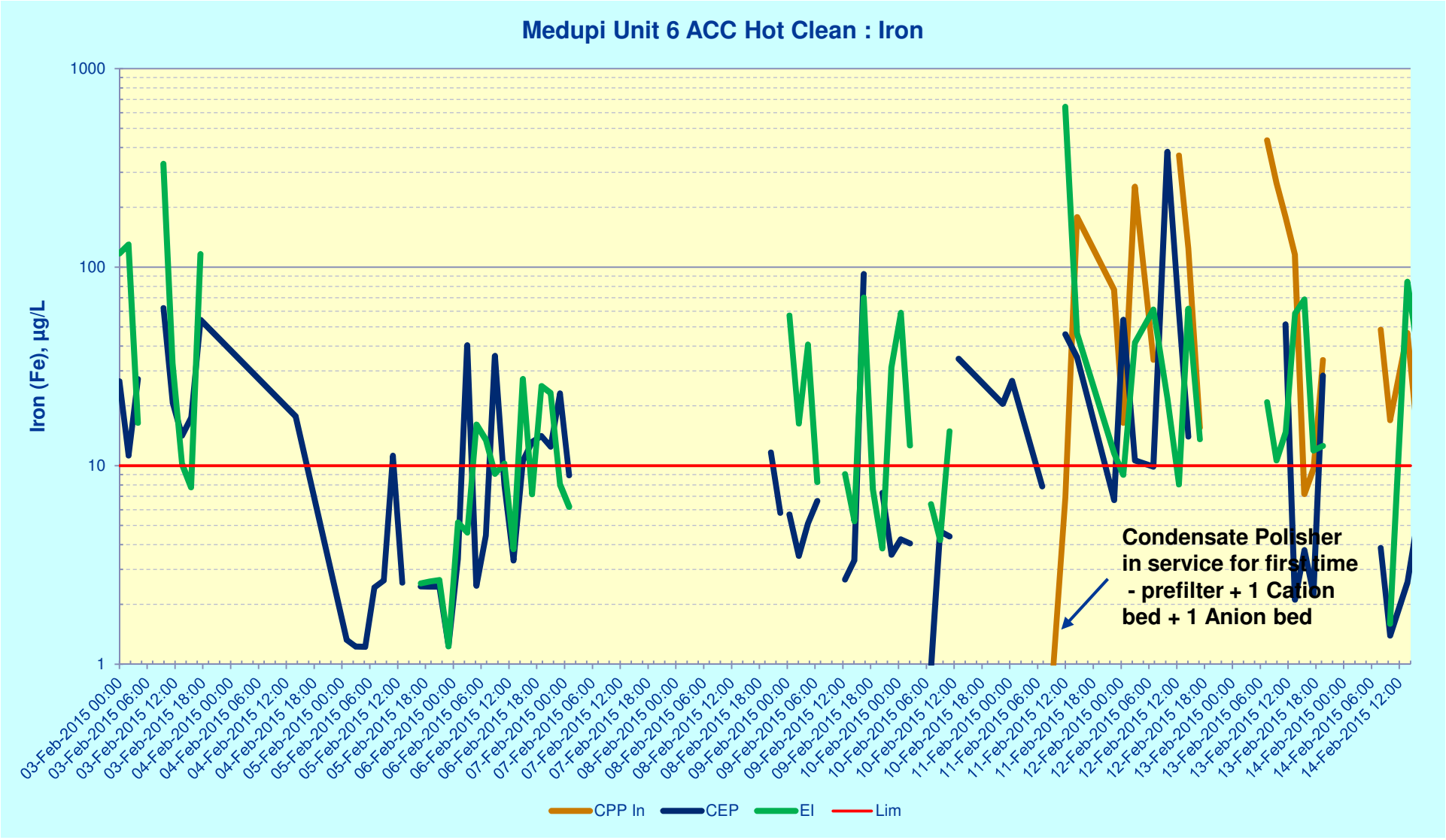
# Hot cleaning results

- SupSt = Superheated steam (main steam)



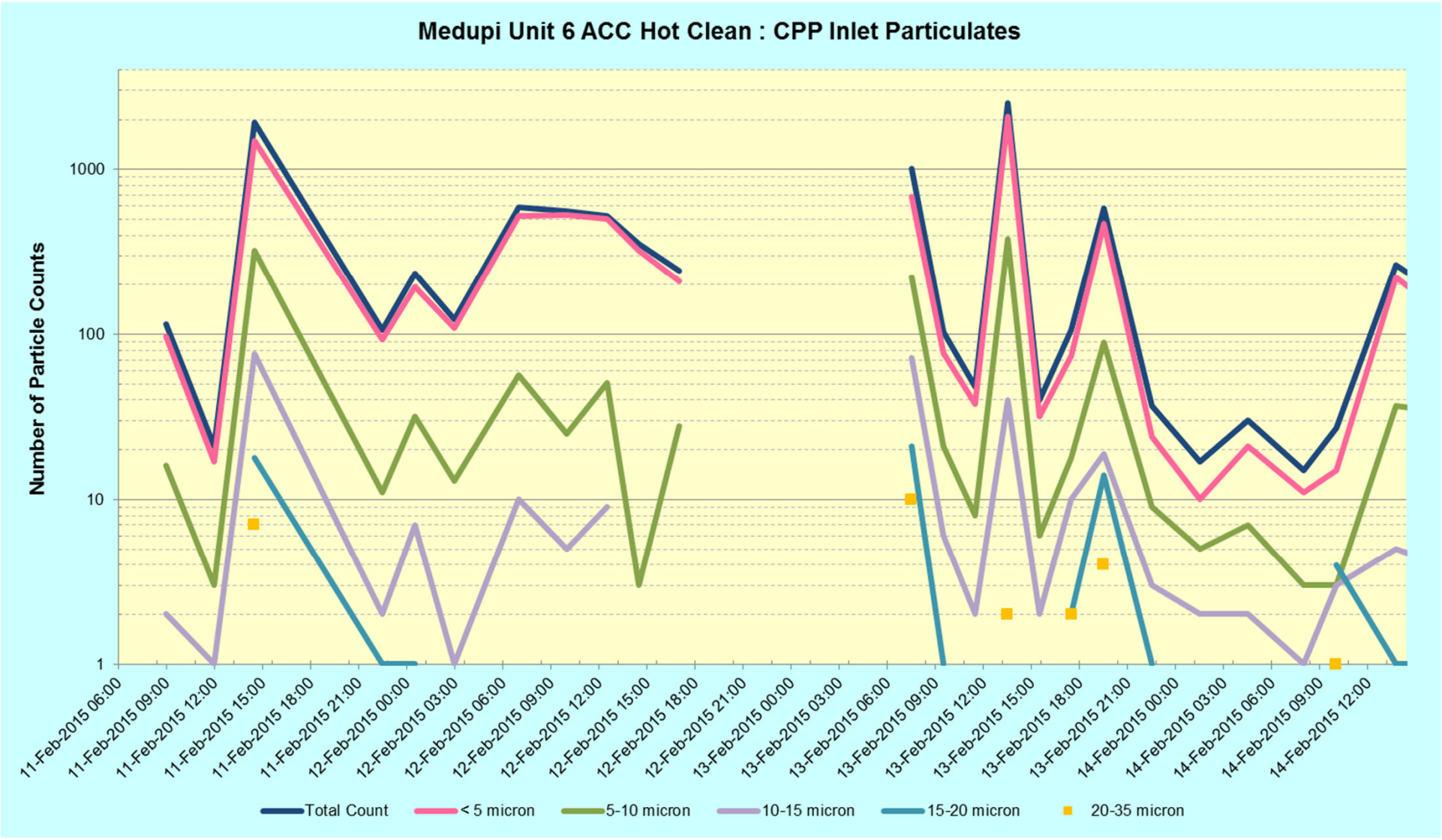
# Hot cleaning results

- CEP = Condensate extraction pump; EI = Economiser inlet



# Hot cleaning results

- Note particulate measurements were done manually every 2 hours



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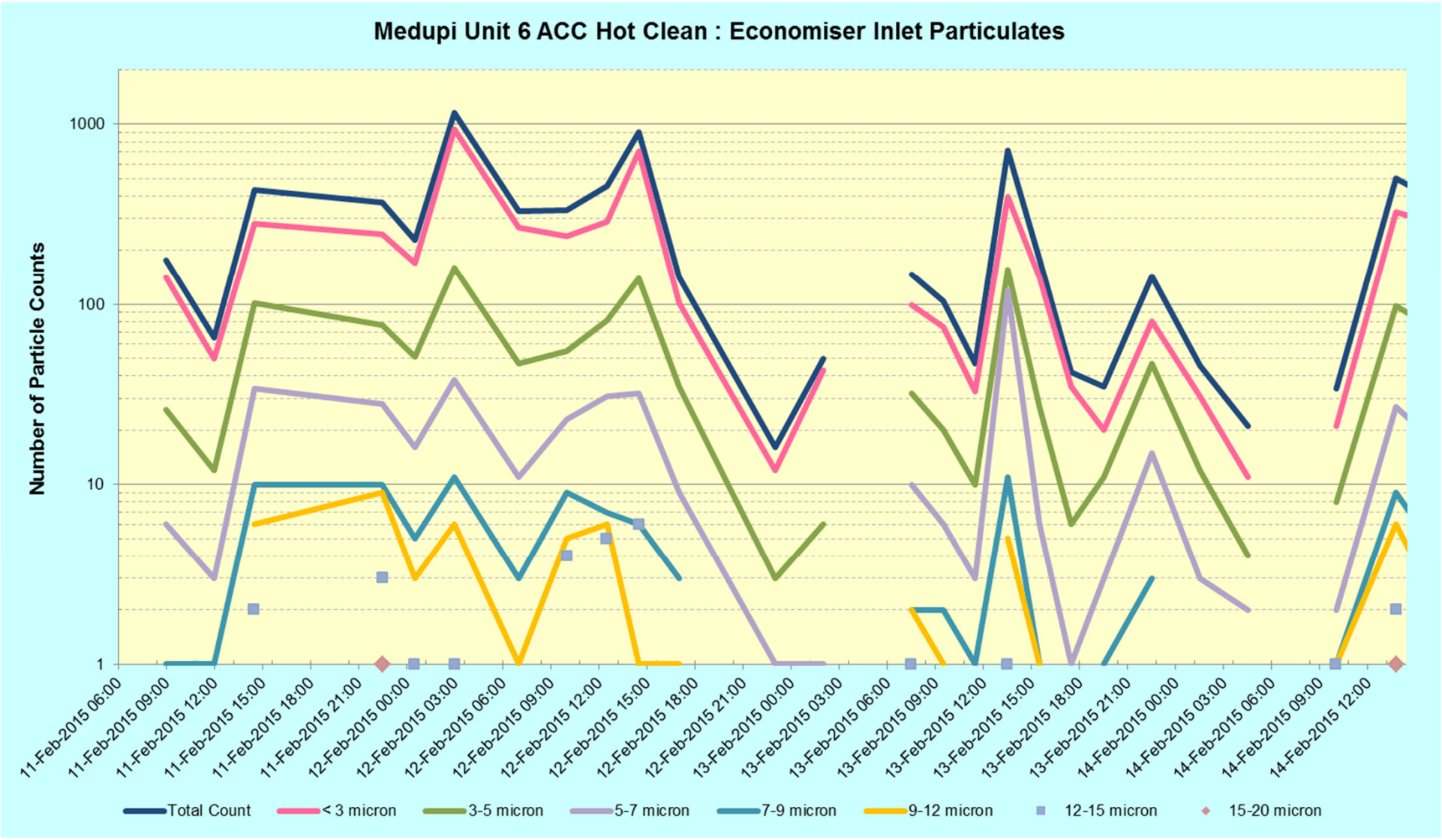
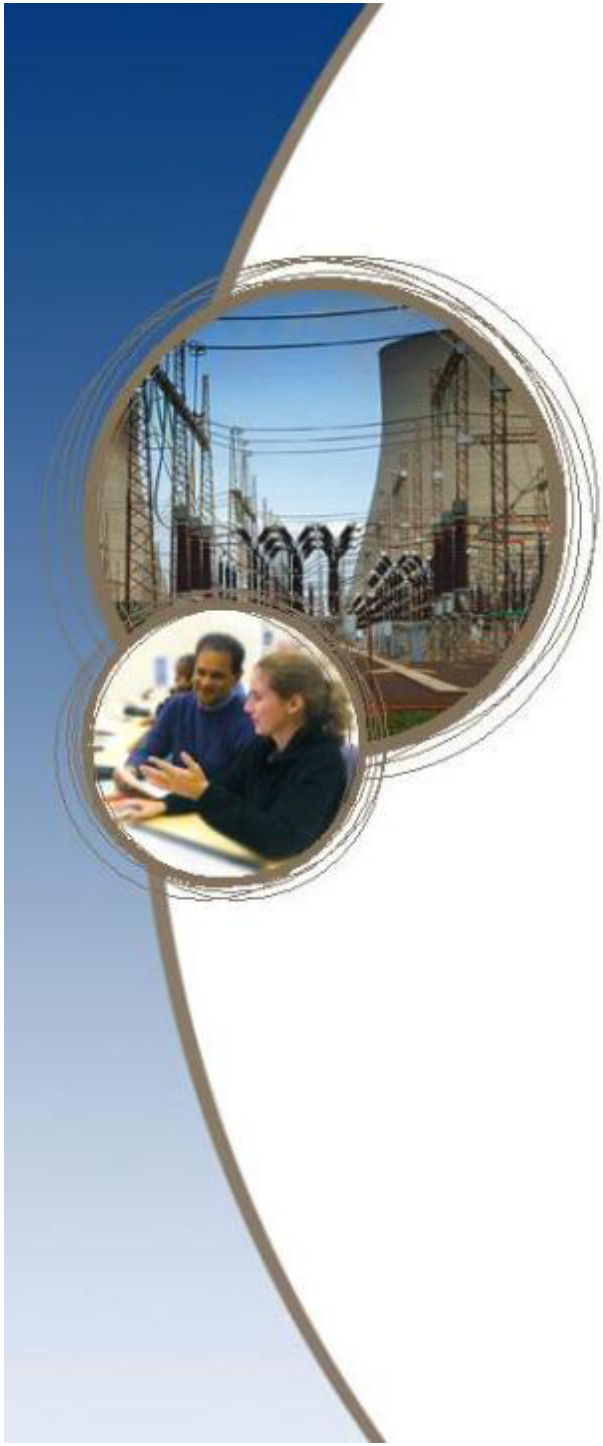


# Conclusion

- Medupi Unit 6 ACC hot cleaning was completed successfully
- Hot cleaning duration (3 days) exceeded expectations substantially, as initial estimations were between 10-14 days effective cleaning time
- Revised hot cleaning plan proved to be the correct decision to expedite hot cleaning activity
    - Given the Unit instability at the time, the requirement to shut-down, change-over blanking plates and restart the Unit (as per the initial hot cleaning plan), would in all probability have resulted delaying completion of the hot cleaning activity by a number of weeks
    - Eskom recommendation for other Medupi Units would also be to follow the revised hot cleaning plan

# Acknowledgements


- Ken Galt for chemistry measurement results
- Sarita Henning for Engineering support on Medupi site



# Thank you

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