PanAust process control strategy and implementation

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CEEC Mineral Processing and Innovation Workshop
Energy Curves: New tools for energy efficiency

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The strategy

- Lift the role of the operator:
  - From setting individual loop setpoints
  - To monitoring the process and only intervening on exception
  - The expertise lies with the metallurgists
- Ensure the process is always running up against a constraint.
- Develop process control solutions that can be implemented at other operations

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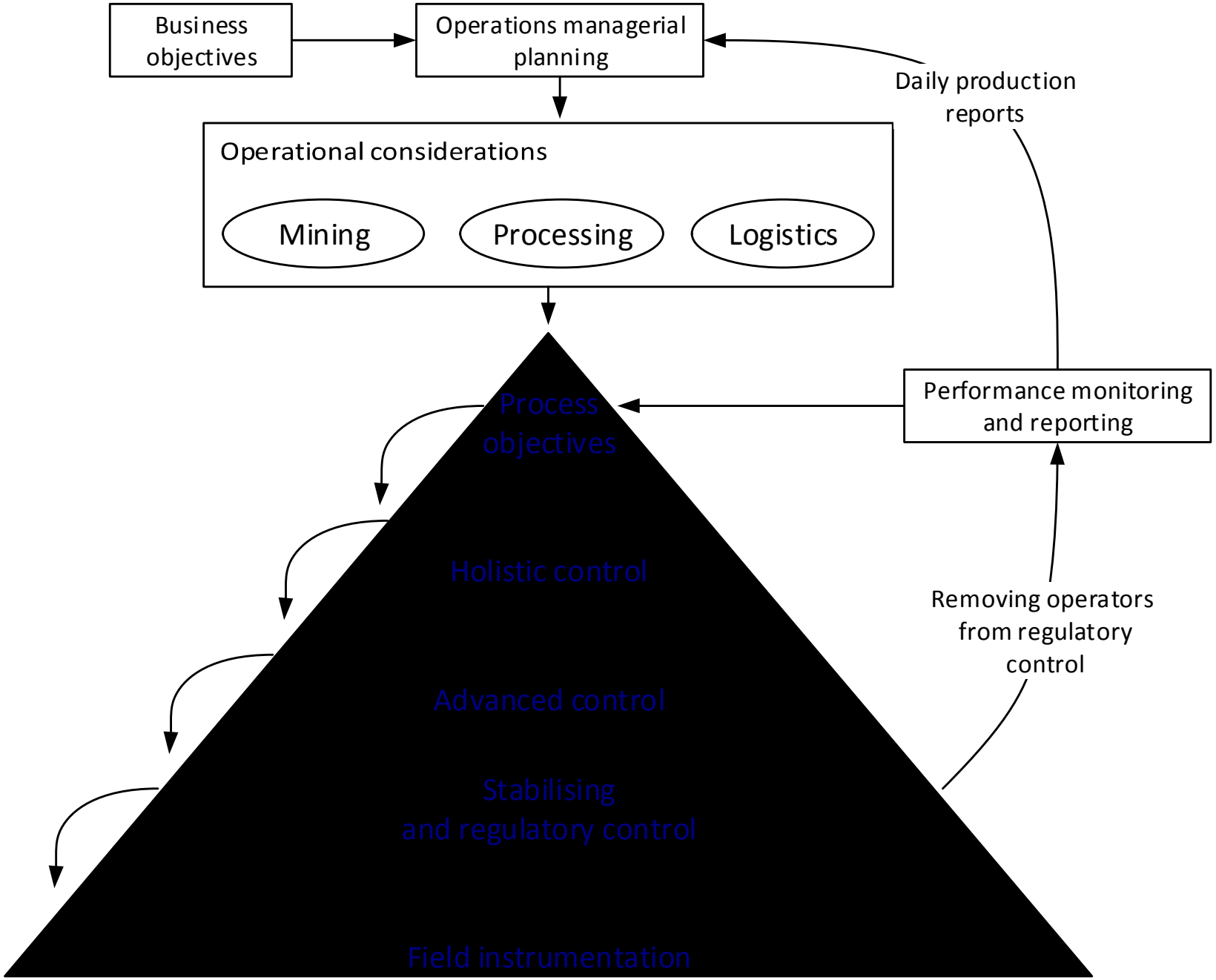
Business objectives
Operations managerial planning
Daily production reports
Operational considerations
Mining
Processing
Logistics
Performance monitoring and reporting
Process objectives
Holistic control
Advanced control
Stabilising and regulatory control
Field instrumentation
Removing operators from regulatory control

The tactics

- Stabilise the plant beginning at the front end
  - Fix the instrumentation and apply good first principles control theory
- Improve the operator situational awareness
  - HMI graphics and alarming
- Identify the best process control solutions
  - Model based and predictive control solutions
  - Developed on the existing DCS platform (No fuzzy black boxes)
- All process automation models are verified against metallurgical first principles

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The crusher

- Added an encoder and implemented a dead time compensator on apron feeder
- This indirectly improved throughput
  - A consistent feed to CV02
  - CV02 is a 1.2km long conveyer
  - Reduced overloading
  - Reduced spillage
    - Often causing pull wire trips
  - Improved the availability of CV02

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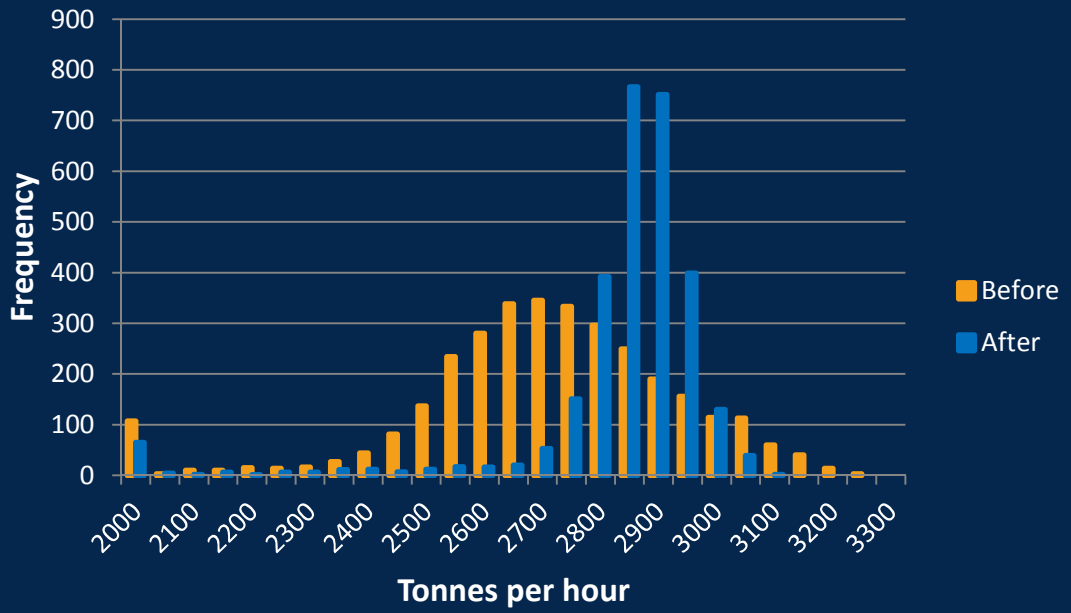
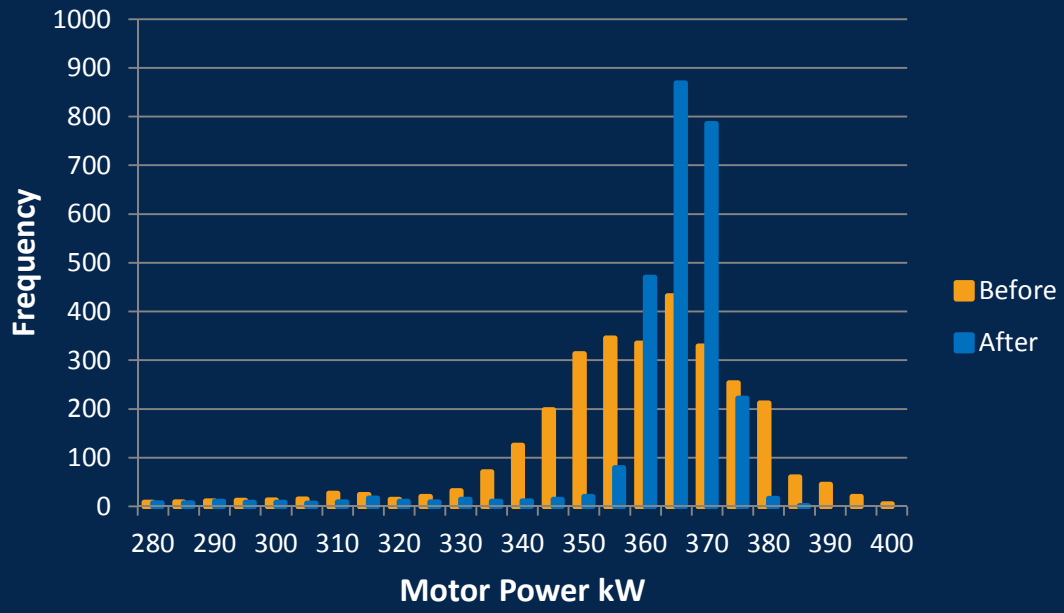
The improvements at the crusher





- Increased throughput
- Reduced the excursions on the high end, increasing availability

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The SAG mill control

- Operate within the following constraints
  - SAG mill motor power and rotor current
  - SAG mill weight
  - SAG mill noise
  - CV04 pebble recycle conveyer
  - Down stream copper tonnes limit (Cleaner constraint of 18t/hr copper)
- Manipulated variables
  - SAG mill feedrate
  - SAG mill speed
  - SAG mill density

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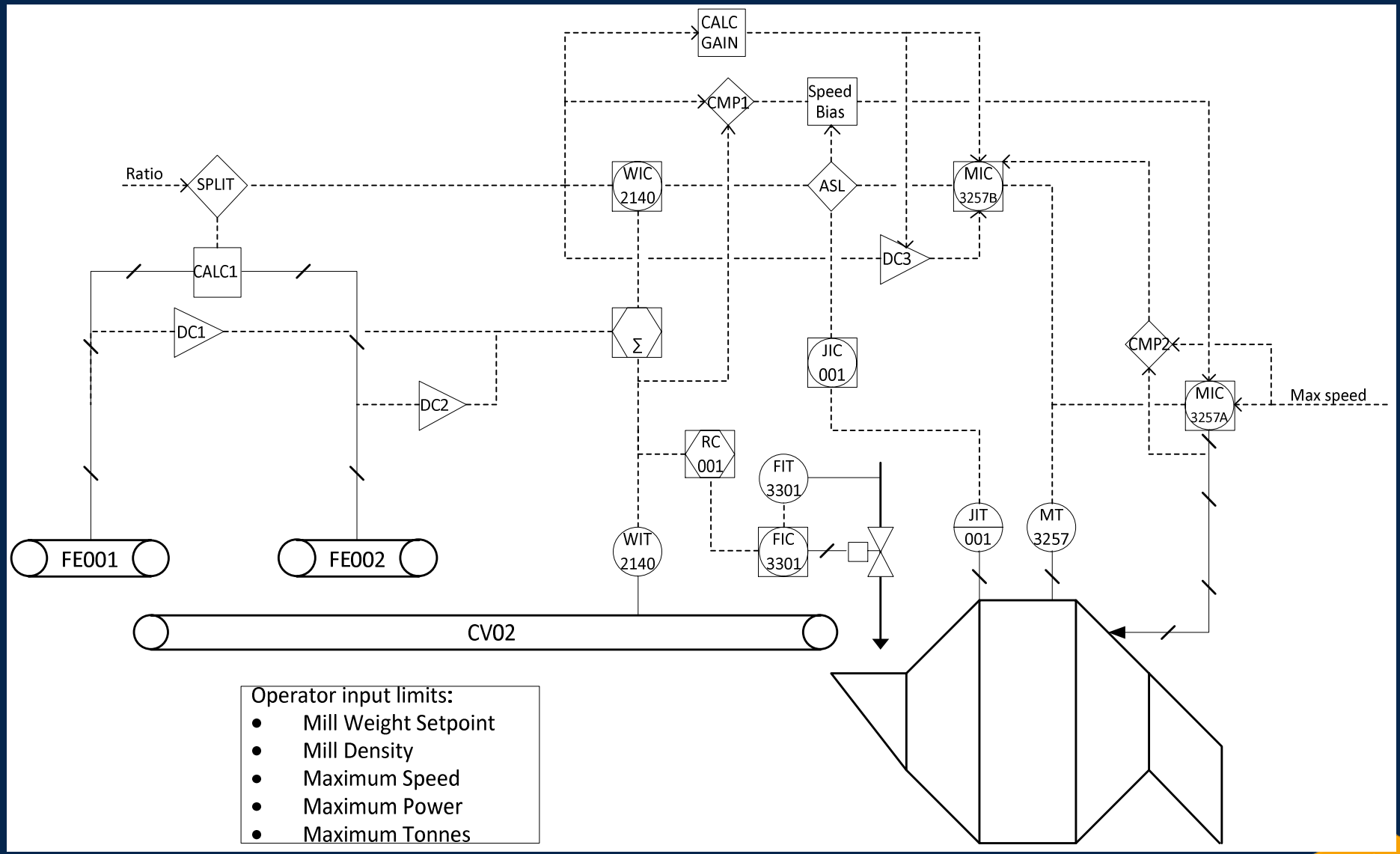
The SAG mill control



SAG mill control represented as a P&ID. This is not adequate (Everything is connected).

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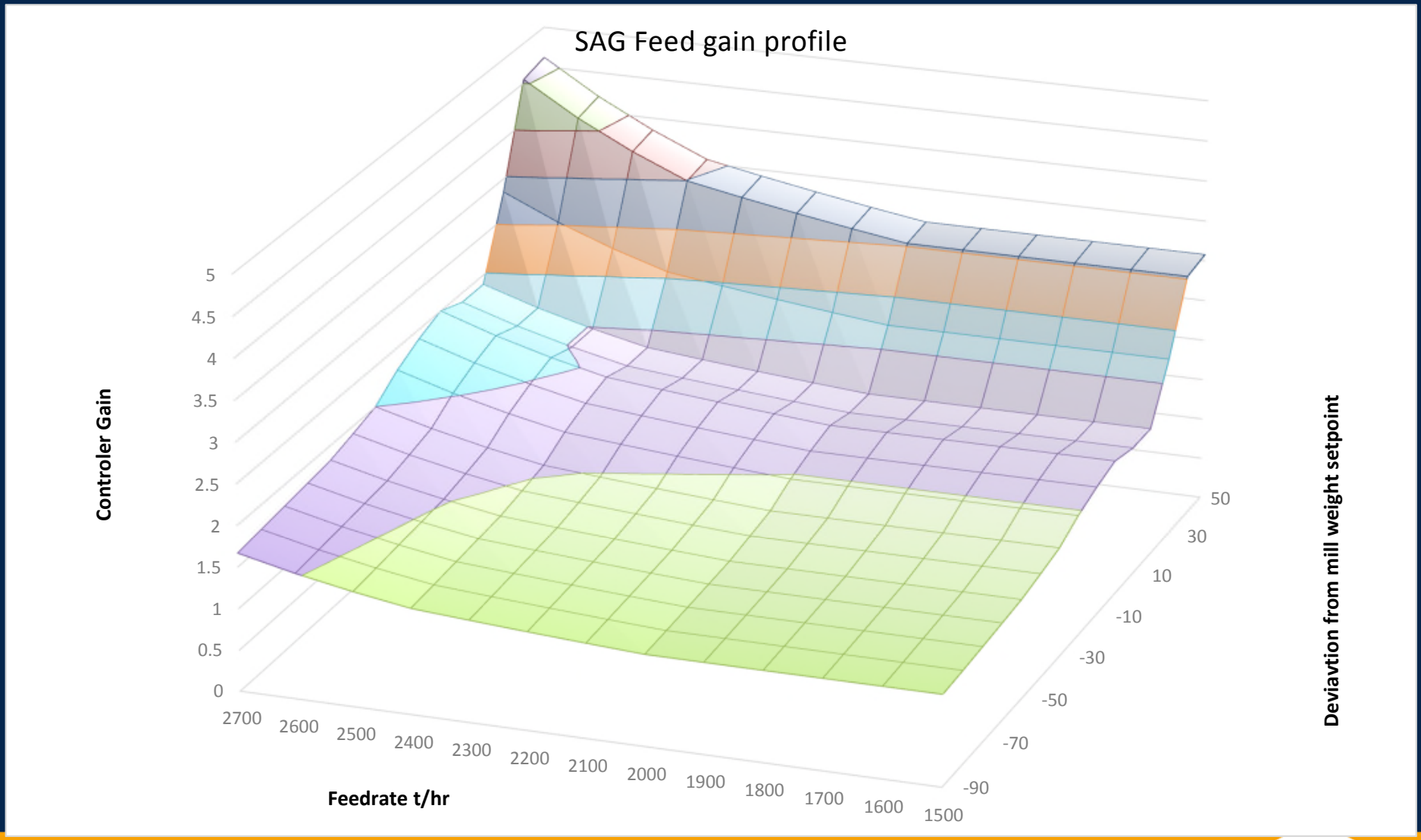
The SAG Gain profile



This gain profile moves depending on SAG mill speed, power and noise

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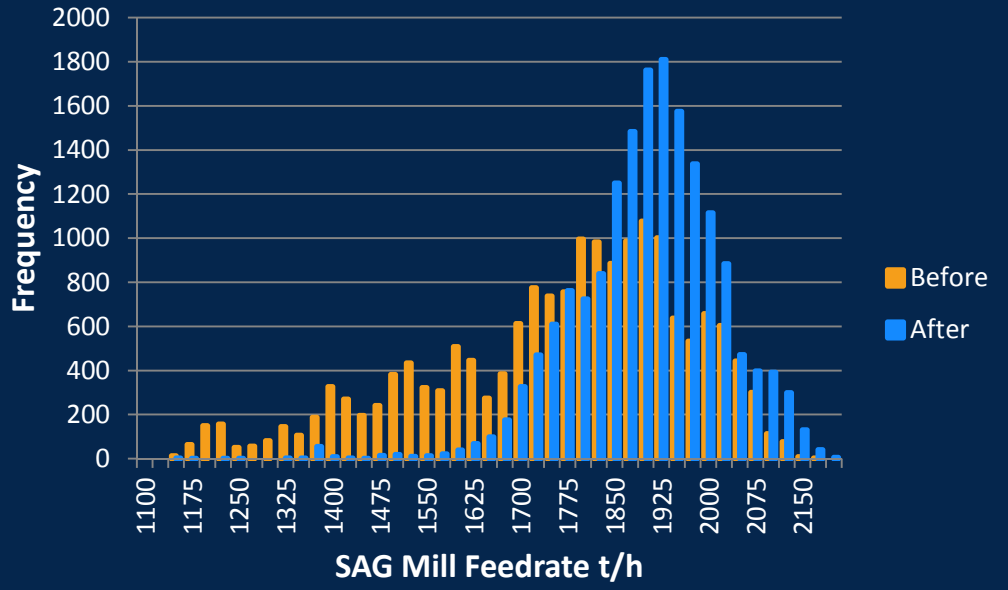
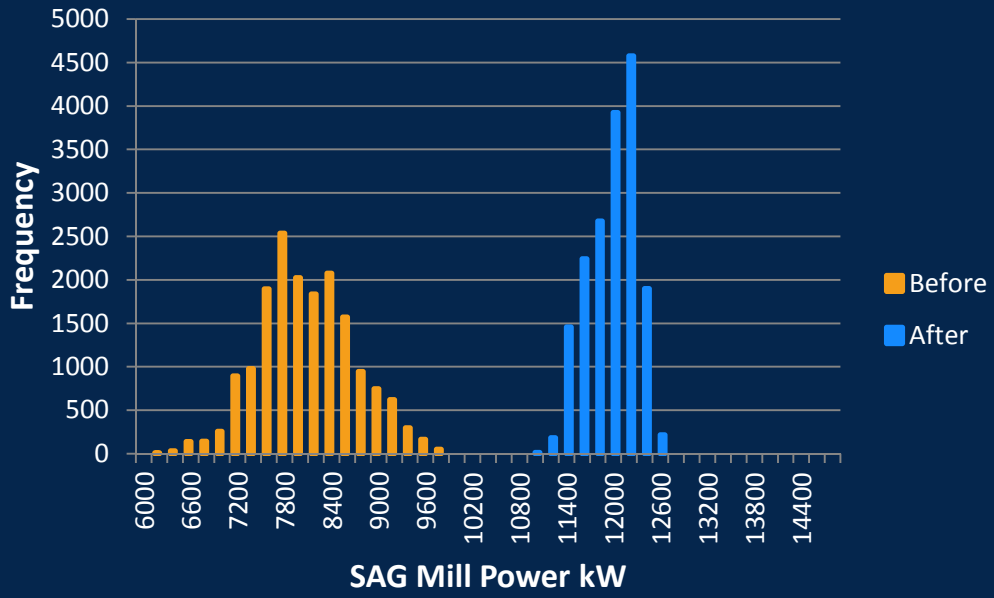
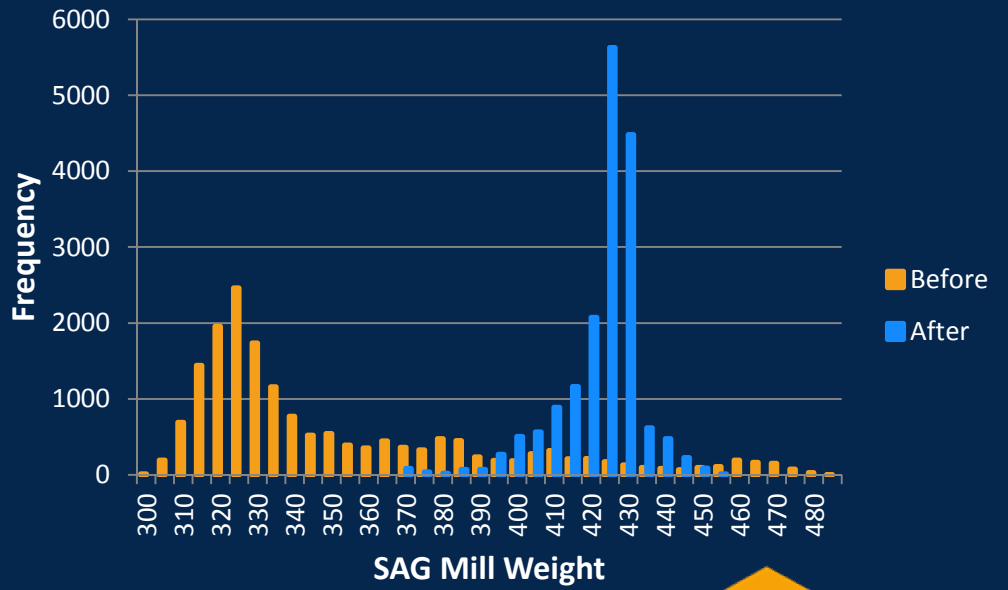
The SAG Improvement

- SAG Mill Throughput increased by 4%
- The SAG Mill is controlled in a much tighter region.
- SAG Mill Control utilisation was 97% in June 2018.







Analysis was done in 2012, no further analysis has been conducted

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Operator situational awareness

- The operator is part of the control system
- Without situational awareness
  - The operator will be slower to respond
  - Be more likely to make the wrong decision
- HMI graphic colours must be meaningful
- Alarms must be informative to the operator
- This is a huge topic and will not be covered in detail

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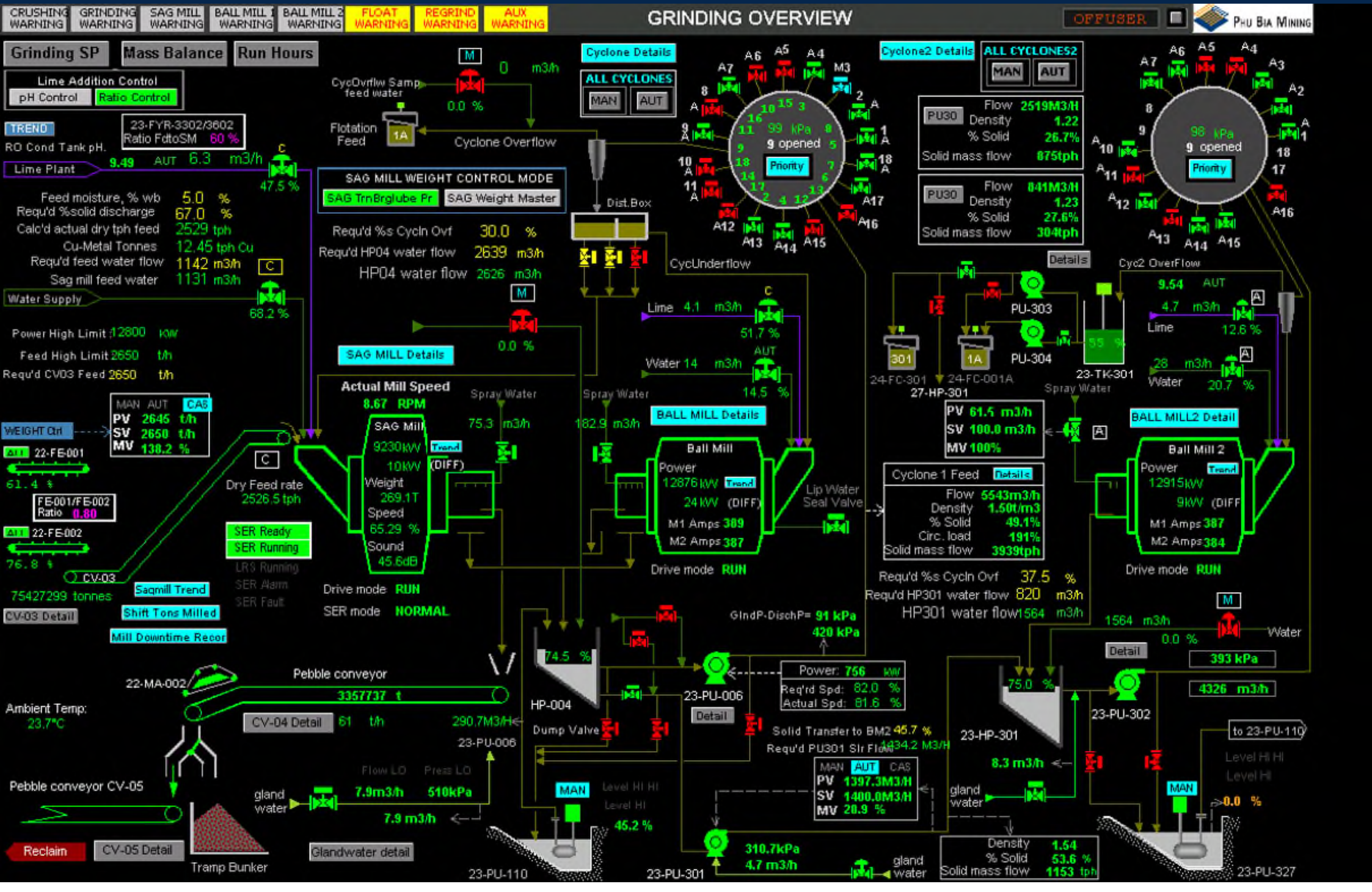
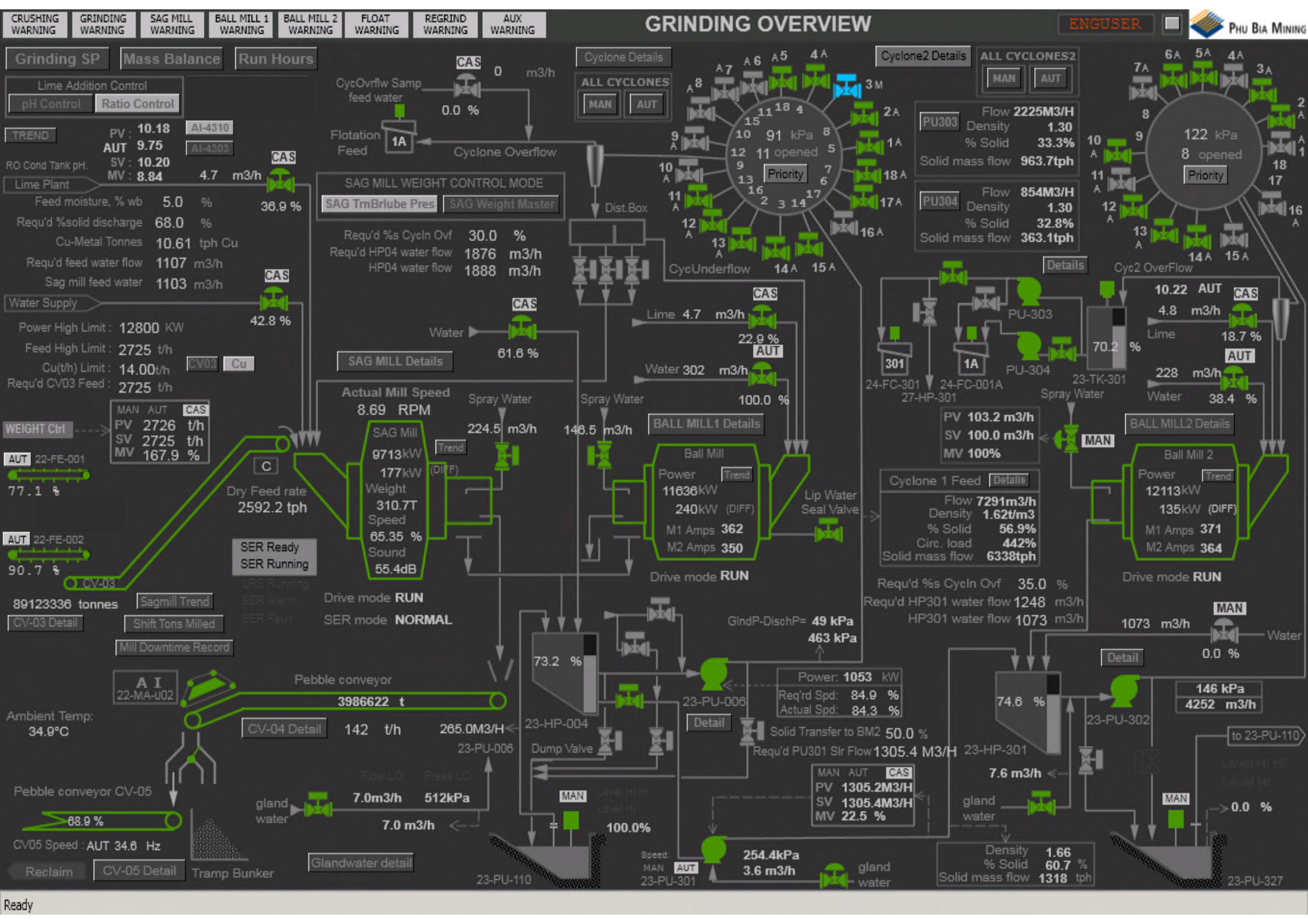
Is the plant running well or not?




CRUSHING WARNING
GRINDING WARNING
SAG MILL WARNING
BALL MILL 1 WARNING
BALL MILL 2 WARNING
FLOAT WARNING
REGRIND WARNING
AUX WARNING
GRINDING OVERVIEW
ENGUSER
PHU BIA MINING
Grinding SP
Mass Balance
Run Hours
Lime Addition Control
pH Control
Ratio Control
TREND
PV : 10.18
AUT 9.75
SV : 10.20
MV : 8.84
AI-4310
AI-4303
RO Cond Tank pH.
Lime Plant
4.7 m3/h
36.9 %
Feed moisture, % wb 5.0 %
Requ'd %solid discharge 68.0 %
Cu-Metal Tonnes 10.61 tph Cu
Requ'd feed water flow 1107 m3/h
Sag mill feed water 1103 m3/h
Water Supply
42.8 %
Power High Limit : 12800 KW
Feed High Limit : 2725 t/h
Cu(t/h) Limit : 14.00t/h
Requ'd CV03 Feed : 2725 t/h
CV03
Cu
WEIGHT Ctrl
MAN AUT CAS
PV 2726 t/h
SV 2725 t/h
MV 167.9 %
AUT 22-FE-001
77.1 %
AUT 22-FE-002
90.7 %
CV-03
89123336 tonnes
CV-03 Detail
Sagmill Trend
Shift Tons Milled
Mill Downtime Record
CycOvrflw Samp feed water
0 m3/h
0.0 %
Flotation Feed
1A
Cyclone Overflow
SAG MILL WEIGHT CONTROL MODE
SAG TrnBrlube Pres
SAG Weight Master
Requ'd %s Cycln Ovf 30.0 %
Requ'd HP04 water flow 1876 m3/h
HP04 water flow 1888 m3/h
Water
61.6 %
SAG MILL Details
Actual Mill Speed
8.69 RPM
Spray Water
224.5 m3/h
SAG Mill
9713kW
177kW (DIFF)
Weight
310.7T
Speed
65.35 %
Sound
55.4dB
Trend
C
Dry Feed rate
2592.2 tph
SER Ready
SER Running
LRS Running
SER Alarm
SER Fault
Drive mode RUN
SER mode NORMAL
Cyclone Details
ALL CYCLONES
MAN
AUT
91 kPa
11 opened
Priority
Dist.Box
CycUnderflow
Lime 4.7 m3/h
22.9 %
Water 302 m3/h
100.0 %
146.5 m3/h
BALL MILL1 Details
Ball Mill
Power
11636kW
240kW (DIFF)
M1 Amps 362
M2 Amps 350
Drive mode RUN
Lip Water Seal Valve
Cyclone2 Details
ALL CYCLONES2
MAN
AUT
PU303
Flow 2225M3/H
Density 1.30
% Solid 33.3%
Solid mass flow 963.7tph
PU304
Flow 854M3/H
Density 1.30
% Solid 32.8%
Solid mass flow 363.1tph
122 kPa
8 opened
Priority
Details
Cyc2 OverFlow
PU-303
PU-304
70.2 %
301
24-FC-301
27-HP-301
1A
24-FC-001A
23-TK-301
Spray Water
PV 103.2 m3/h
SV 100.0 m3/h
MV 100%
MAN
Cyclone 1 Feed
Details
Flow 7291m3/h
Density 1.62t/m3
% Solid 56.9%
Circ. load 442%
Solid mass flow 6338tph
Requ'd %s Cycln Ovf 35.0 %
Requ'd HP301 water flow 1248 m3/h
HP301 water flow 1073 m3/h
10.22 AUT
4.8 m3/h
Lime
18.7 %
228 m3/h
Water
38.4 %
BALL MILL2 Details
Ball Mill 2
Power
12113kW
135kW (DIFF)
M1 Amps 371
M2 Amps 364
Drive mode RUN
1073 m3/h
0.0 %
Water
Detail
146 kPa
4252 m3/h
to 23-PU-110
A I 22-MA-U02
Ambient Temp: 34.9°C
Pebble conveyor
3986622 t
CV-04 Detail
142 t/h
265.0M3/H
23-PU-006
Pebble conveyor CV-05
68.9 %
CV05 Speed : AUT 34.6 Hz
Reclaim
CV-05 Detail
Tramp Bunker
gland water
7.0m3/h
512kPa
7.0 m3/h
Glandwater detail
73.2 %
23-HP-004
Dump Valve
GlndP-DischP= 49 kPa
463 kPa
23-PU-006
Detail
Power: 1053 kW
Req'rd Spd: 84.9 %
Actual Spd: 84.3 %
Solid Transfer to BM2 50.0 %
Requ'd PU301 Slr Flow 1305.4 M3/H
MAN AUT CAS
PV 1305.2M3/H
SV 1305.4M3/H
MV 22.5 %
100.0%
23-PU-110
Speed:
MAN AUT
23-PU-301
254.4kPa
3.6 m3/h
gland water
74.6 %
23-HP-301
23-PU-302
7.6 m3/h
gland water
Density 1.66
% Solid 60.7 %
Solid mass flow 1318 tph
23-PU-327
0.0 %
Ready

Phu Kham Processing plant improvements achieved

- SAG mill and grinding circuit automation
  - 2012 SAG speed and feedrate automation
  - 2015 SAG noise analyser improves control
  - 2017 SAG motor constrains improve reliability
  - 2018 SAG density control – volumetric scanner on CV03
- Rougher automation
  - 2013 froth analysers control froth depth and airflow
  - 2015 mass recovery determined by feed grade
  - 2016 reagent automation
- Jameson cell, Cleaner 1, 2, 3 automation
  - 2015 Airflow and froth depth profiles adjusted to suit the grade
  - 2017 Concentrate grade setpoints of each cleaner bank automated
- The utilisation of the advanced automation exceeds 95%

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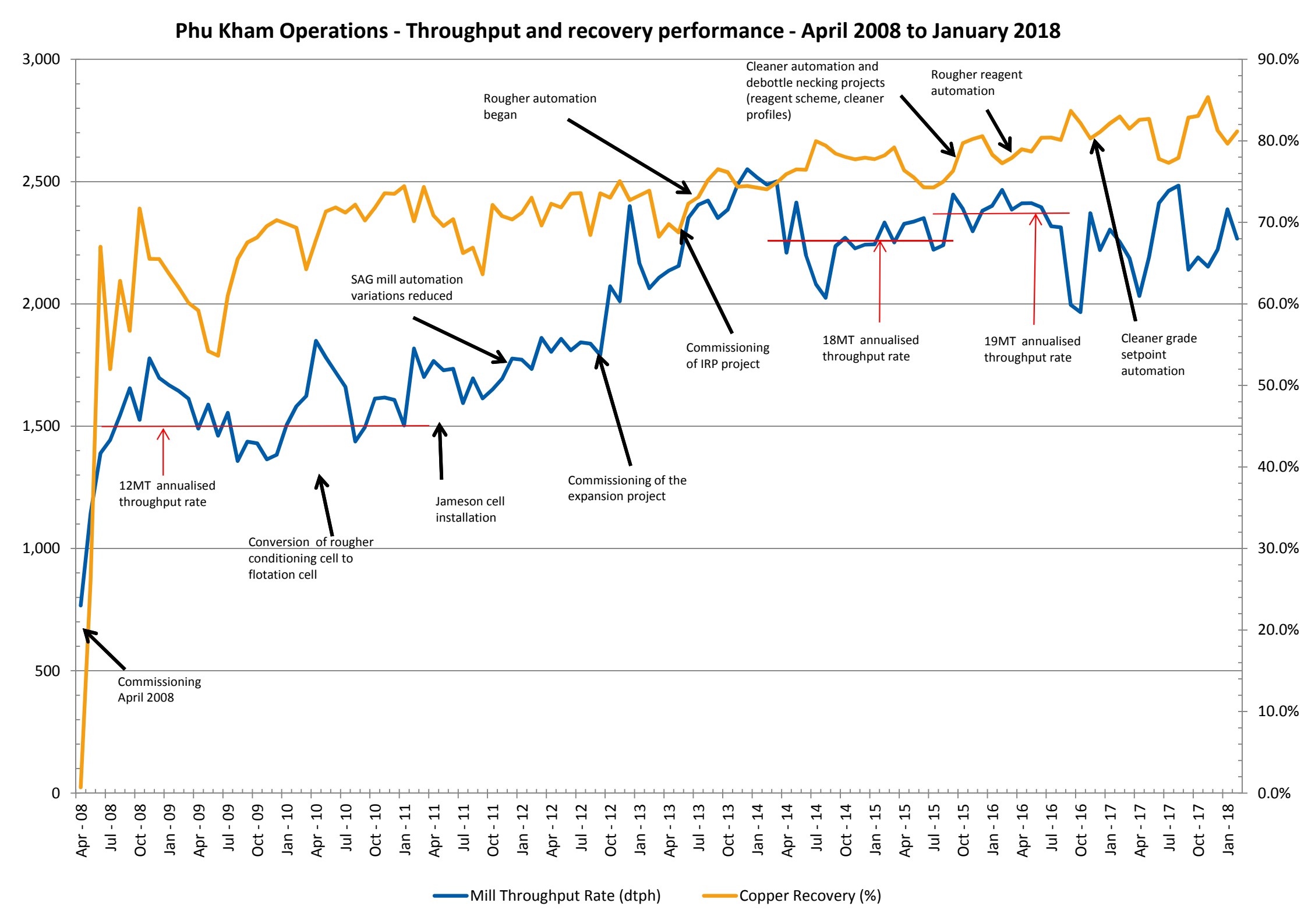
Phu Kham Operations - Throughput and recovery performance - April 2008 to January 2018
3,000
2,500
2,000
1,500
1,000
500
0
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Commissioning April 2008
12MT annualised throughput rate
Conversion of rougher conditioning cell to flotation cell
SAG mill automation variations reduced
Jameson cell installation
Rougher automation began
Commissioning of the expansion project
Commissioning of IRP project
Cleaner automation and debottle necking projects (reagent scheme, cleaner profiles)
18MT annualised throughput rate
Rougher reagent automation
19MT annualised throughput rate
Cleaner grade setpoint automation
Apr - 08
Jul - 08
Oct - 08
Jan - 09
Apr - 09
Jul - 09
Oct - 09
Jan - 10
Apr - 10
Jul - 10
Oct - 10
Jan - 11
Apr - 11
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Jan - 16
Apr - 16
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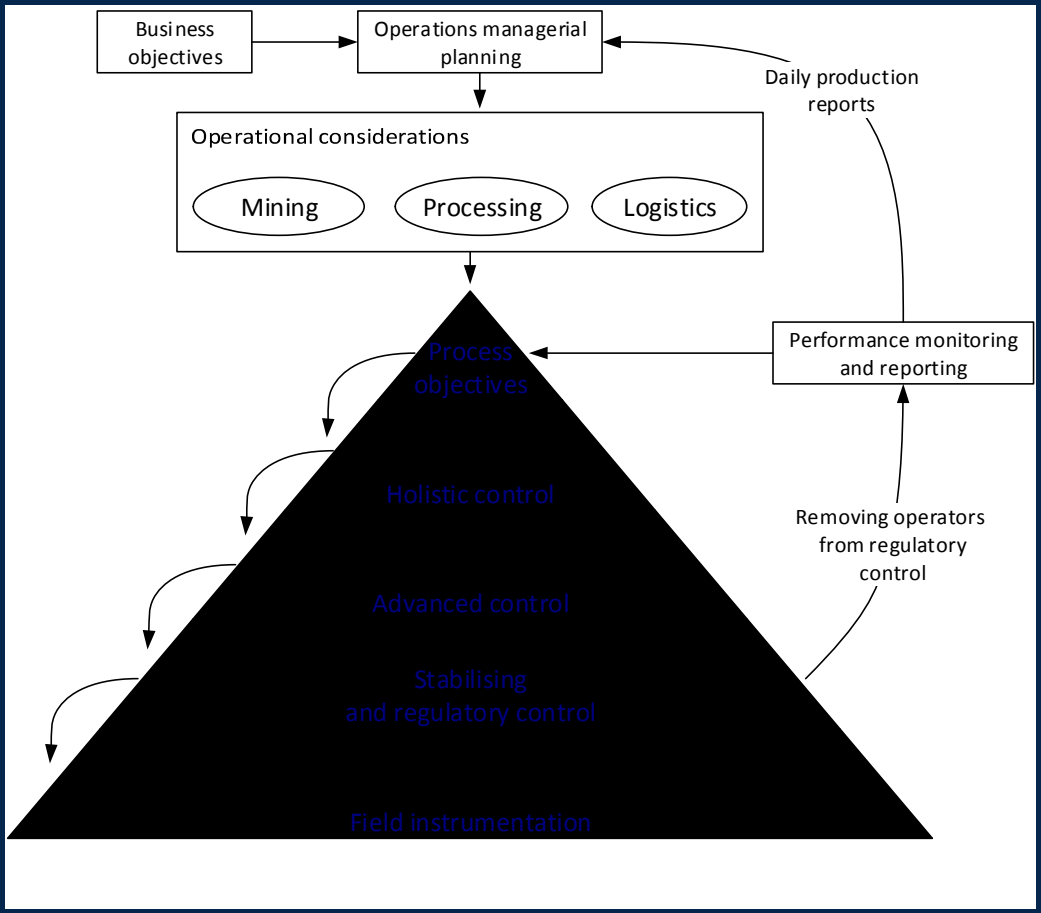
Jan - 17
Apr - 17
Jul - 17
Oct - 17
Jan - 18
Mill Throughput Rate (dtph)
Copper Recovery (%)

Automating a new plant



- Define the high level process control objective.
  - The top of the hierarchy of control
- This determines the holistic and advanced control required
- Which leads to the stabilising and regulatory control needed.
- Finally, the instrumentation required to achieve the objective is identified

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Conclusion

- Process control requires a strategic approach
- The obvious improvements realised by reduced variation are:
  - Allowing the process to run closer to its constraints
    - Increases throughput, recovery and grades
    - Reduces unnecessary stress on the asset
- The understated benefits are:
  - The accuracy of metallurgical test work improves
  - Allowing the control model to be further improved
  - The plant availability increases

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