Functional Design Specification for Advanced Process Controller APC-J140_BIN_005C

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Executive Summary

This document is the Functional Design Specification (FDS) for the Advanced Process Controller (APC) that is being implemented. The document is structured into the following six sections:

Section 1 is a process background and description the process whereby the APC controller will be implemented. Based on the S88 standard, the process descriptions are covered.Also included are the stability and efficiency measures on the each unit which drive APC systems to align with Anglo American strategy.

Section 2 is an explanation of the basic control philosophy of the process unit.

Section 3 is a detailed explanation of the APC controller, including descriptions of the control, manipulated and disturbance variables as well as the controller objectives and key performance indicators (KPI's). This section also describes the logic for the detection of the four types of plant process state alarms which are; critical, high, low and default.

Section 4 (optional) is a description of the control technologies that will be used in the implementation of the APC controller. The control technologies are Fuzzy Control and Model Predictive Control (MPC).

Section 5 (optional) is a list of the heartbeats.

Section 6 (optional) is a list of all the tags that will be used in the implementation of the DMS Feed process unit APC controller.

Addendums (optional) is the final section of the document which is an explanation of the basic principles of operations for Process States, Fuzzy Control, Model Based Control and finally Model Predictive Control.

1) Process Background And Description

1.1) SIS-JIG (Site)

1.1.1) Background

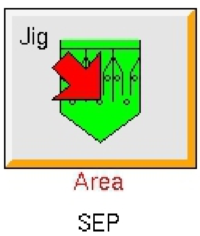


Fig 1: The members of the SIS-JIG Site - Highlighting the Jig-Area - SEP

1.2) SEP (Jig-Area)

1.2.1) Background

The jig plant at Sishen Iron Ore Mine consists of a primary, secondary and tertiary crushing circuit crushing the feed material to a -25 mm top size and longitudinally stacking it on two ROM (run of mine) feed beds. The ROM feed bed material is reclaimed by a bucket reclaimer and conveyed to eight feed bunkers.

After beneficiation the lumpy ore (-25 mm +8 mm) is conveyed and stacked on the blending beds while the fine material (-8 mm +1 mm) is conveyed to the dewatering bunkers and then stacked on the fine blending beds. The jig plant consist of eight modules with three jigs each, the coarse jig (-25 mm +8 mm), medium jig (-8 mm +3 mm) and fine jig (-3 mm +1 mm).

Jigging is a process of particle stratification in which the particle rearrangement results from an alternate expansion and compaction of a bed of particles by a pulsating fluid flow. The rearrangement results in layers of particles that are arranged by increasing density from top to bottom of the jig bed. The particles, in addition to the vertically expanded and compacted bed motion, move continuously and horizontally across the supporting jig screen helped by the feed material that is introduced at one end. The feed rate influences the retention time of the material in the jig and thus the number of pulses the material will receive. Following the particle stratification, the particle bed is physically cut at a desired horizontal particle density plane to separate the desired product from the less dense gangue material.

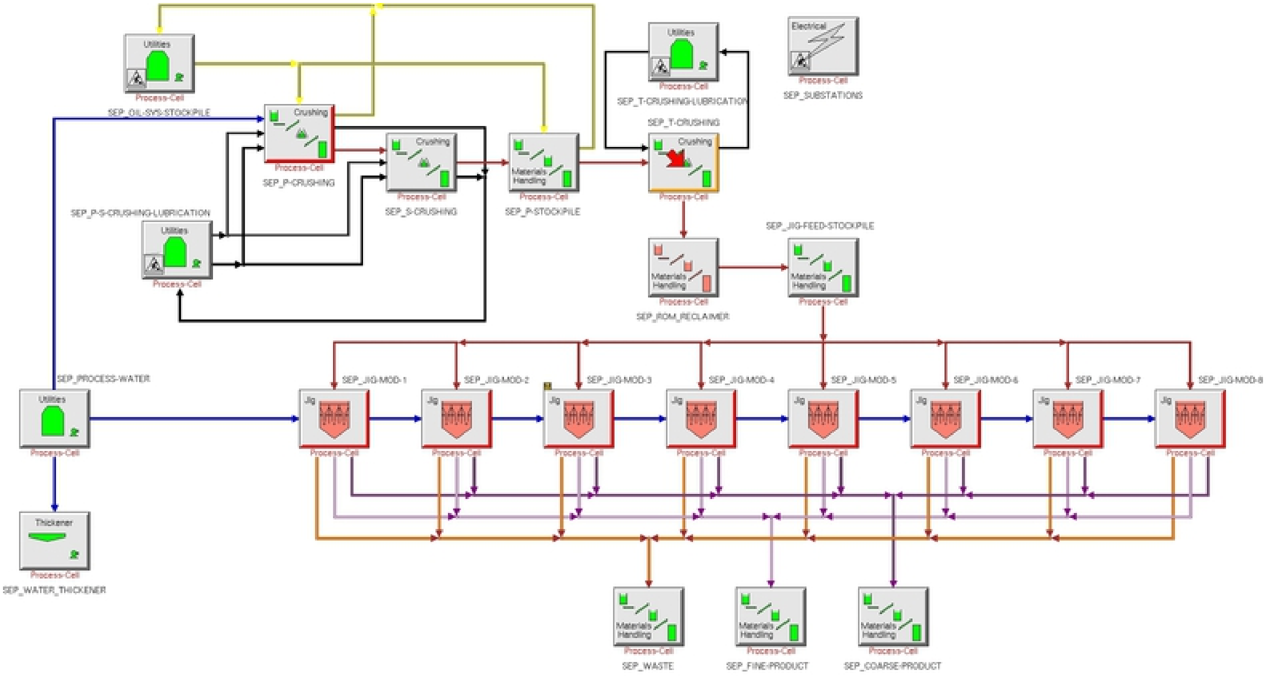


Fig 2: The members of the SEP Jig-Area - Highlighting the Crushing-Process-Cell - T-CRUSHING

1.3) T-CRUSHING (Crushing-Process-Cell)

1.3.1) Background

The tertiary crusher stage is fed from the primary stockpile, which contains the primary and secondary crusher product. The tertiary crushing plant consists of four tertiary cone crushers, each of which are fed at a controlled rate through a feed bin, two feeders per crusher. The tertiary crushing plant is in closed circuit and produces a -25mm which is conveyed to one of two pre-blending beds, these beds are fed to the beneficiation process (jigging).

1.3.2) Purpose

1.3.3) Theory

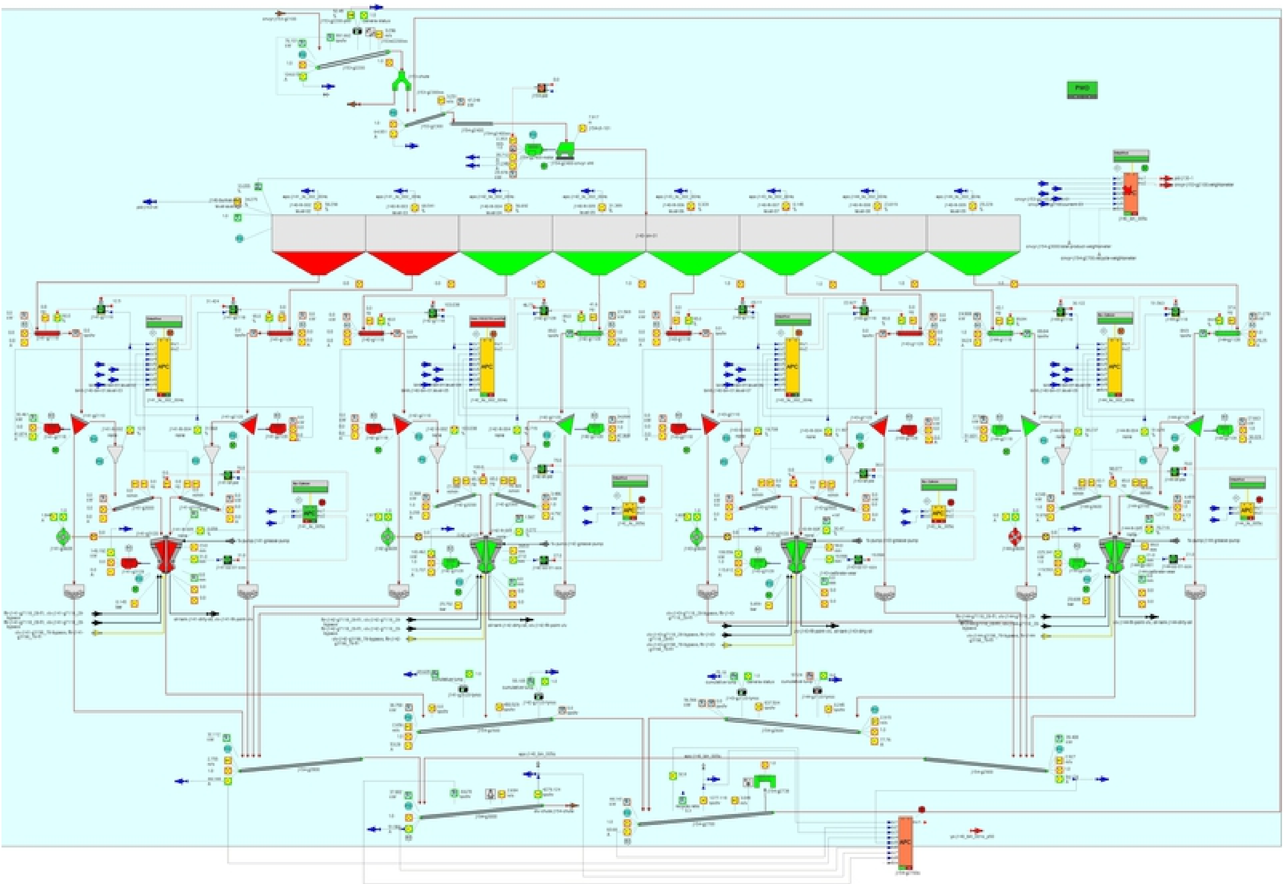


Fig 3: The members of the BIN-FEED unit which is a member of T-CRUSHING Crushing-Process-Cell - Highlighting J140_BIN_005C

1.4) BIN-FEED (Unit)

1.4.1) Background

Material from the primary stockpile (J130-ST-01) is discharged via up to four vibrating feeders (J130-G4100/200/300/400) onto a conveyor (J153-G2100) which transports the material onto another conveyor (J153-G2200). The fresh feed along with the recycle stream from recycle conveyor (J154-G2700) reports to the T-Crusher Shuttle Feed Conveyor (J154-G2400) which reports directly into T-Crusher Feed Bin (J140-BIN-01).
The T-Crusher Feed Bin is divided into eight smaller bins which are arranged in two rows of four bins above four tertiary crushers. Bins 1 and 2 discharge to T-Crusher J141-G3000, 3 and 4 to T-Crusher J142-G3000, 5 and 6 to T-Crusher J-143-G3000 and 7 and 8 to t-Crusher J144-G3000.
Each tertiary crusher module therefore consists of two bins, each discharging via an apron feeder onto a single deck vibrating screen. The undersize of the vibrating screen reports to a rock box and then onto the circuit product conveyors. The oversize reports to a chute from where it is extracted via conveyor to the crusher. Crusher product is discharged onto the crusher product conveyors and then onto the recycle conveyors where it is transported to T-Crusher Feed Bin (J140-BIN-01).

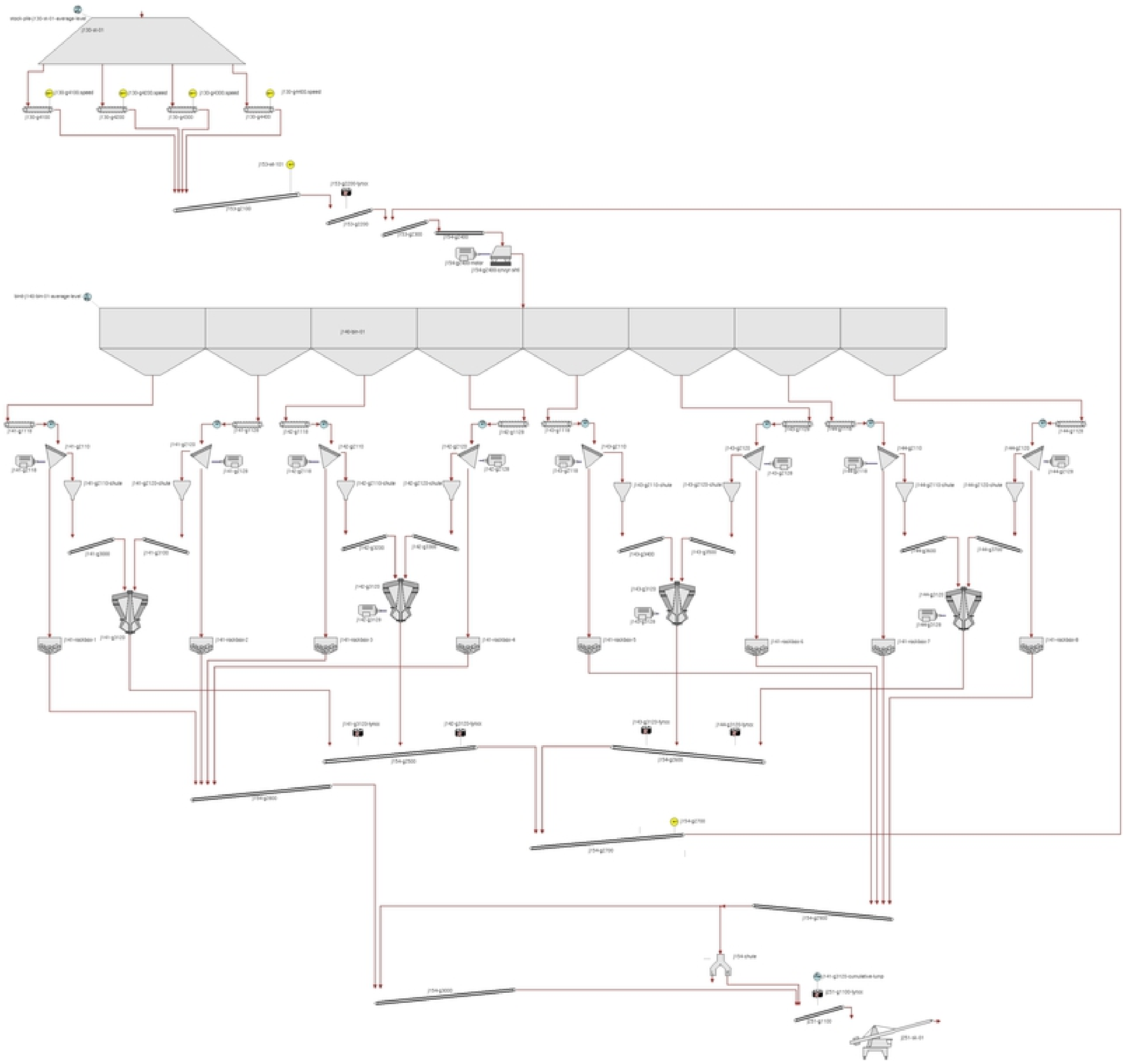


Fig 4: Relevant Circuit Schematic

1.4.2) Measures

1.4.2.1) Cnvyr-Shtl-J154-G2400-Cnvyr-Shtl: Measure: Nr-Starts

Nr-Starts Measure							
Measure	Goal	EU	Owner	Key Performance Indicator (KPI)?	Lower Control Limit (LCL)	Target Value	Upper Control Limit (UCL)
NR-STARTS	MINIMIZE		APC-CUSTODIAN	false	0	0	10

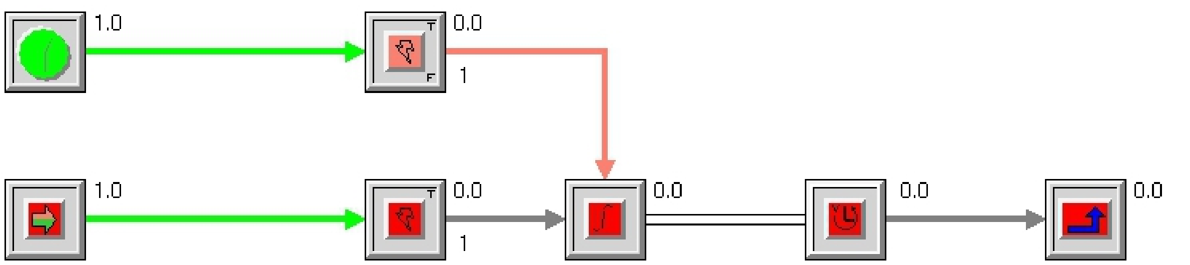


Fig 5: Determining Nr-Starts

2) Basic Control

2.1) Description

The T-Crushing Feed Bin Level controller (PID-J154-PID) controls the average level in T-Crushing Feed Bin (J140-BIN-01) as shown in Figure 2 by manipulating fresh feed setpoints of each of the T-Crushing Feed Bin Fresh Feed PID Controllers (PID-J130-1/2/3/4). Each of these PID controllers will speed up or slow down their respective extraction feeders to achieve the desired Fresh Feed rate as measured by weightometer (J153-WT-101). The extraction by the apron feeder(s) will be stopped should any of the bins in T-Crushing Feed Bin (J140-BIN-01) exceed a bin level of high-high. The weightometer (CNVYR-J154-G2700.RECYCLE-WEIGHTOMETER) on the Recycle Conveyor will provide measurement of the recycle feed to the T-Crushing Feed Bin.

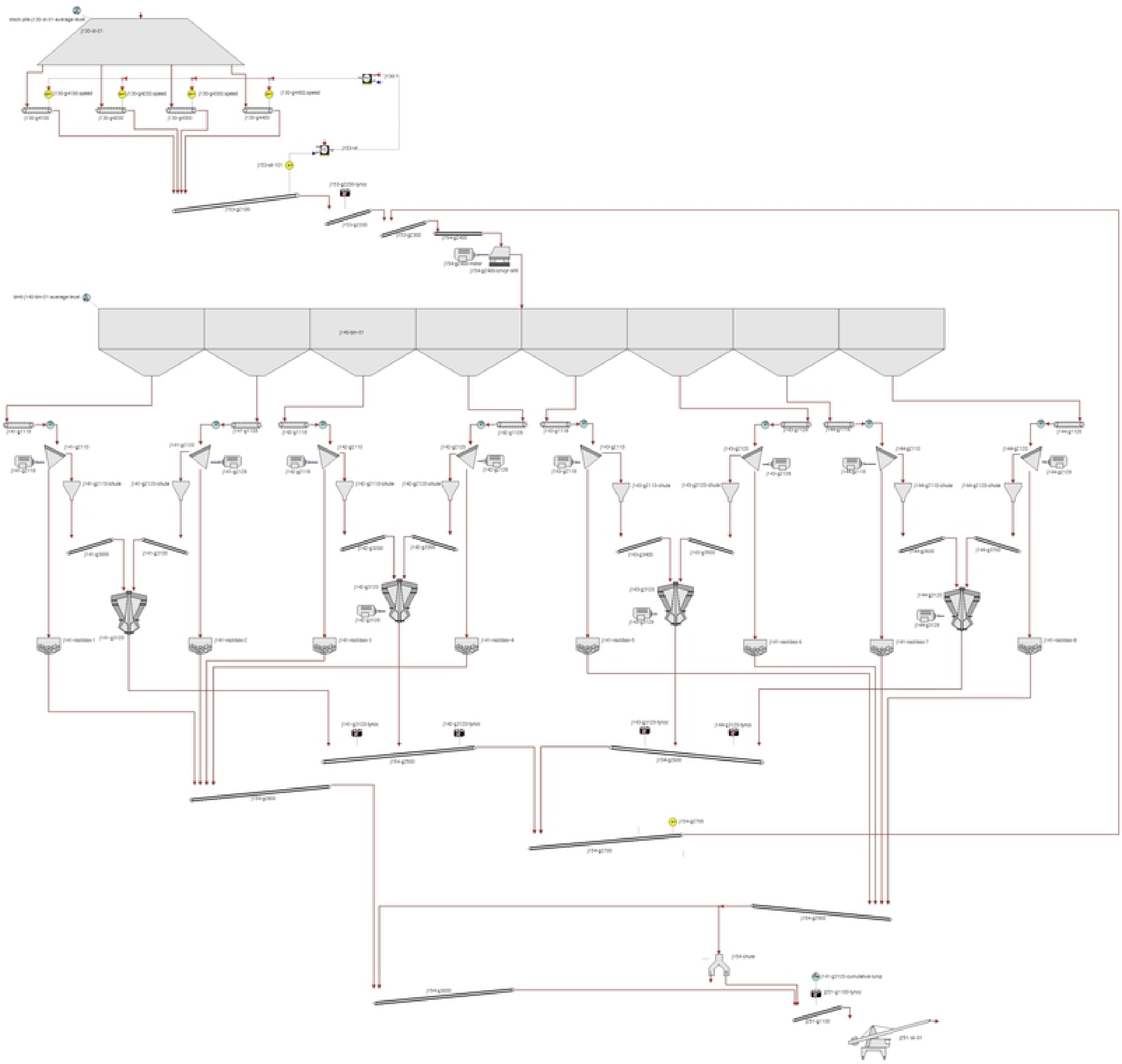


Fig 6: Circuit with Basic Control

2.2) PID Tuning Parameters

PID Tuning			
Controller ID	P	I	D
J130-1	0.10	0.10	0.00
J153-WT	0.10	0.10	0.00
J154-PID	0.10	0.10	0.00

3) Advanced Control

3.1) Description

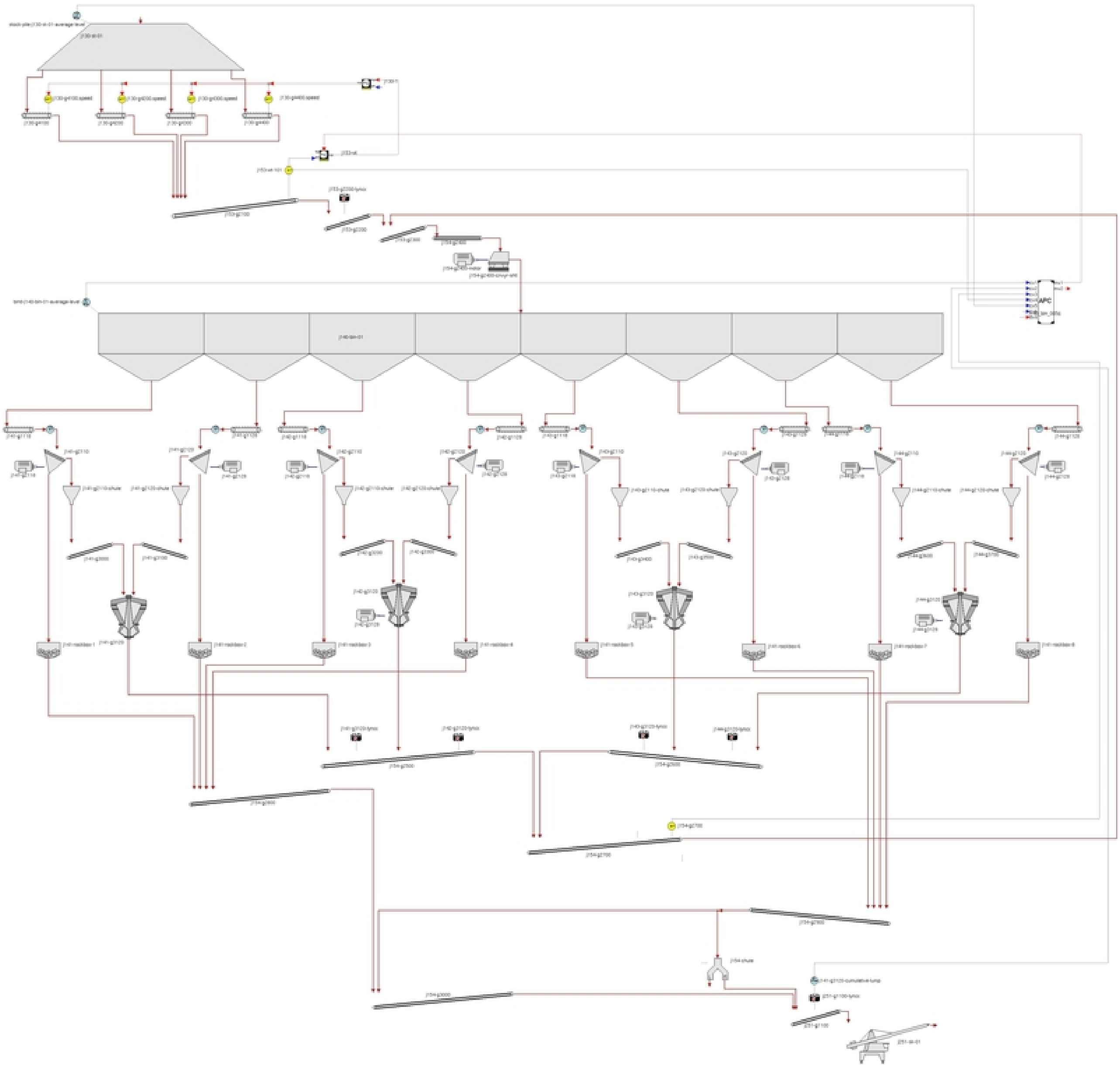


Fig 7: Circuit with Advanced Control

3.2) Controlled Variables

The first controlled variable is the tertiary crusher feed bin average level (BIN8-J140-BIN-01.LEVEL-01). The tertiary crusher feed bin (BIN8-J140-BIN-01) is an important intermediate buffer between the primary stockpile (APC-STOCK-PILE-J130-ST-01) and the four tertiary crushers (J141/2/3/4-G3120). The tertiary crusher feed bin (BIN8-J140-BIN-01) has a fresh feed input, via the primary stockpile product conveyor (J153-G2100), and has a recycle stream input, via the tertiary crusher product conveyor (J154-G2700). These two inputs are fed to conveyor (J153-G2300) which feeds the tertiary crusher feed bin tripper car conveyor (J154-G2400) which feeds all eight of the compartments in the tertiary crusher feed bin (BIN8-J140-BIN-01). The average bin level (BIN8-J140-BIN-01.LEVEL-01) is used in the APC (APC-J140_BIN_005C) controller and was calculated as the average of all eight compartment levels in the bin.

In the event that the tertiary crusher feed bin average level (BIN8-J140-BIN-01.LEVEL-01) reaches a high limit as entered on the SCADA faceplate the following will be implemented:

1. The rate of extraction from the primary stockpile (APC-STOCK-PILE-J130-ST-01) is decreased by:

a. Reducing the primary stockpile conveyor weightometer setpoint (APC-J140_BIN_001C-SP-CONNECTION-CP-001), which is the setpoint for the speed PID (PID-J130-1) controller for the four feeders extracting ore from the primary stockpile (APC-STOCK-PILE-J130-ST-01) and feeding the primary stockpile product conveyor(J153-G2100). This will reduce the fresh feed to the tertiary crusher feed bin (BIN8-J140-BIN-01). The inverse is also true for a low tertiary crusher feed bin average level (BIN8-J140-BIN-01.LEVEL-01).

The second controlled variable is the tertiary crushing feed bin fresh feed mass flow rate (J153-G2100.WEIGHTOMETER) . This weightometer is located on the primary stockpile product conveyor (J153-G2100) which is fed by four feeders situated below the primary stockpile (APC-STOCK-PILE-J130-ST-01).

The intenstion of ths variable is to continuously increase the tertiary crushing fresh feed mass flow (J153-G2100.WEIGHTOMETER) towards its high limit, given that none of the other controlled variables are operating at their limits.

The third controlled variable is the primary stockpile average level (APC-STOCK-PILE-J130-ST-01.LEVEL-05). This level transmitter calculates the average level of the primary stockpile (APC-STOCK-PILE-J130-ST-01) by calculating the average of the four primary stockpile level transmitters located on the stockpile.

In the event that the primary stockpile average level (APC-STOCK-PILE-J130-ST-01.LEVEL-05) reaches a high limit as entered in the SCADA face plate the following will be implemented:

1. Increasing the primary stockpile conveyor weightometer setpoint (APC-J140_BIN_001C-SP-CONNECTION-CP-001), which is the setpoint for the speed PID (PID-J130-1) controller for the four feeders extracting ore from the primary stockpile (APC-STOCK-PILE-J130-ST-01) and feeding the primary stockpile product conveyor(J153-G2100). This will increase the fresh feed to the tertiary crusher feed bin (BIN8-J140-BIN-01). The inverse is also true for a low tertiary crusher feed bin average level (BIN8-J140-BIN-01.LEVEL-01).

Note: If the primary stockpile average level (APC-STOCK-PILE-J130-ST-01.LEVEL-05) goes to far above its high limit the primary crusher (J110-G3100) and secondary crusher (J120-G3100) circuits will be interlocked, no trucks will be allowed to tip ore into the primary crusher.

The fourth controlled variable is the recirculating load % (J154-G2700.RECIRC-PERC), which is calculated as the ratio between the recycle mass flow (J154-G2700.RECYCLE-WEIGHTOMETER) and the sum of the recyle mass flow and the tertiary crushing circuit total product flow (J154-G3000.TOTAL-PRODUCT-WEIGHTOMETER). The recirculating load % setpoint is determined by the primary stockpile average level (APC-STOCK-PILE-J130-ST-01.LEVEL-05) .

1. If the primary stockpile average level is above 40 %, the tertiary crushing circuit throughput is prioritised, and the recirculating load % setpoint is set to 45 %. This will start the following actions taken by the APC (APC-J140_BIN_005C):

a. The APC will decrease the tertiary crushing circuit p50 target

b. This p50 target will be written to each tertiary crusher cavity level APC (J141 /2/3/4_LIC_005C) p50setpoint (YC-J141 /2/3/4-P50).

c. The tertiary crusher cavity level APC will decrease the CSS (J141/2/3/4-G3120.CSS) of each crusher achieve the desired p50.

d. The smaller CSS will result in higher throughput through the tertiary crushing circuit increasing the tertiary crusing circuit total product mass flow (J154-G3000.TOTAL-PRODUCT-WEIGHTOMETER), which will result in lower recirculating load %.

2. If the primary stockpile average level (APC-STOCK-PILE-J130-ST-01.LEVEL-05) is below 40 % the tertiary crushing circuit cumulative lump needs to be prioritised. The recirculating load % setpoint is set to 55 %, and the reverse action of the actions mentioned above is taken.

The fifth controlled variable is the first reading of amps of the conveyor motor fo conveyor j153-g2100 (J153-G2100.CURRENT-01). If the amps reaches its high limit, the APC (APC-J140_BIN_005C) will decrease the tertiary crushing feed bin fresh feed mass flow (J153-G2100.WEIGHTOMETER) which in turn will decrease the amps on the the conveyor motor j153-g2100.

The sixth controlled variable is the second reading of amps of the conveyor motor fo conveyor j153-g2100 (J153-G2100.CURRENT-03). If the amps reaches its high limit, the APC (APC-J140_BIN_005C) will decrease the tertiary crushing feed bin fresh feed mass flow (J153-G2100.WEIGHTOMETER) which in turn will decrease the amps on the the conveyor motor j153-g2100.

The seventh controlled variable is the reading of amps of the conveyor motor fo conveyor j153-g2200 (J153-G2200.CURRENT). If the amps reaches its high limit, the APC (APC-J140_BIN_005C) will decrease the tertiary crushing feed bin fresh feed mass flow (J153-G2100.WEIGHTOMETER) which in turn will decrease the amps on the the conveyor motor j153-g2200.

The following table lists the relevant controlled variables for this controller along with their engineering units and control limits. Note that these control limits can be adjusted from the SCADA faceplate

APC CVs for APC-J140_BIN_005C				
Description	ID	EU	Low	High
CV1: T-Crushing Feed Bin J154-BIN-01 Level-01	BIN8-J140-BIN-01-AVERAGE-LEVEL	%	20.00	70.00
CV2: Tertiary Crusher Feed Conveyor J153-G2300 Current	J153-G2368	A	0.00	137.70
CV3: Primary Stockpile Level-05	STOCK-PILE-J130-ST-01-AVERAGE-LEVEL	%	50.00	90.00

CV4: Primary Stockpile Reclaim Conveyor 153-G2100 Current-01	J153-G2168.CURRENT	A	0.00	137.70
CV5: Primary Stockpile Reclaim Conveyor 153-G2100 Current-03	J153-G2178.CURRENT	A	0.00	137.70
CV6: Tertiary Crusher Feed Conveyor J153-G2200 Current	J153-G2268	A	0.00	118.08

3.3) Manipulated Variables

The first manipulated variable is the tertiary crushing circuit fresh feed mass flow set point (APC-J140_BIN_001C-SP-CONNECTION-CP-001) which is the setpoint for the speed PID (PID-J130-1) controller for the four feeders extracting ore from the primary stockpile (APC-STOCK-PILE-J130-ST-01) and feeding the primary stockpile product conveyor(J153-G2100).
This controller will drive each of the primary stockpile feeders to:
a. Increase/decrease the feeders speed feeding the primary stockpile product conveyor (J153-G2100).
The following CV's are manipulated via this MV:
1. Tertiary crusher feed bin average level (BIN8-J140-BIN-01.LEVEL-01) **(CV1)**.
2. Tertiary crushing feed bin fresh feed mass flow rate (J153-G2100.WEIGHTOMETER) **(CV2)**.
3. Primary stockpile average level (APC-STOCK-PILE-J130-ST-01.LEVEL-05) **(CV3)**.
4. Conveyor j153-G2100 amps reading 1 (J153-G2100.CURRENT-01) **(CV5)**.
5. Conveyor j153-G2100 amps reading 2 (J153-G2100.CURRENT-03) **(CV6)**.
6. Conveyor j153-G2200 amps reading (J153-G2200.CURRENT) **(CV7)**.
The second manipulated variable is the tertiary crusher circuit p50 setpoint (J140_BIN_001C_P50) which will write the same p50 setpoint to all the tertiary crusher cavity APCs (APC-J141/142/143/144_LIC_005C) p50 controlled variables.
This will drive each of the tertiary crusher cavity level APC controllers to either:
a. Increase/decrease the CSS for each crusher.
b. Increase/decrease the feeders speed feeding the crushers.
The following CV's are manipulated via this MV:
1. Recirculating load % (J154-G2700.RECIRC.PERC) **(CV4)**.

The following table lists the relevant manipulated variables for this controller along with their engineering units and control limits. Note that these control limits can be adjusted from the SCADA faceplate

APC MVs for APC-J140_BIN_005C				
Description	ID	EU	Low	High
MV1: Primary Stockpile Reclaim Conveyor 153-G2100 Weightometer PID-Controller J130-1	J130-1	ton/hr	300.00	5000.00

3.4) Disturbance Variables

The first disturbance variable is the recycle mass flow (J154-G2700.RECYCLE-WEIGHTOMETER). The recycle mass flow affects the tertiary crusher feed bin level. If the recycle mass flow increases, the bin level will increase, and if it decreases the bin level should decrease.
This variable is used by the APC to predict disturbances in the tertiary crusher feed bin level.

The following table lists the relevant disturbance variables for this controller along with their engineering units.

APC DVs for APC-J140_BIN_005C		
Description	ID	EU
DV1: Tertiary Crusher Conveyor J154-G2700 Recycle-Weightometer	J154-G2700	ton/hr
DV2: Tertiary Crusher Conveyor J154-G3000 Total-Product-Weightometer	154-G3000	ton/hr

3.5) Objectives and KPI's

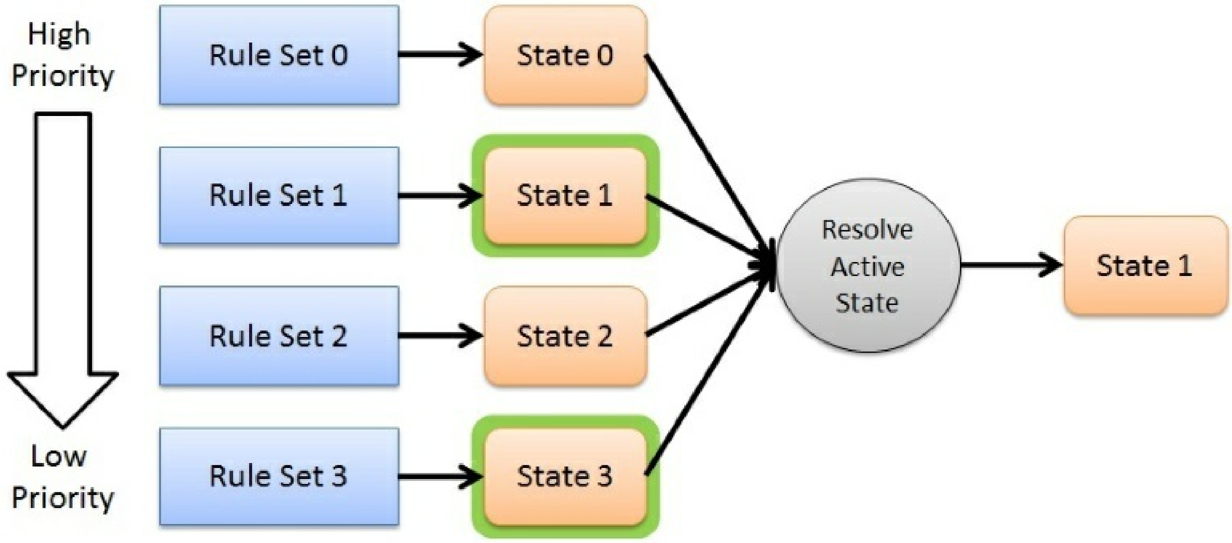
Objectives For Apc-J140_Bin_005c				
Measure	Goal	Owner	KPI	Weight

3.6) Process States

In APET, control philosophies are built around the state of the process. Different process conditions (broadly speaking) require different actions to be taken to achieve performance targets. In APET, process states are resolved through graphical rules and used in a hierarchical bidding system to determine the current process state. The governing state is then used in deciding which control scheme to implement.
These two steps are briefly described below.

1) Active State Resolution

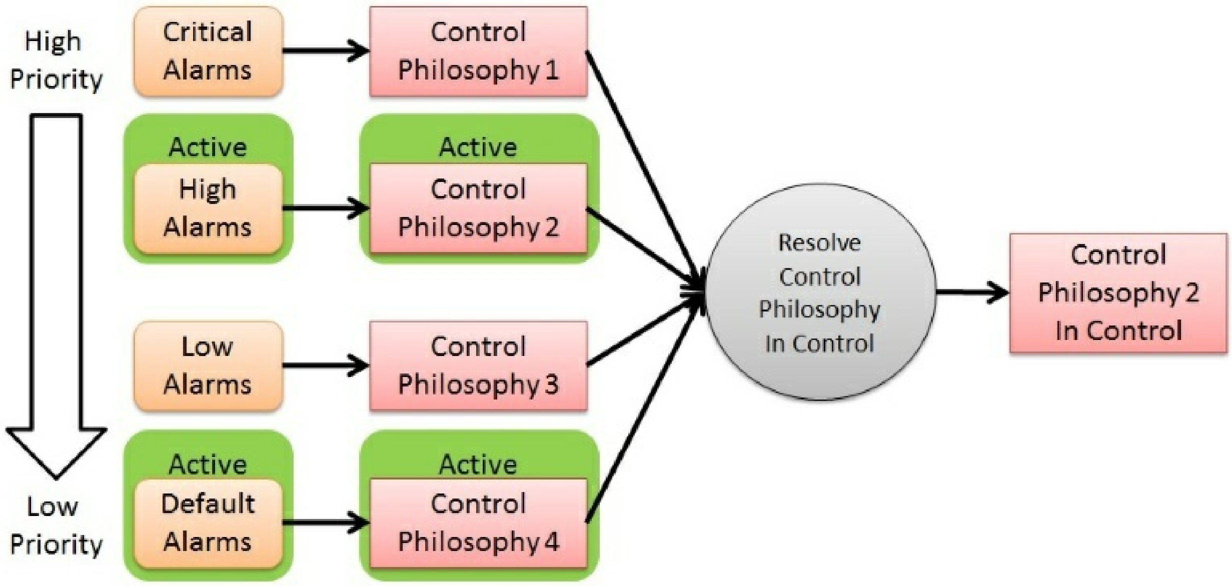
Each state is determined by a set of rules. These are usually built up using graphical rules and may monitor any information available within the APET application. A state is considered active if all specified conditions are met. This means that it is possible the more than one state can be active at a time. To deal with this, states are ranked based on a priority, so that the active state with the highest priority becomes the in-control state.



Because it is also possible that no states are active, it is important to select a state that acts as the default state. The default state usually corresponds to the state with the lowest priority (default alarms).

2) Control Philosophy Resolution

Each state corresponds to a specific control philosophy that will be implemented. Once the active state has been determined, the corresponding control philosophy is activated.



There are always 4 controller states for every APC controller in APET. These controller states are grouped together as follows:

1. Critical Alarms
2. High Alarms
3. Low Alarms
4. Default Alarms

Each of these 4 controller states may containing at least one referencing state. For example, the Default Alarms container will contain the MPC optimizer and default states amongst others.

Based on the referenced states of each controller state, the State Index of the controller state may be:

0 if it is not active

1 active but not in-control

2 active AND in-control
All of the attributes of the controller states are display on the SCADA faceplate.

3.6.1) CRITICAL-ALARMS

There are no critical-alarms defined.

3.6.2) HIGH-ALARMS

There are no high-alarms defined.

3.6.3) LOW-ALARMS

The following LOW-ALARMS are defined:

3.6.3.1) Conveyor-J153-G2100-Constrained

This process state becomes true when the conveyor weightometer is at its high limit and the weightometer rate of change is higher than 1, or the conveyor currents (current 1 and current 2) are at their high limit, and these high limits are 1 for longer than 10 seconds. While this state is true, the controller will revert to default control and the MPC controller will be switched off.
The conveyor constrained process state is a unwanted process state, this means that the conveyor (J153-G1200) is overloaded and operating above the designed specifications of this conveyor.

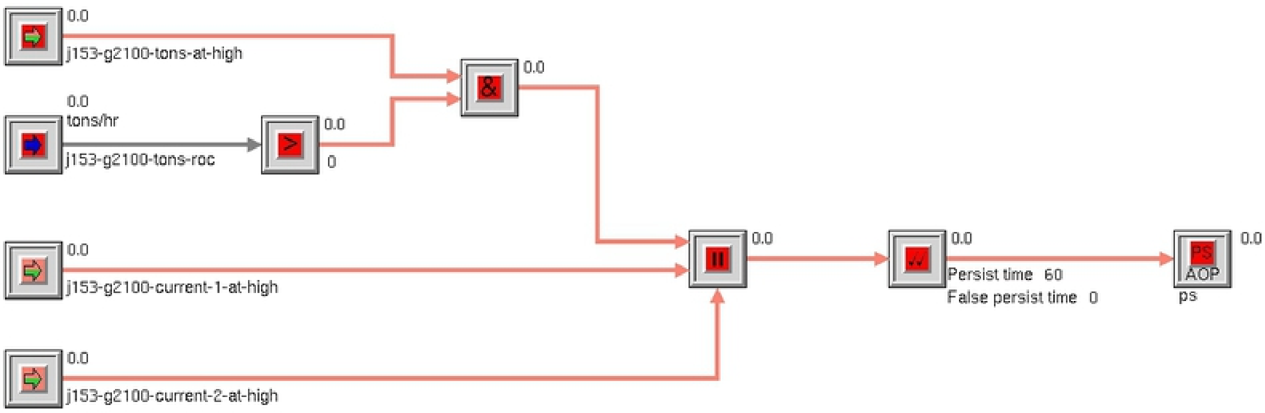


Fig 8: Determining Conveyor-J153-G2100-Constrained

3.6.3.2) Conveyor-J153-G2200-Constrained

This process state becomes true when the conveyor motor current reaches the high limit set on the APC faceplate for at least 10 seconds. While this state is true, the controller will revert to default control and the MPC controller will be switched off.
The conveyor constrained process state is a unwanted process state, this means that the conveyor is over loaded and operating above the designed specifications of this conveyor.

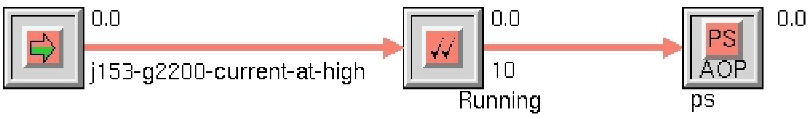


Fig 9: Determining Conveyor-J153-G2200-Constrained

3.6.3.3) Conveyor-J153-G2300-Constrained

This process state becomes true when the conveyor motor current reaches the high limit set on the APC faceplate

for at least 10 seconds. While this state is true, the controller will revert to default control and the MPC controller will be switched off.
The conveyor constrained process state is a unwanted process state, this means that the conveyor is over loaded and operating above the designed specifications of this conveyor.

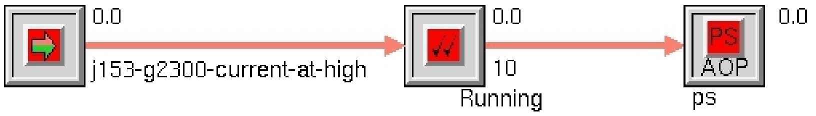


Fig 10: Determining Conveyor-J153-G2300-Constrained

3.6.3.4) Tripper-J154-G2400-Constrained

This process state becomes true when the tripper conveyor motor currents reaches either of their high limits set on the APC faceplate for at least 10 seconds. While this state is true, the controller will revert to default control and the MPC controller will be switched off.
The tripper conveyor constrained process state is a unwanted process state, this means that the conveyor is over loaded and operating above the designed specifications of this conveyor.

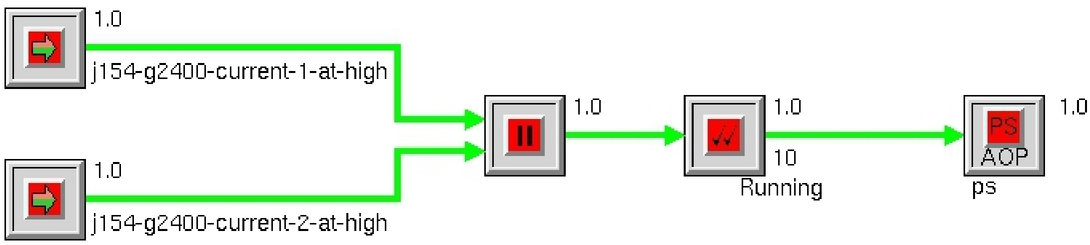


Fig 11: Determining Tripper-J154-G2400-Constrained

3.6.4) DEFAULT-ALARMS

The following DEFAULT-ALARMS are defined:

3.6.4.1) Mpc-Optimizer

Discrete logic ensuring that:
the operator request is ON;
the MPC controller is switched ON; and
the communications between the MPC and APET are OK (HB healty).
Note that the MPC optimizer state will be true (Active) if the logic above is true. The MPC optimizer will be In Control if none of the higher priority states are true.

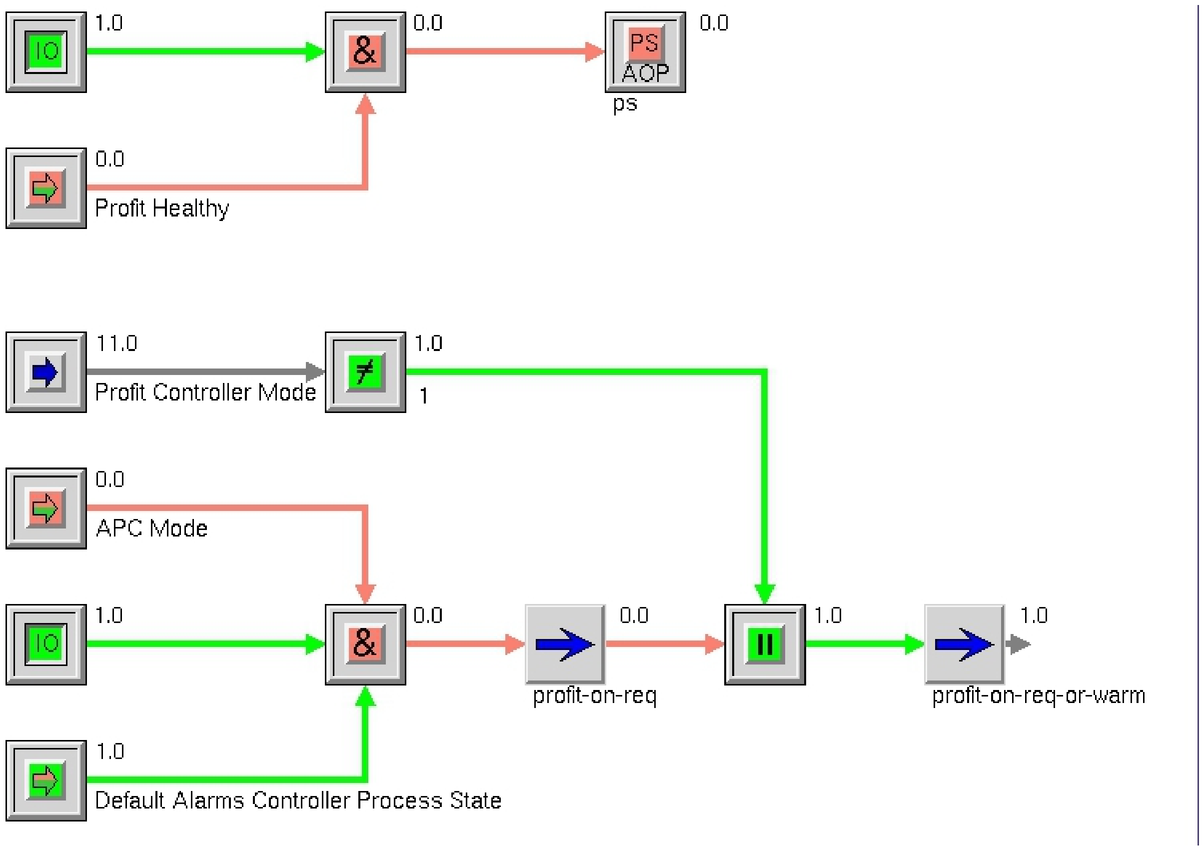


Fig 12: Determining Mpc-Optimizer

3.6.4.2) Default-Root

This process state determines if the crusher bin level is above 40.0%. When the Secondary Crusher feed bin lelel is high, the APC controller should not attempt to make CSS changes to Crusher 1 (Belief = 0.5) . The reason being that once a new CSS SP is written to the PLC, the Crusher Feeder will be I/Locked, which will cause the bin level High High Limit to be reached. This will I/Lock all the conveyors upstream in a cascade mode, which will result in a ZERO production scenario. Zero production is worse than production at a less than optimal Lump:Fine Ratio.

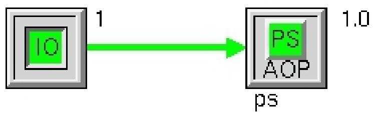


Fig 13: Determining Default-Root

3.7) Interlocks

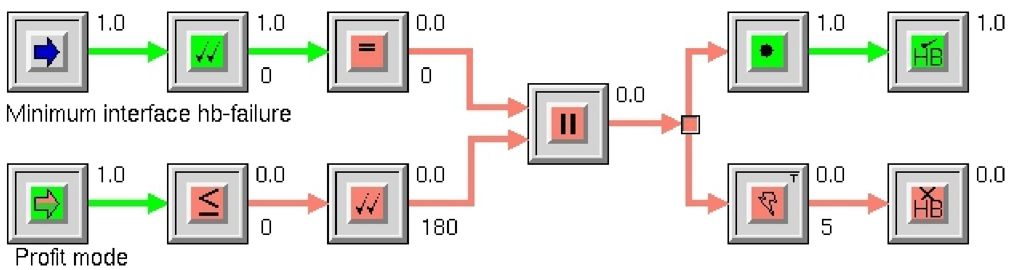


Fig 14: Interlocks: Apc-J140_Bin_005c.interlocks

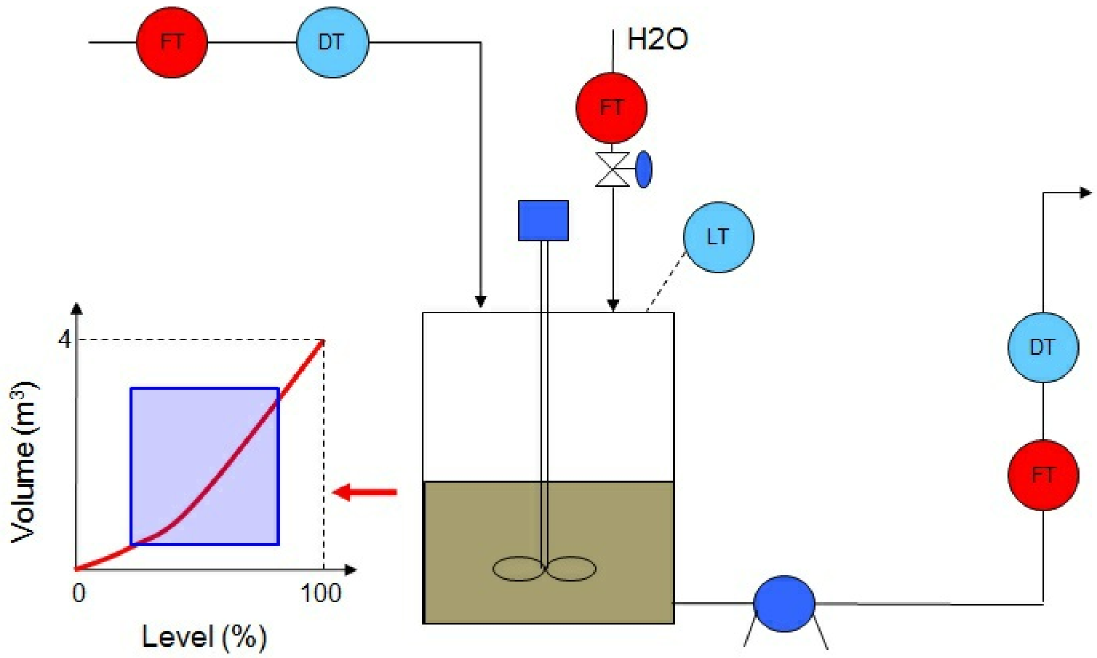
4) Control Technologies

Model predictive control (MPC) is an advanced method of process control that has been in use in the process industries in chemical plants and oil refineries since the 1980s. Model predictive controllers rely on dynamic models of the process, most often linear empirical models obtained by system identification. Dynamic process models describe how the process parameters will respond in the future for changes made to the process in the present time. These models can therefore predict process responses into the future. The main advantage of MPC is the fact that it allows for the current process conditions (current timeslot) to be optimized, while accounting for future process conditions (future timeslots) still to happen as a result of changes to the current process conditions. This is achieved by optimizing over a finite time-horizon (the future predictions), implementing the current timeslot actions and then relying on feedback to account for unmeasured disturbances and model/plant mismatches. This implies that the model prediction error that may exist (or develop over time) is also taken into account by the MPC algorithm. MPC models therefore do not have to be 100% accurate. As a result of this the MPC technology is very robust, and typically outperforms most other advanced process control techniques. The MPC further has the ability to anticipate/predict future events and can take control actions accordingly. An example of this is that the MPC can predict that the bin level will drop below the low level limit, which will result in the feeder being interlocked and stopped. The feeder stop will again cause the bin level to increase sharply. The MPC can take all of these future predictions into account and prevent this scenario from happening. PID controllers normally implemented as part of the base layer (PLC) control do not have this predictive ability. Therefore the PID controller in the base layer (PLC) control will not be able to prevent the above feeder interlock and stop.

The models used in MPC are generally intended to represent the behaviour of complex dynamic systems, which cannot be effectively controlled by base layer (PLC) controllers such as PID controllers. Dynamic characteristics that are difficult for PID controllers include large time delays, variable interaction and high-order dynamics.

MPC uses current and historical plant responses/measurements, the current dynamic state of the process, the MPC models, and the process variable targets and limits to calculate future changes in the dependent variables (the variables to be controlled, such as bin levels and product mass flowrates). These changes are calculated to hold the dependent variables close to target while honoring constraints on both independent (the levers that can be pulled by the MPC system, such as feeder speeds or PID setpoints) and dependent variables. The MPC typically sends out only the first setpoint change (of the sequence of calculated changes required going into the future) in each independent variable to be implemented, and repeats the calculation when the next change is required (by updating the sequence of calculated changes required going into the future).

Below is an image to illustrate the concepts:



In summary, Model Predictive Control (MPC) is a multivariable control algorithm that uses:

1. an internal dynamic model of the process
2. a history of past control moves and
3. an optimization cost function J over the receding prediction horizon,

to calculate the optimum control moves.

An example of a quadratic cost function for optimization is given by:

$$J = \sum_{i=1}^{N} w_{x_i}(r_i - x_i)^2 + \sum_{i=1}^{N} w_{u_i}\,\Delta {u_i}^2$$

With:

X_i = *i*-th controlled variable (e.g. measured bin level)

r_i = *i*-th reference variable (e.g. required bin level)

u_i = *i*-th manipulated variable (e.g. feeder speed)

w_{Xi} = weighting coefficient reflecting the relative importance of X_i

w_{ui} = weighting coefficient penalizing relative big changes in u_i

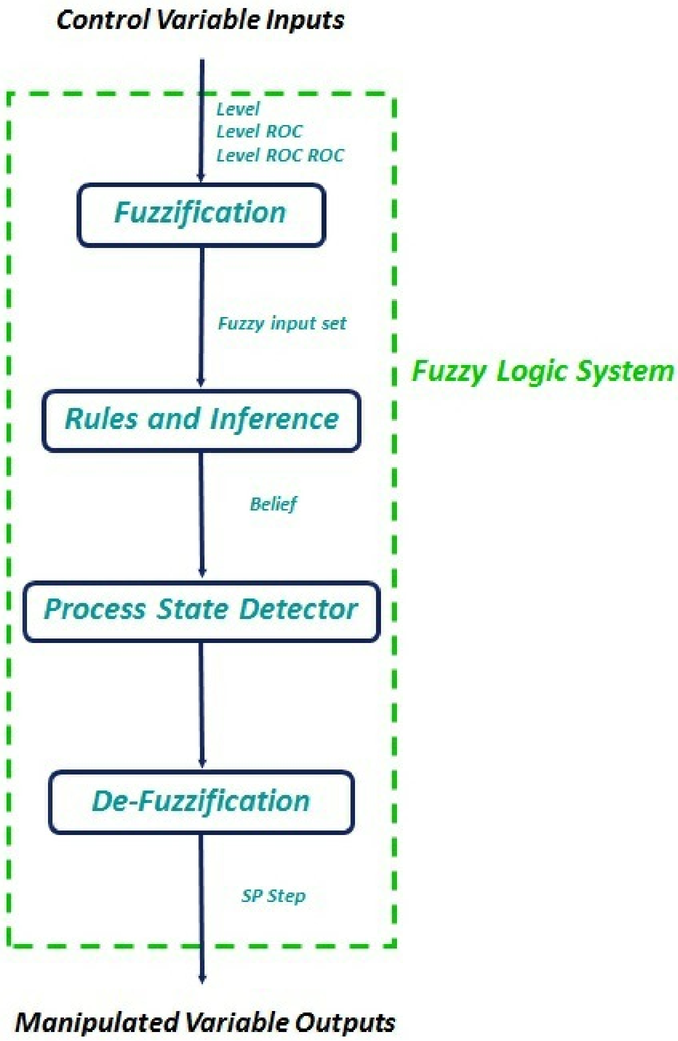
The figure below represents the model matrix for the secondary crusher model predictive controller, showing the dynamic step response between each controller input-output pair.

4.1) Expert Rule Based Control

4.2) Fuzzy Control

4.2.1) Fuzzy Sets

A fuzzy logic system (FLS) can be defined as the nonlinear mapping of an input data set to a scalar output data. A FLS consists of four main parts: fuzzifier, rules, inference engine, and defuzzifier. These components and the general architecture of a FLS is shown in the figure below.



The process of fuzzy logic is defined as follows: Firstly, a crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. This step is known as fuzzification. Afterwards, an inference is made based on a set of rules. Lastly, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification step.
The fuzzy logic algorithm can be summarized as follows:
1. Define the linguistic variables and terms (initialization)
2. Construct the membership functions (initialization)
3. Construct the rule base (initialization)
4. Convert crisp input data to fuzzy values using the membership functions (fuzzification)
5. Evaluate the rules in the rule base (inference)
6. Combine the results of each rule (inference)
7. Convert the output data to non-fuzzy values (defuzzification)
Linguistic variables are the input or output variables of the system whose values are words or sentences from a natural language, instead of numerical values. A linguistic variable is generally decomposed into a set of linguistic terms. Example: Leven in a bin. Let level (LVL) be the linguistic variable which represents the amount of metarial in the bin. To qualify the level, terms such as high and low are used in real life. These are the linguistic values of the level. Then, LVL(t) = extremely low, low, ok, high, extremely high can be the set of decompositions for the linguistic variable level. Each member of this decomposition is called a linguistic term and can cover a portion of the overall values of the bin level.
Membership functions are used in the fuzzification and defuzzification steps of a FLS, to map the non-fuzzy input values to fuzzy linguistic terms and vice versa. A membership function is used to quantify a linguistic term. Note that, an important characteristic of fuzzy logic is that a numerical value does not have to be fuzzified using only one membership function. In other words, a value typically belongs to multiple sets at the same time. For example the bin level value can be considered as extremely low and low at the same time, with different degrees of memberships.
APET includes a powerful fuzzy controller toolset which includes a very flexible editing environment as well as a variety of membership functions to be used.
Each CV feeding into the controller is fuzzified (classified within a fuzzy membership function) by one or more FIS-INPUTS. For control variables (CV) there are typically three types of classification: proximity (this relates to the

normalised value), slope (rate of change) and slope rate of change (this implies acceleration).
For each of the fuzzy families, a specific input must be provided based on the value of the CV (and its recent history).
1. Proximity: this is a comparison of the normalised value of the CV
2. Slope: this represents the slope or rate of change of the CV over a defined period and is calculated within the APC system
3. Slope Rate of Change: this represents the rate of change of the slope of the CV and is calculated within the APC system

4.2.1.1) Fuzzy Sets For BIN8-J140-BIN-01.LEVEL-01

There are no fuzzy memberships for the T-Crushing Feed Bin Avg Level measurement (J140-BIN-01.LEVEL-01). This is a calculated value that represents the bin inventory.
The inventory is calculated as the average of all T-Crushing Feed Bin levels, there are eight level transmitter, one per bin section.

4.2.1.2) Fuzzy Sets For CNVYR-J153-G2300.CURRENT

4.2.1.3) Fuzzy Sets For APC-STOCK-PILE-J130-ST-01.LEVEL-05

There are no fuzzy sets for the primary stockpile average level (APC-STOCK-PILE-J130-ST-01.LEVEL-05). This reading is used by the model predictive controller as a control variable (CV).

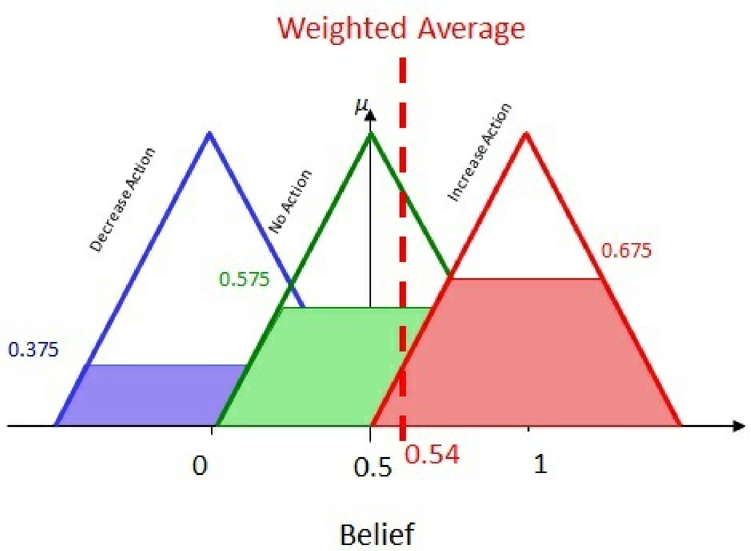
4.2.1.4) Fuzzy Sets For CNVYR-J153-G2100.CURRENT-01

4.2.1.5) Fuzzy Sets For CNVYR-J153-G2100.CURRENT-03

4.2.1.6) Fuzzy Sets For CNVYR-J153-G2200.CURRENT

4.2.2) Defuzzy Function

After the inference step, the overall result is a fuzzy value. This result should be defuzzified based on the process state which is In Control to obtain a final crisp output. This is the purpose of the defuzzifier component of a FLS. Defuzzification is performed according to the membership function of the output variable. For instance, assume that we have the result in the figure below at the end of the inference. In this figure, the shaded areas all belong to the fuzzy result. The purpose is to obtain a crisp value, represented by the dotted line in the figure below, from this fuzzy result.



The crisp value (or belief) is then converted back to a setpoint change using the defuzzy function.

4.2.2.1) Defuzzy functions for PID-J130-1

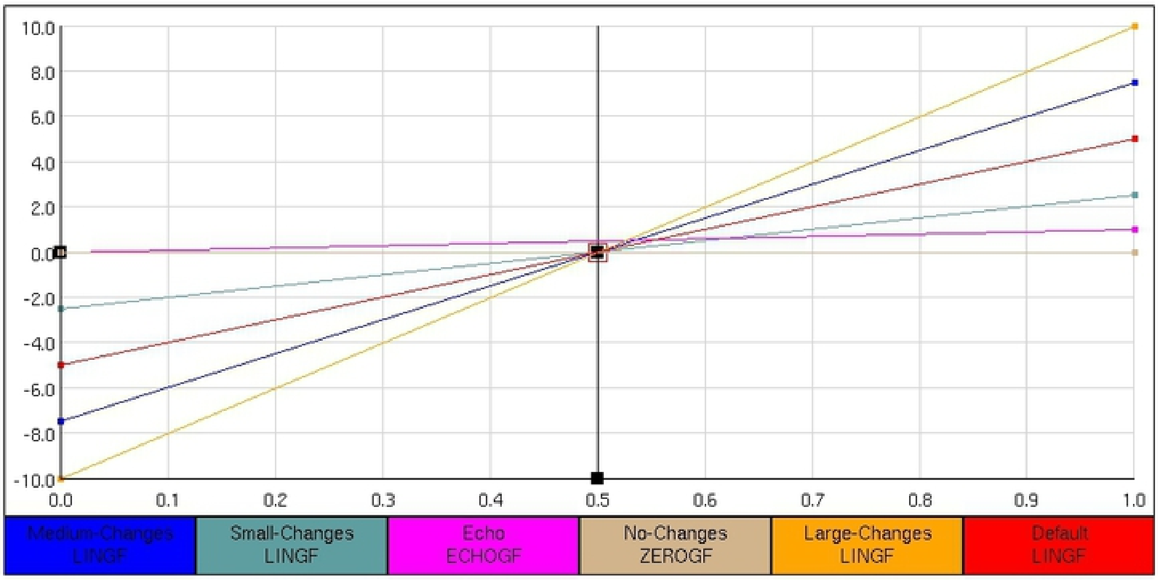


Fig 15: The defuzzy function for PID-J130-1.SP-STEP.FIS

4.3) Model Based Control

4.4) Model Predictive Control (MPC)

4.4.1) Model Matrix: PROFIT-CONTROLLER - J140_BIN_005c

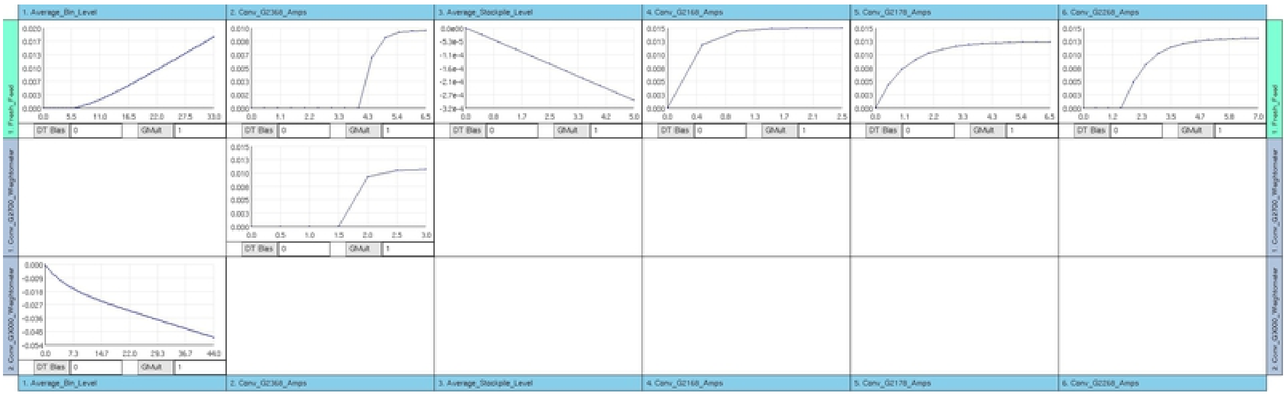
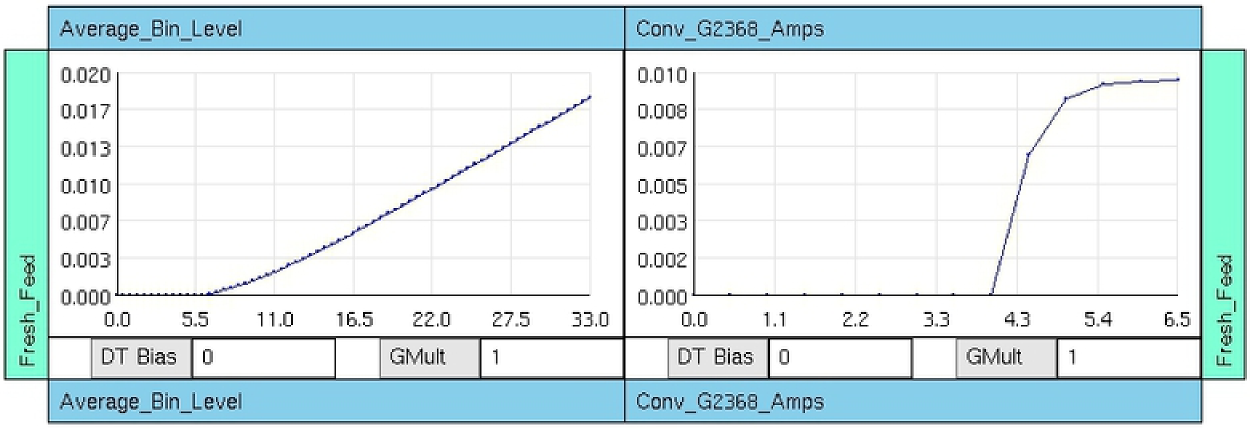
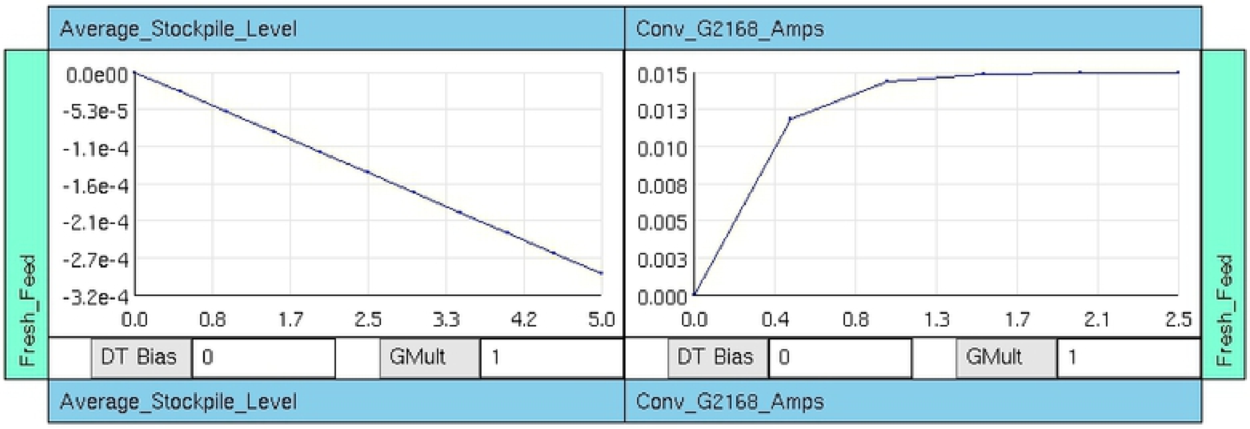
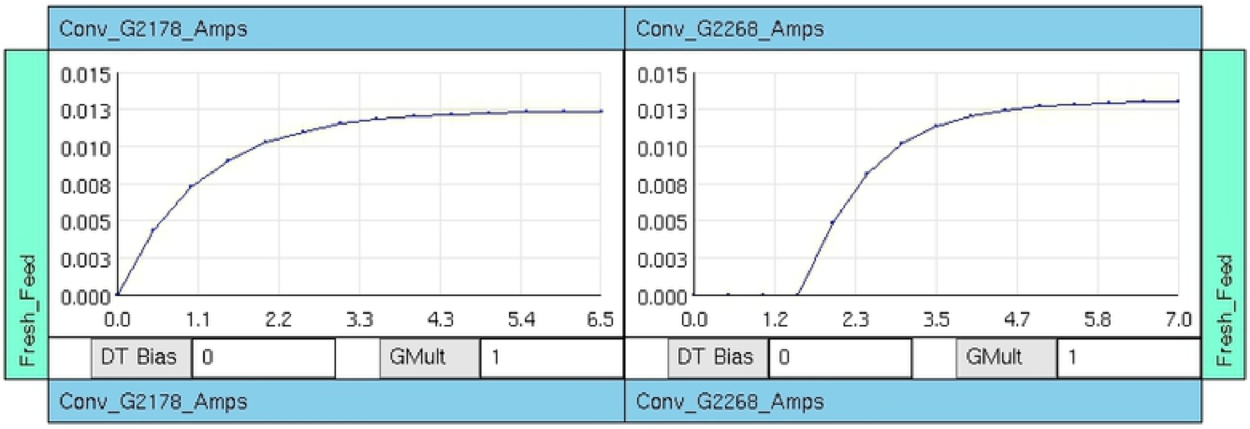
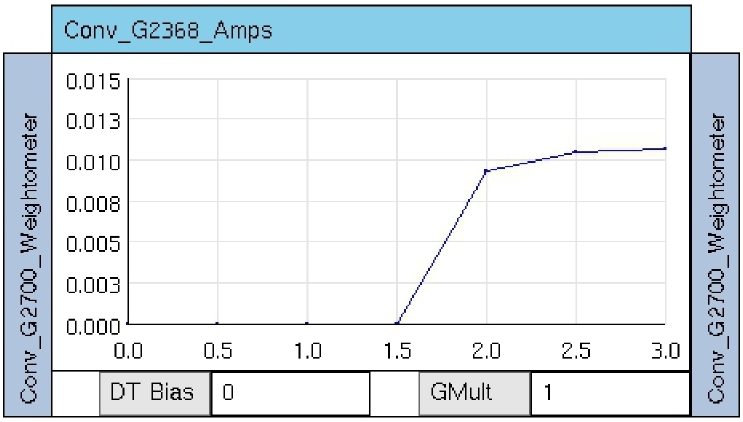


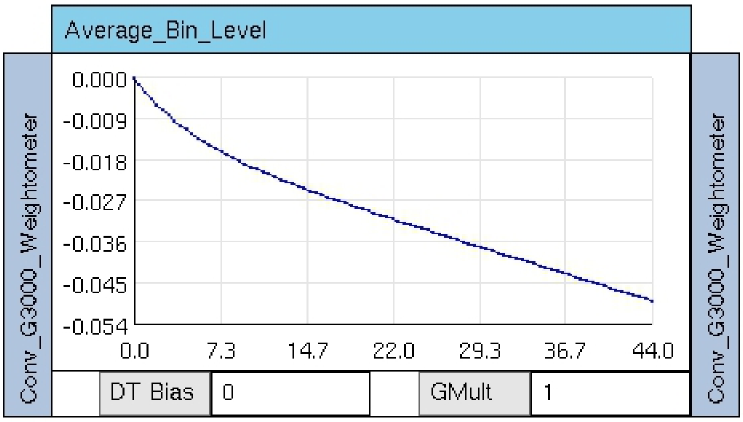
Fig 16: Model Matrix: PROFIT-CONTROLLER - J140_BIN_005c











5) Heartbeats

Heartbeats			
Name	Type	Parameter	Update Interval
SIS-JIG.SEP.APC-J140_BIN_005C.HB-IN	TIMED-TOGGLE	TIMEOUT:45	15
SIS-JIG.SEP.APC-J140_BIN_005C.HB-OUT	TOGGLE	MIN:0; MAX:1	15

6) Tag Listing

6.1) APC Tags

6.1.1) GSI Interface: IDX_COMMON

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.OBJECTIVE	
SIS-JIG.SEP.APC-J140_BIN_005C.OBJECTIVE-BEST-PERF	
SIS-JIG.SEP.APC-J140_BIN_005C.PROCESS-RUN-SIGNAL	

6.1.2) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.AUTO-MANUAL-MODE	G02M100.G02M100.DB940;DBX383.1

6.2) CV1 Tags

6.2.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-01.HH	G02M100.G02M100.DB940;REAL436
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-01.LL	G02M100.G02M100.DB940;REAL444

6.3) CV2 Tags

6.3.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.CNVYR-J153-G2300.CURRENT.HH	G02M100.G02M100.DB942;REAL448
SIS-JIG.SEP.CNVYR-J153-G2300.CURRENT.LL	G02M100.G02M100.DB942;REAL456
SIS-JIG.SEP.CNVYR-J153-G2300.CURRENT.PV	JIG_Galaxy.J153G2368_T25.S_Current

6.4) CV3 Tags

6.4.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-05.HH	G02M100.G02M100.DB940;REAL448
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-05.LL	G02M100.G02M100.DB940;REAL456

6.5) CV4 Tags

6.5.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-01.HH	G02M100.G02M100.DB941;REAL690
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-01.INT-HI	JIG_Galaxy.J140BIN001C_MVC3.PV2_H
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-01.INT-LO	JIG_Galaxy.J140BIN001C_MVC3.PV2_L
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-01.LL	G02M100.G02M100.DB941;REAL698
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-01.PV	G02M100.G02M100.DB941;REAL44

6.6) CV5 Tags

6.6.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag

SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-03.HH	G02M100.G02M100.DB941;REAL702
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-03.INT-HI	JIG_Galaxy.J140BIN001C_MVC3.PV3_H
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-03.INT-LO	JIG_Galaxy.J140BIN001C_MVC3.PV3_L
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-03.LL	G02M100.G02M100.DB941;REAL710
SIS-JIG.SEP.CNVYR-J153-G2100.CURRENT-03.PV	G02M100.G02M100.DB941;REAL70

6.7) CV6 Tags

6.7.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.CNVYR-J153-G2200.CURRENT.HH	G02M100.G02M100.DB941;REAL714
SIS-JIG.SEP.CNVYR-J153-G2200.CURRENT.INT-HI	JIG_Galaxy.J140BIN001C_MVC3.PV4_H
SIS-JIG.SEP.CNVYR-J153-G2200.CURRENT.INT-LO	JIG_Galaxy.J140BIN001C_MVC3.PV4_L
SIS-JIG.SEP.CNVYR-J153-G2200.CURRENT.LL	G02M100.G02M100.DB941;REAL722
SIS-JIG.SEP.CNVYR-J153-G2200.CURRENT.PV	G02M100.G02M100.DB941;REAL96

6.8) MV1 Tags

6.8.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.CNVYR-J153-G2100.WEIGHTOMETER.HH	G02M100.G02M100.DB940;REAL484
SIS-JIG.SEP.CNVYR-J153-G2100.WEIGHTOMETER.INT-LO	JIG_Galaxy.J140BIN001C_MVC.C1_SP_L
SIS-JIG.SEP.CNVYR-J153-G2100.WEIGHTOMETER.LL	G02M100.G02M100.DB940;REAL492
SIS-JIG.SEP.CNVYR-J153-G2100.WEIGHTOMETER.PV	JIG_Galaxy.J153G2100_T4.S_ProcessValue
SIS-JIG.SEP.PID-J130-1.ACTUAL-SP	G02M100.G02M100.DB940;REAL128
SIS-JIG.SEP.PID-J130-1.APC-SP	G02M100.G02M100.DB940;REAL396
SIS-JIG.SEP.PID-J130-1.AUTO-MANUAL-MODE	JIG_Galaxy.J130PID1_T22.C_ManualOn_Off

6.9) DV1 Tags

6.9.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.CNVYR-J154-G2700.RECYCLE-WEIGHTOMETER.HH	G02M100.G02M100.DB940;REAL460
SIS-JIG.SEP.CNVYR-J154-G2700.RECYCLE-WEIGHTOMETER.LL	G02M100.G02M100.DB940;REAL468
SIS-JIG.SEP.CNVYR-J154-G2700.RECYCLE-WEIGHTOMETER.PV	JIG_Galaxy.J140_DIAG01.TC_RECIRC_RATE

6.10) DV2 Tags

6.10.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.CNVYR-J154-G3000.TOTAL-PRODUCT-WEIGHTOMETER.HH	G02M100.G02M100.DB903;REAL702
SIS-JIG.SEP.CNVYR-J154-G3000.TOTAL-PRODUCT-WEIGHTOMETER.LL	G02M100.G02M100.DB903;REAL610
SIS-JIG.SEP.CNVYR-J154-G3000.TOTAL-PRODUCT-WEIGHTOMETER.PV	G02M100.G02M100.DB932;REAL70

6.11) PROCESS-STATES Tags

6.11.1) GSI Interface: IDX_COMMON

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.CONVEYOR-J153-G2100-CONSTRAINED.STATE-BELIEF	
SIS-JIG.SEP.APC-J140_BIN_005C.CONVEYOR-J153-G2100-CONSTRAINED.STATE-INDEX	
SIS-JIG.SEP.APC-J140_BIN_005C.CONVEYOR-J153-G2200-CONSTRAINED.STATE-	

BELIEF	
SIS-JIG.SEP.APC-J140_BIN_005C.CONVEYOR-J153-G2200-CONSTRAINED.STATE-INDEX	
SIS-JIG.SEP.APC-J140_BIN_005C.CONVEYOR-J153-G2300-CONSTRAINED.STATE-BELIEF	
SIS-JIG.SEP.APC-J140_BIN_005C.CONVEYOR-J153-G2300-CONSTRAINED.STATE-INDEX	
SIS-JIG.SEP.APC-J140_BIN_005C.CRIT-ALARMS.STATE-BELIEF	
SIS-JIG.SEP.APC-J140_BIN_005C.DEF-ROOT.STATE-BELIEF	
SIS-JIG.SEP.APC-J140_BIN_005C.DEF-ROOT.STATE-INDEX	
SIS-JIG.SEP.APC-J140_BIN_005C.HIGH-ALARMS.STATE-BELIEF	
SIS-JIG.SEP.APC-J140_BIN_005C.MPC-OPTIMIZER.STATE-BELIEF	
SIS-JIG.SEP.APC-J140_BIN_005C.MPC-OPTIMIZER.STATE-INDEX	
SIS-JIG.SEP.APC-J140_BIN_005C.STATE-INDEX	
SIS-JIG.SEP.APC-J140_BIN_005C.TRIPPER-J154-G2400-CONSTRAINED.STATE-BELIEF	
SIS-JIG.SEP.APC-J140_BIN_005C.TRIPPER-J154-G2400-CONSTRAINED.STATE-INDEX	

6.12) PROFIT-CONTROLLER Tags

6.12.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT.CONTROL-RESTART	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Control Restart.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT.DEMAND	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/urtDemand.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT.HB	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/urtIntervalCount.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT.URT-COUNTDOWN	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/urtCountdown.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT.URT-EXEC-STATE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/urtExecState.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CTRL-MODE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Controller Mode.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_DISPLAY-STATUS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Displayed Status.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_MPC-STATE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MPC_State.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_ON-OFF-TOGGLE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Turn ON OFF.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_OPT-ACC-TOL	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Opt Acceleration Tol.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_OPT-SPEED-FACTOR	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Optimizer Speed Factor.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_READ-MODEL-FLAG	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Read Model Flag.InternalValue

6.13) PROFIT-CONTROLLER-CV1 Tags

6.13.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.BALANCE-FACTOR	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Factor Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.CLOSED-LOOP-RESP-TIME	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Loop Resp Time.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.DV2.DTBIAS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Dead Time Bias.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.DV2.GMULT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Gain Multiplier.Value[
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve This CV.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.FF-TO-FB-PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Perf Ratio.Value

SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.FUTURE-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.HIGH-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Soft High Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.HIGH-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.HIGH-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Limit Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.INTEGRATING	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve type.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.LIMIT-VIOLATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Value.Color
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.LINEAR-COEFF	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Coeff.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.LOW-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Soft Low Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.LOW-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.LOW-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.MV1.DTBIAS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Dead Time Bias.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.MV1.GMULT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Gain Multiplier.Value[(
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.NUMBER-OF-BLOCKS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve of Blocks.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Value DCS.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.SS-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.STATE-ESTIMATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Estimation.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.TARGET	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_BIN_LEVEL.TARGET-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_Bin_Leve Coeff.Value

6.14) PROFIT-CONTROLLER-CV2 Tags

6.14.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.BALANCE-FACTOR	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Factor Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.CLOSED-LOOP-RESP-TIME	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/(Loop Resp Time.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.DV1.DTBIAS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Dead Time Bias.Value[3
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.DV1.GMULT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Gain Multiplier.Value[3]
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/(This CV.InternalValue

SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.FF-TO-FB-PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Perf Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.FUTURE-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.HIGH-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Soft High Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.HIGH-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.HIGH-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Limit Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.INTEGRATING	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I type.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.LIMIT-VIOLATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Value.Color
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.LINEAR-COEFF	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Coeff.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.LOW-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Soft Low Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.LOW-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.LOW-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.MV1.DTBIAS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Dead Time Bias.Value[2
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.MV1.GMULT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Gain Multiplier.Value[2]
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.NUMBER-OF-BLOCKS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I of Blocks.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Value DCS.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.SS-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/S Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.STATE-ESTIMATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/S Estimation.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.TARGET	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/I Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2368_AMPS.TARGET-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2368_Amps/(Coeff.Value

6.15) PROFIT-CONTROLLER-CV3 Tags

6.15.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.BALANCE-FACTOR	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Factor Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.CLOSED-LOOP-RESP-TIME	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Loop Resp Time.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S This CV.InternalValue
SIS-JIG.SEP.APC-	

J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.FF-TO-FB-PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Perf Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.FUTURE-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.HIGH-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Soft High Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.HIGH-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.HIGH-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Limit Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.INTEGRATING	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S type.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.LIMIT-VIOLATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Value.Color
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.LINEAR-COEFF	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Coeff.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.LOW-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Soft Low Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.LOW-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.LOW-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.MV1.DTBIAS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Dead Time Bi
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.MV1.GMULT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Gain Multiplie
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.NUMBER-OF-BLOCKS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S of Blocks.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Value DCS.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.SS-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.STATE-ESTIMATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Estimation.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.TARGET	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_AVERAGE_STOCKPILE_LEVEL.TARGET-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Average_S Coeff.Value

6.16) PROFIT-CONTROLLER-CV4 Tags

6.16.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.BALANCE-FACTOR	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Factor Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.CLOSED-LOOP-RESP-TIME	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/(Loop Resp Time.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/(This CV.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.FF-TO-FB-	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Perf Ratio.Value

PERF-RATIO	
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.FUTURE-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.HIGH-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Soft High Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.HIGH-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.HIGH-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Limit Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.INTEGRATING	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I type.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.LIMIT-VIOLATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Value.Color
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.LINEAR-COEFF	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Coeff.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.LOW-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Soft Low Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.LOW-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.LOW-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.MV1.DTBIAS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Dead Time Bias.Value[5
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.MV1.GMULT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Gain Multiplier.Value[5]
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.NUMBER-OF-BLOCKS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I of Blocks.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Value DCS.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.SS-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/S Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.STATE-ESTIMATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/S Estimation.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.TARGET	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/I Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2168_AMPS.TARGET-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2168_Amps/(Coeff.Value

6.17) PROFIT-CONTROLLER-CV5 Tags

6.17.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.BALANCE-FACTOR	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Factor Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.CLOSED-LOOP-RESP-TIME	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/(Loop Resp Time.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/(This CV.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.FF-TO-FB-PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Perf Ratio.Value

SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.FUTURE-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.HIGH-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Soft High Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.HIGH-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.HIGH-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Limit Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.INTEGRATING	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I type.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.LIMIT-VIOLATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Value.Color
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.LINEAR-COEFF	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Coeff.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.LOW-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Soft Low Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.LOW-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.LOW-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.MV1.DTBIAS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Dead Time Bias.Value[6
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.MV1.GMULT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Gain Multiplier.Value[6]
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.NUMBER-OF-BLOCKS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I of Blocks.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Value DCS.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.SS-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/S Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.STATE-ESTIMATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/S Estimation.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.TARGET	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/I Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2178_AMPS.TARGET-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2178_Amps/(Coeff.Value

6.18) PROFIT-CONTROLLER-CV6 Tags

6.18.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.BALANCE-FACTOR	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Factor Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.CLOSED-LOOP-RESP-TIME	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/(Loop Resp Time.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/(This CV.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.FF-TO-FB-PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Perf Ratio.Value
SIS-JIG.SEP.APC-	

J140_BIN_005C.PROFIT_CONV_G2268_AMPS.FUTURE-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.HIGH-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Soft High Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.HIGH-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.HIGH-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Limit Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.INTEGRATING	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I type.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.LIMIT-VIOLATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Value.Color
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.LINEAR-COEFF	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Coeff.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.LOW-LIMIT-DELTA	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Soft Low Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.LOW-LIMIT-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.LOW-LIMIT-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Error Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.MV1.DTBIAS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Dead Time Bias.Value[7
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.MV1.GMULT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/Gain Multiplier.Value[7]
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.NUMBER-OF-BLOCKS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I of Blocks.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.PERF-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Value DCS.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.SS-VALUE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/ Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.STATE-ESTIMATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/ Estimation.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.TARGET	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/I Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2268_AMPS.TARGET-WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/CV/Conv_G2268_Amps/ Coeff.Value

6.19) PROFIT-CONTROLLER-MV1 Tags

6.19.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.APC-SP	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Sent Value.Valu
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.CONSTRAINT-TYPE	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Constraint Type.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.DELTA-SOFT-HIGH-LIMIT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Delta Soft High Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.DELTA-SOFT-LOW-LIMIT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Delta Soft Low Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Use This MV.InternalValue

SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.HIGH-LIMIT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/High Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.LIMIT-VIOLATION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Read Value.Col
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.LINEAR-COEFF	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Linear Coeff.Val
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.LOW-LIMIT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Low Limit.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.MAIN-CV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/SSMove Main CV.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.MAX-MOVE-DOWN	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Max Move Down.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.MAX-MOVE-UP	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Max Move Up.V
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.MV-MAN-ACTION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/MV Man Action.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.NUMBER-OF-BLOCKS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Number of Blocks.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.OP	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Read OP Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.OP-HIGH	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/OP High Windup.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.OP-HIGH-TRANSITION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/OP High Transition.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.OP-LOW	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/OP Low Windup.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.OP-LOW-TRANSITION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/OP Low Transition.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.OP-TO-PV-GAIN	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/OP to PV Gain.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.PB-ANTIWINDUP-RATIO	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/PB AntiWindup Ratio.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Read Process Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.QUADRATIC-COEFF	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Quadratic Coeff.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.RESOLUTION	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Resolution.Valu
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.SP	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Read Value.Val
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.STATUS	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Status.InternalV
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.TARGET	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Desired Value.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.USE-ARCH-LIMIT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Use Ach Limit.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.WEIGHT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Weight.Value
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_FRESH_FEED.WINDUP-SLOT	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/MV/Fresh_Feed/Windup Status.InternalValue

6.20) PROFIT-CONTROLLER-DV1 Tags

6.20.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2700_WEIGHTOMETER.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/DV/Conv_G2700_ This DV.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G2700_WEIGHTOMETER.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/DV/Conv_G2700_ Value.Value

6.21) PROFIT-CONTROLLER-DV2 Tags

6.21.1) GSI Interface: IDX_SIS_MPC_26583_JIG_T_CRUSHING_HONEYWELL

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G3000_WEIGHTOMETER.ENABLED	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/DV/Conv_G3000_ This DV.InternalValue
SIS-JIG.SEP.APC-J140_BIN_005C.PROFIT_CONV_G3000_WEIGHTOMETER.PV	(J140_BIN_005c)/$J140_BIN_005c/J140_BIN_005c/ProfCon/DV/Conv_G3000_ Value.Value

6.22) OTHER Tags

6.22.1) GSI Interface: IDX_SIS_EXPERT_22583_JIG_T_CRUSHING

Tag	OPC Tag
SIS-JIG.SEP.APC-J140_BIN_005C.HB-IN	G02M100.G02M100.DB940;INT664
SIS-JIG.SEP.APC-J140_BIN_005C.HB-OUT	G02M100.G02M100.DB940;INT14
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-01.HH	JIG_Galaxy.J140BIN001C_MVC5.PV2HH_OP
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-01.INT-HI	JIG_Galaxy.J140BIN001C_MVC5.PV2_H
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-01.INT-LO	JIG_Galaxy.J140BIN001C_MVC5.PV2_L
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-01.LL	JIG_Galaxy.J140BIN001C_MVC5.PV2LL_OP
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-01.PV	JIG_Galaxy.J130LIT002C_T4.S_ProcessValue
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-02.HH	JIG_Galaxy.J140BIN001C_MVC5.PV3HH_OP
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-02.INT-HI	JIG_Galaxy.J140BIN001C_MVC5.PV3_H
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-02.INT-LO	JIG_Galaxy.J140BIN001C_MVC5.PV3_L
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-02.LL	JIG_Galaxy.J140BIN001C_MVC5.PV3LL_OP
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-02.PV	JIG_Galaxy.J130LIT002D_T4.S_ProcessValue
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-03.HH	JIG_Galaxy.J140BIN001C_MVC5.PV1HH_OP
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-03.INT-HI	JIG_Galaxy.J140BIN001C_MVC5.PV1_H
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-03.INT-LO	JIG_Galaxy.J140BIN001C_MVC5.PV1_L
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-03.LL	JIG_Galaxy.J140BIN001C_MVC5.PV1LL_OP
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-03.PV	JIG_Galaxy.J130LIT002B_T4.S_ProcessValue
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-04.HH	JIG_Galaxy.J140BIN001C_MVC4.PV4HH_OP
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-04.INT-HI	JIG_Galaxy.J140BIN001C_MVC4.PV4_H
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-04.INT-LO	JIG_Galaxy.J140BIN001C_MVC4.PV4_L
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-04.LL	JIG_Galaxy.J140BIN001C_MVC4.PV4LL_OP
SIS-JIG.SEP.APC-STOCK-PILE-J130-ST-01.LEVEL-04.PV	JIG_Galaxy.J130LIT002A_T4.S_ProcessValue
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-02.PV	JIG_Galaxy.J140LIT002_T4.S_ProcessValue
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-03.PV	JIG_Galaxy.J140LIT003_T4.S_ProcessValue
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-04.PV	JIG_Galaxy.J140LIT004_T4.S_ProcessValue
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-05.PV	JIG_Galaxy.J140LIT005_T4.S_ProcessValue
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-06.PV	JIG_Galaxy.J140LIT006_T4.S_ProcessValue
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-07.PV	JIG_Galaxy.J140LIT007_T4.S_ProcessValue
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-08.PV	JIG_Galaxy.J140LIT008_T4.S_ProcessValue
SIS-JIG.SEP.BIN8-J140-BIN-01.LEVEL-09.PV	JIG_Galaxy.J140LIT009_T4.S_ProcessValue
SIS-JIG.SEP.CNVYR-J153-G2200.STATUS.PV	JIG_Galaxy.J153G2268_T25.S_Running
SIS-JIG.SEP.CNVYR-J153-G2300.STATUS.PV	JIG_Galaxy.J153G2368_T25.S_Running
SIS-JIG.SEP.CNVYR-J154-G2700.STATUS.PV	JIG_Galaxy.J154G2768_T25.S_Running
SIS-JIG.SEP.CNVYR-J154-G3000.STATUS.PV	JIG_Galaxy.J154G3068_T25.S_Running
SIS-JIG.SEP.FDR-J141-G1118.STATUS.PV	JIG_Galaxy.J141G1118_T12.S_Running
SIS-JIG.SEP.FDR-J141-G1128.STATUS.PV	JIG_Galaxy.J141G1128_T12.S_Running
SIS-JIG.SEP.FDR-J142-G1118.STATUS.PV	JIG_Galaxy.J142G1118_T12.S_Running
SIS-JIG.SEP.FDR-J142-G1128.STATUS.PV	JIG_Galaxy.J142G1128_T12.S_Running

SIS-JIG.SEP.FDR-J143-G1118.STATUS.PV	JIG_Galaxy.J143G1118_T12.S_Running
SIS-JIG.SEP.FDR-J143-G1128.STATUS.PV	JIG_Galaxy.J143G1128_T12.S_Running
SIS-JIG.SEP.FDR-J144-G1118.STATUS.PV	JIG_Galaxy.J144G1118_T12.S_Running
SIS-JIG.SEP.FDR-J144-G1128.STATUS.PV	JIG_Galaxy.J144G1128_T12.S_Running
SIS-JIG.SEP.MOTOR-J153-G2168.STATUS.PV	JIG_Galaxy.J153G2168_T25.S_Running
SIS-JIG.SEP.MOTOR-J153-G2178.STATUS.PV	JIG_Galaxy.J153G2178_T25.S_Running
SIS-JIG.SEP.MOTOR-J154-G2400-MOTOR.CURRENT-01.HH	JIG_Galaxy.J140BIN001C_MVC4.PV3HH_OP
SIS-JIG.SEP.MOTOR-J154-G2400-MOTOR.CURRENT-01.INT-HI	JIG_Galaxy.J140BIN001C_MVC4.PV3_H
SIS-JIG.SEP.MOTOR-J154-G2400-MOTOR.CURRENT-01.PV	JIG_Galaxy.J154G2478_T1.S_Current
SIS-JIG.SEP.MOTOR-J154-G2400-MOTOR.CURRENT-02.HH	JIG_Galaxy.J140BIN001C_MVC4.PV2HH_OP
SIS-JIG.SEP.MOTOR-J154-G2400-MOTOR.CURRENT-02.INT-HI	JIG_Galaxy.J140BIN001C_MVC4.PV2_H
SIS-JIG.SEP.MOTOR-J154-G2400-MOTOR.CURRENT-02.PV	JIG_Galaxy.J154G2468_T1.S_Current

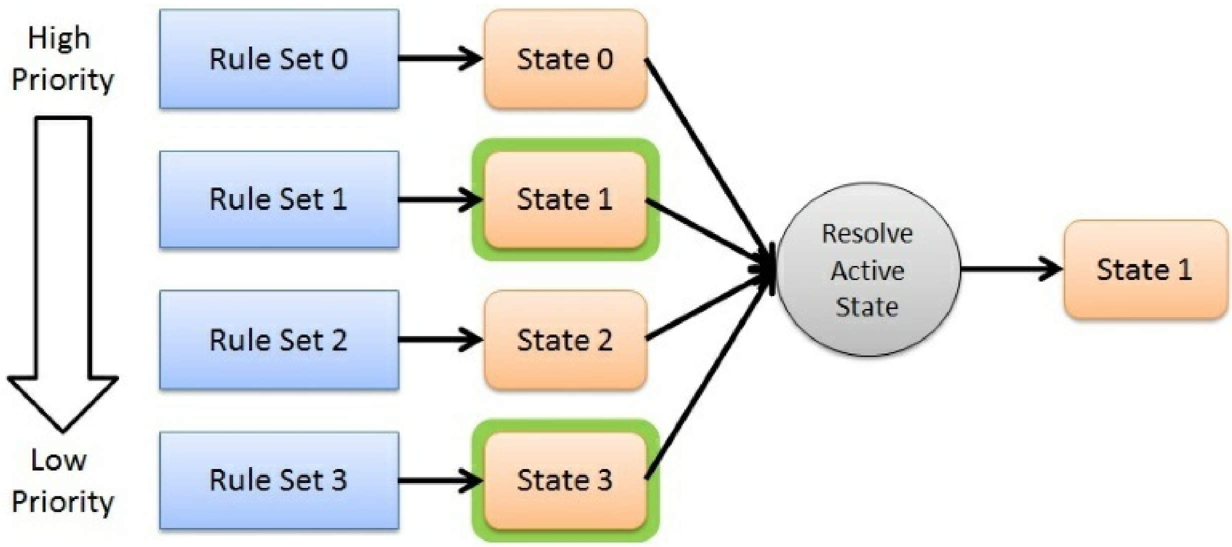
ADDENDUMS

A1 - Basic Principles of Process States

In APET, control philosophies are built around the state of the process. Different process conditions (broadly speaking) require different actions to be taken to achieve performance targets. In APET, process states are resolved through graphical rules and used in a hierarchical bidding system to determine the current process state. The governing state is then used in deciding which control scheme to implement.

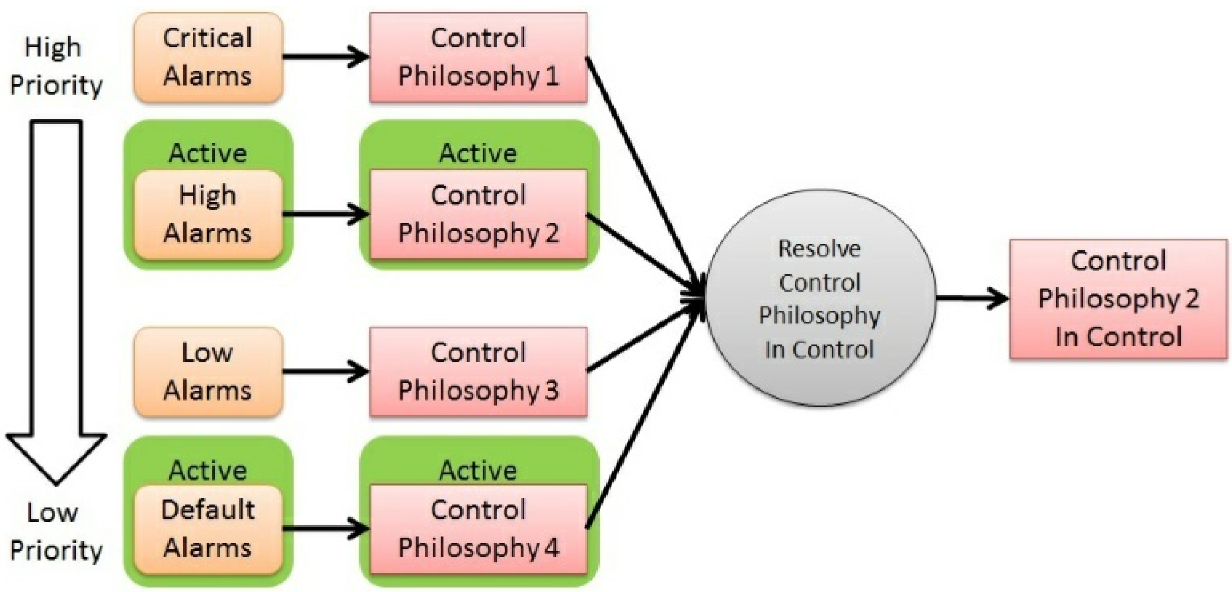
These two steps are briefly described below.

1) Active State Resolution
Each state is determined by a set of rules. These are usually built up using graphical rules and may monitor any information available within the APET application. A state is considered active if all specified conditions are met. This means that it is possible the more than one state can be active at a time. To deal with this, states are ranked based on a priority, so that the active state with the highest priority becomes the in-control state.



Because it is also possible that no states are active, it is important to select a state that acts as the default state. The default state usually corresponds to the state with the lowest priority (default alarms).

2) Control Philosophy Resolution
Each state corresponds to a specific control philosophy that will be implemented. Once the active state has been determined, the corresponding control philosophy is activated.



There are always 4 controller states for every APC controller in APET. These controller states are grouped together as follows:
1. Critical Alarms
2. High Alarms
3. Low Alarms
4. Default Alarms

Each of these 4 controller states may containing at least one referencing state. For example, the Default Alarms container will contain the MPC optimizer and default states amongst others.

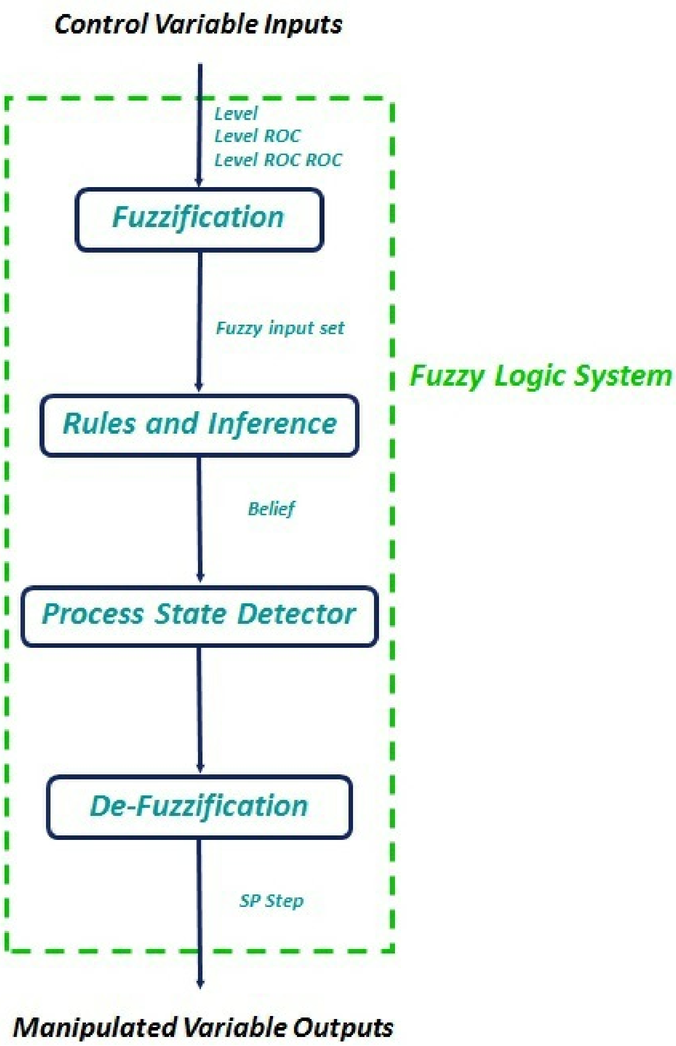
Based on the referenced states of each controller state, the State Index of the controller state may be:
0 if it is not active
1 active but not in-control
2 active AND in-control

All of the attributes of the controller states are display on the SCADA faceplate.

If the controller has detected a certain process state scenario, it will take corrective actions in an attempt to resolve this scenario. The corresponding BELIEF value displayed next to a PROCESS STATE is an indication of how true this state is. The belief value of each state will determine the size of the control actions implemented. If the PROCESS STATE belief state is 65.0% true, than less aggressive control actions will be implemented to resolve this condition compared to a scenario where the belief value is 90.0% true. This approach implies that the controller will never wait for any process state (excluding the DEFAULT state, which represents the stable state) to reach a value of 100.0% before implementing any control actions to resolve the state. All of the PROCESS STATES other than the DEFAULT state are less desirable state conditions and the controller will attempt to keep their belief values as low as possible.

A2 - Basic principles of Fuzzy Control

A fuzzy logic system (FLS) can be defined as the nonlinear mapping of an input data set to a scalar output data. A FLS consists of four main parts: fuzzifier, rules, inference engine, and defuzzifier. These components and the general architecture of a FLS is shown in the figure below.



The process of fuzzy logic is defined as follows: Firstly, a crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. This step is known as fuzzification. Afterwards, an inference is made based on a set of rules. Lastly, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification step.

The fuzzy logic algorithm can be summarized as follows:

1. Define the linguistic variables and terms (initialization)
2. Construct the membership functions (initialization)
3. Construct the rule base (initialization)
4. Convert crisp input data to fuzzy values using the membership functions (fuzzification)
5. Evaluate the rules in the rule base (inference)
6. Combine the results of each rule (inference)
7. Convert the output data to non-fuzzy values (defuzzification)

Linguistic variables are the input or output variables of the system whose values are words or sentences from a natural language, instead of numerical values. A linguistic variable is generally decomposed into a set of linguistic terms. Example: Leven in a bin. Let level (LVL) be the linguistic variable which represents the amount of material in the bin. To qualify the level, terms such as high and low are used in real life. These are the linguistic values of the level. Then, LVL(t) = extremely low, low, ok, high, extremely high can be the set of decompositions for the linguistic variable level. Each member of this decomposition is called a linguistic term and can cover a portion of the overall values of the bin level.

Membership functions are used in the fuzzification and defuzzification steps of a FLS, to map the non-fuzzy input values to fuzzy linguistic terms and vice versa. A membership function is used to quantify a linguistic term. Note that, an important characteristic of fuzzy logic is that a numerical value does not have to be fuzzified using only one membership function. In other words, a value typically belongs to multiple sets at the same time. For example the bin level value can be considered as extremely low and low at the same time, with different degrees of memberships.

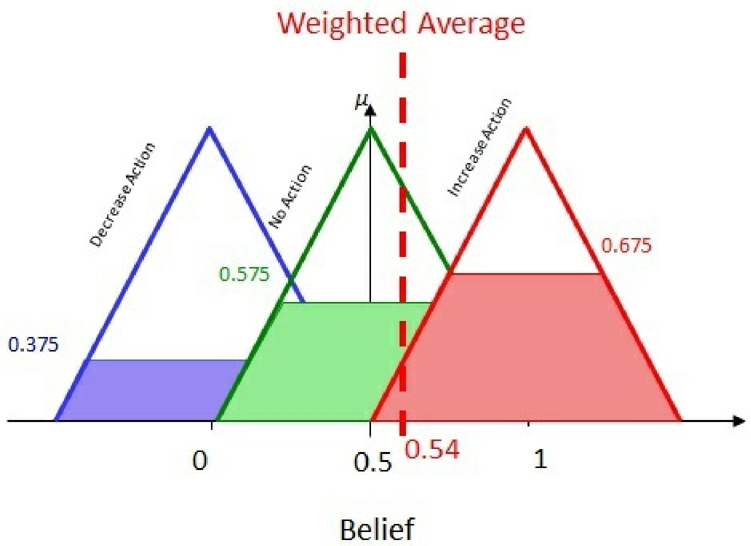
APET includes a powerful fuzzy controller toolset which includes a very flexible editing environment as well as a variety of membership functions to be used.

Each CV feeding into the controller is fuzzified (classified within a fuzzy membership function) by one or more FIS-INPUTS. For control variables (CV) there are typically three types of classification: proximity (this relates to the normalized value), slope (rate of change) and slope rate of change (this implies acceleration).

For each of the fuzzy families, a specific input must be provided based on the value of the CV (and its recent history).

1. Proximity: this is a comparison of the normalized value of the CV
2. Slope: this represents the slope or rate of change of the CV over a defined period and is calculated within the APC system
3. Slope Rate of Change: this represents the rate of change of the slope of the CV and is calculated within the APC system

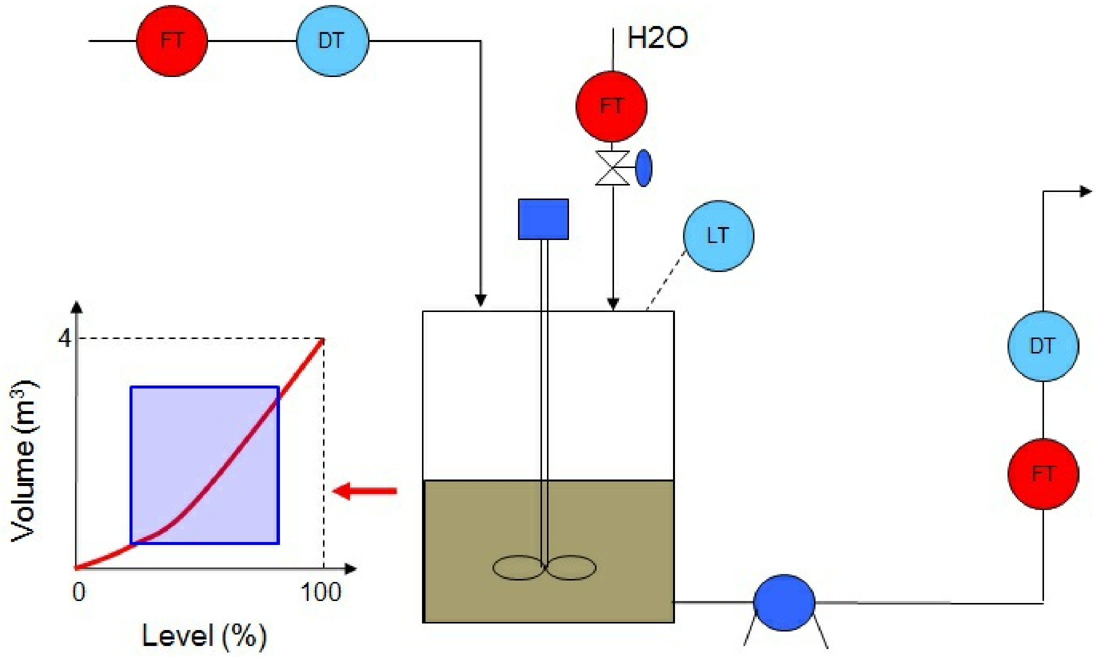
After the inference step, the overall result is a fuzzy value. This result should be defuzzified based on the process state which is In Control to obtain a final crisp output. This is the purpose of the defuzzifier component of a FLS. Defuzzification is performed according to the membership function of the output variable. For instance, assume that we have the result in the figure below at the end of the inference. In this figure, the shaded areas all belong to the fuzzy result. The purpose is to obtain a crisp value, represented by the dotted line in the figure below, from this fuzzy result.



The crisp value (or belief) is then converted back to a setpoint change using the defuzzy function.

A3 - Basic principles of Model Based Control (MBC)

Sumps and surge tanks form a buffer between processes, and can be used to reject large disturbances and thereby improve stability in downstream operations. They typically resemble the diagram below, with multiple input lines (some possibly unmeasured) and a single discharge.



Fundamentally, the change in sump volume (dV/dt) is equal to the net flow into the sump, or:

$$\frac{dV(t)}{dt} = F_{in}(t) - F_{out}(t)$$

Where: F_{in} and F_{out} = respective flow measured in m^3/s

Integrating to get the current sump volume:

$$V(t) = \int_0^t F_{in}(\tau) - F_{out}(\tau)d\tau = \int_0^t \Delta F(\tau)d\tau$$

This is the principle on which all derivations are done The sump tank is a pure integrating process, where the model based control aims to minimize flow out deviation by modifying the sump level via its derivative DeltaF(t).

To minimize the discharge flowrate variation, there are two basic approaches the model based controller can take:
1. Delay control action until it is really necessary, or
2. Perform minimal control action now in the event that it will stave off drastic changes later.

Principle: There exists a time Tc such that if we ramp Fout(t) at a rate of Mout then we will be at capacity at Tc, with a net flowrate of zero, given that Fin(t) remains constant.

This implies that we begin the ramp now, and depending on the volume between the capacity and our current level, we will reach the capacity limit at Tc. Therefore if there is a large DeltaV (effectively - capacity available), the ramp will have an extremely slow rate and the flow out will hardly be affected, whereas if we are at capacity (DeltaV), the flow out will track the flow in. It is possible to even allow for discharge flow overshoot if we are over capacity.

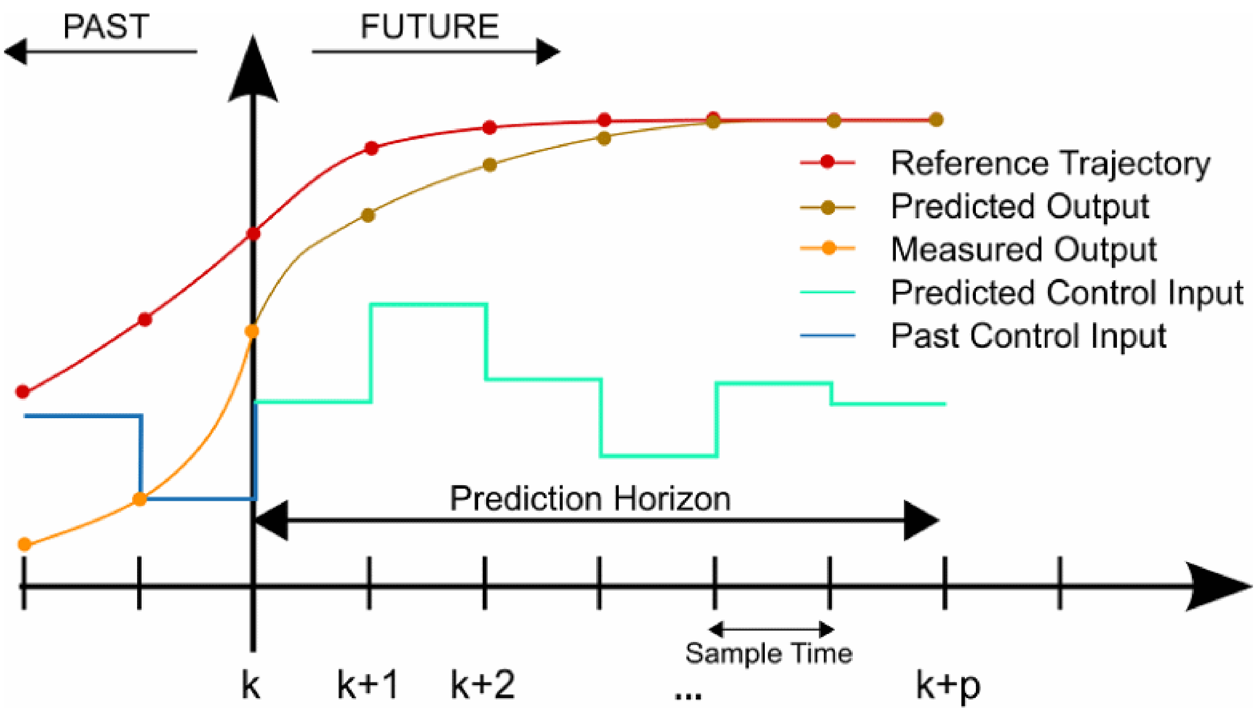
A4 - Basic Principles of Model Predictive Control (MPC)

Model predictive control (MPC) is an advanced method of process control that has been in use in the process industries in chemical plants and oil refineries since the 1980s. Model predictive controllers rely on dynamic models of the process, most often linear empirical models obtained by system identification. Dynamic process models describe how the process parameters will respond in the future for changes made to the process in the present time. These models can therefore predict process responses into the future. The main advantage of MPC is the fact that it allows for the current process conditions (current timeslot) to be optimized, while accounting for future process conditions (future timeslots) still to happen as a result of changes to the current process conditions. This is achieved by optimizing over a finite time-horizon (the future predictions), implementing the current timeslot actions and then relying on feedback to account for unmeasured disturbances and model/plant mismatches. This implies that the model prediction error that may exist (or develop over time) is also taken into account by the MPC algorithm. MPC models therefore do not have to be 100% accurate. As a result of this the MPC technology is very robust, and typically outperforms most other advanced process control techniques. The MPC further has the ability to anticipate/predict future events and can take control actions accordingly. An example of this is that the MPC can predict that the bin level will drop below the low level limit, which will result in the feeder being interlocked and stopped. The feeder stop will again cause the bin level to increase sharply. The MPC can take all of these future predictions into account and prevent this scenario from happening. PID controllers normally implemented as part of the base layer (PLC) control do not have this predictive ability. Therefore the PID controller in the base layer (PLC) control will not be able to prevent the above feeder interlock and stop.

The models used in MPC are generally intended to represent the behaviour of complex dynamic systems, which cannot be effectively controlled by base layer (PLC) controllers such as PID controllers. Dynamic characteristics that are difficult for PID controllers include large time delays, variable interaction and high-order dynamics.

MPC uses current and historical plant responses/measurements, the current dynamic state of the process, the MPC models, and the process variable targets and limits to calculate future changes in the dependent variables (the variables to be controlled, such as bin levels and product mass flowrates). These changes are calculated to hold the dependent variables close to target while honoring constraints on both independent (the levers that can be pulled by the MPC system, such as feeder speeds or PID setpoints) and dependent variables. The MPC typically sends out only the first setpoint change (of the sequence of calculated changes required going into the future) in each independent variable to be implemented, and repeats the calculation when the next change is required (by updating the sequence of calculated changes required going into the future).

Below is an image to illustrate the concepts:



In summary, Model Predictive Control (MPC) is a multivariable control algorithm that uses:
1. an internal dynamic model of the process
2. a history of past control moves and
3. an optimization cost function J over the receding prediction horizon,
to calculate the optimum control moves.

An example of a quadratic cost function for optimization is given by:

$$J = \sum_{i=1}^{N} w_{x_i}(r_i - x_i)^2 + \sum_{i=1}^{N} w_{u_i}\, \Delta u_i{}^2$$

With:

X_i = *i*-th controlled variable (e.g. measured bin level)

r_i = *i*-th reference variable (e.g. required bin level)

u_i = *i*-th manipulated variable (e.g. feeder speed)

w_{Xi} = weighting coefficient reflecting the relative importance of X_i

w_{ui} = weighting coefficient penalizing relative big changes in u_i