


Innovation in Control System and Information in the copper mining. Experiences at Minera Los Pelambres.

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Manager Minera Los Pelambres and
CONTAC Ingenieros
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Presented by



Introduction,from 2013 to 2015



PI System at Compañía Minera Los Pelambres (MLP)

Presented by
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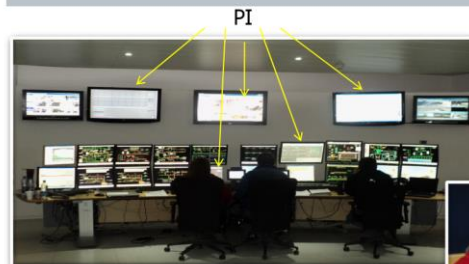
- ✓ Increased role of the PI System as a core business system
- ✓ Increased support of the value chain: Mine and commercial systems (product dispatch)
- ✓ System availability (HA and DR site)
- ✓ Base technology (virtualization)
- ✓ Enhanced User support procedures
- ✓ Enhanced system support procedures

PI at MLP, Quick facts


- PI manages data from the mine to the port. Also includes concentrate pipeline and tailings supervision; electrical and water supply, consumables and environmental.
- Every expansion projects includes as a standard the integration to the PI infrastructure.
- A mission critical infrastructure. Support the daily work of operators, process engineers, area managers, reliability and maintenance, logistics, business planners, operational accounting and analysis, engineering.
- PI System administration and evolutionary development in charge of a central team, "SCAPIE", that also manages the control systems, advanced applications and instrumentation. SCAPIE belongs to the Operations management Organization.
- Evolutionary development being implemented using dedicated project teams, with a high involvement of the key users.



PI at MLP, from tactical to strategic, across all the organization



From the operators to the supervision, along the value chain



Every day from 8:00 to 8:30, operations board meeting, uses the MINCO report, automatically generated, validated by the "data owners" (many)

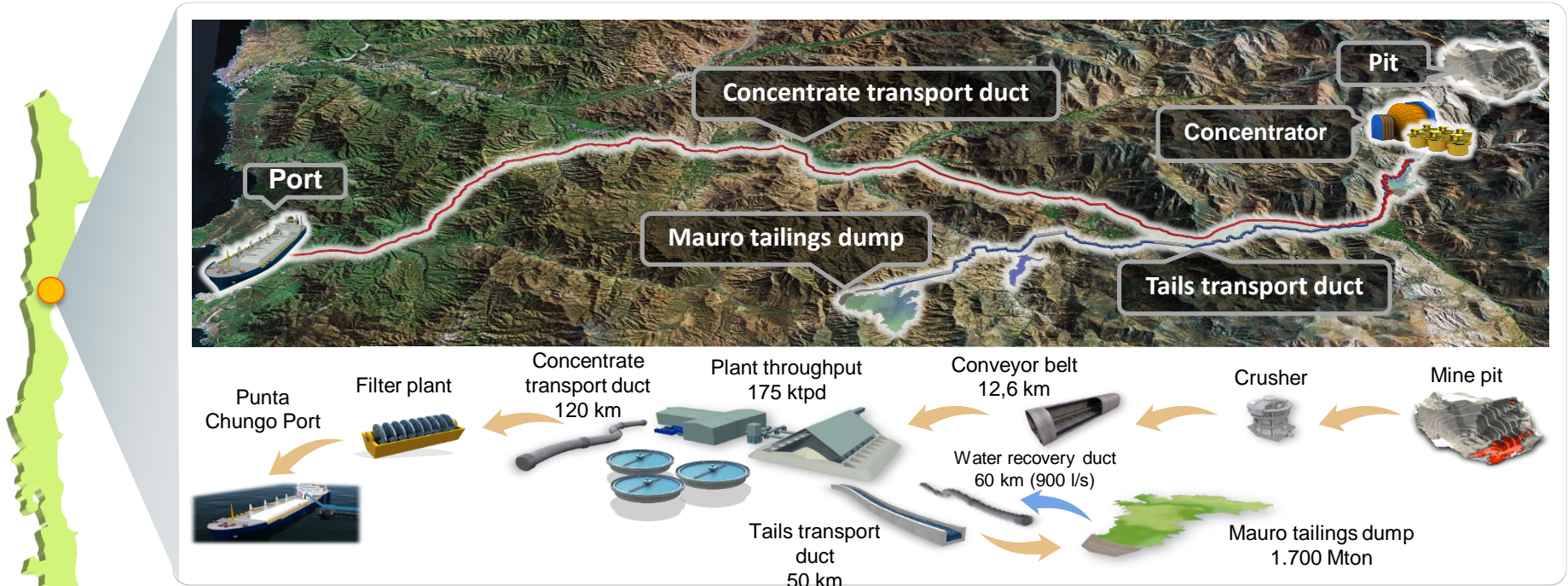
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Operational Intelligence

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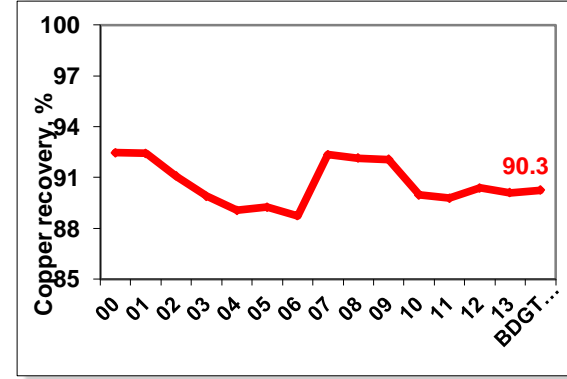
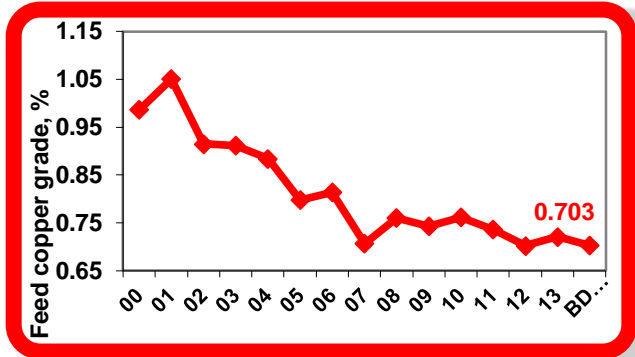
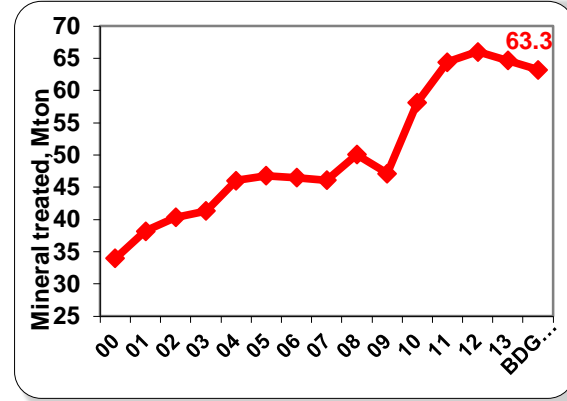
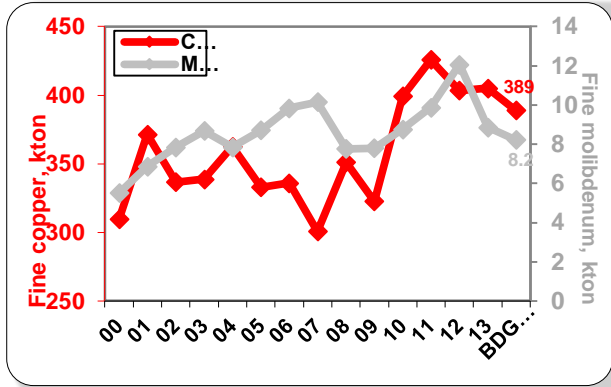
Antofagasta Minerals - LOS PELAMBRES (MLP) @ glance



200 km north of Santiago - Coquimbo Region – El Choapa Valley, Chile

Mine pit at 3.600 m.a.s.l. – Plant facilities at 1.600 m.a.s.l. Plant to Port distance: 120 km

SOME METALLURGICAL INDICATORS



OPERATIONAL EXCELLENCE

The Challenges

- Improve Equipment performance & availability
- Improve Productivity
- Minimize safety & environmental risks
- Increasing complexity of technology
- Energy & Water efficient usage
- Acquire & retain knowledge
- Tighter environmental regulations

The MLP drivers

- ✓ *Technology* : the engine of productivity
- ✓ Link processes to core business
- ✓ Integration of *process knowledge - technology - innovation*
- ✓ Find new ways for relationships (collaborative development)
- ✓ Develop Advanced Process Control (APC) solutions
- ✓ Deliver in-time relevant statistics and KPI's to decision makers
- ✓ Secure process continuity and optimize production
- ✓ Leverage best practices and process knowledge

Operational Excellence Eco System



- Operators
- Plant Management
- Process Engineering
- Reliability and Maintenance Team
- SCAPIE, Process Control Team

- Technology
- Training
- Operational continuity
- Evolutionary development
- Standards & methodologies
- Best practices

(extended) Team with key players
Use available expert resources
Develop strategic alliances
Develop and maintain a knowledge network



- Operational Excellence
- Innovation
- Operational Improvement
- Sustainability



The operational intelligence challenge

Week, Month, Year



Business Management
Planning & Programming
Engineering
Knowledge Management



Process Control Eng.
Process Engineers
Metallurgical Eng.



Decision
Horizon



Shift, Real Time

Process Control Systems
Advanced Operational Support Systems

Empower the 1st line of
decision, those who
need to:

- ✓ Interpretate the past
- ✓ Predict the future
- ✓ Develop actionable Knowledge
- ✓ **Act NOW**

The MLP actions towards the operational intelligence goal, some examples

The goal: support and empower the “1st line” of decision

How to:

- ✓ Interpretate the past
- ✓ Predict the future
- ✓ Generate actionable information

PI System, as a core technology
PI Data Archive, as the system of records



Analyze
 ↳ Find
 ↳ Structure
 ↳ Deploy

Cases and examples

SCAPIE Remote Site

P80 Model development

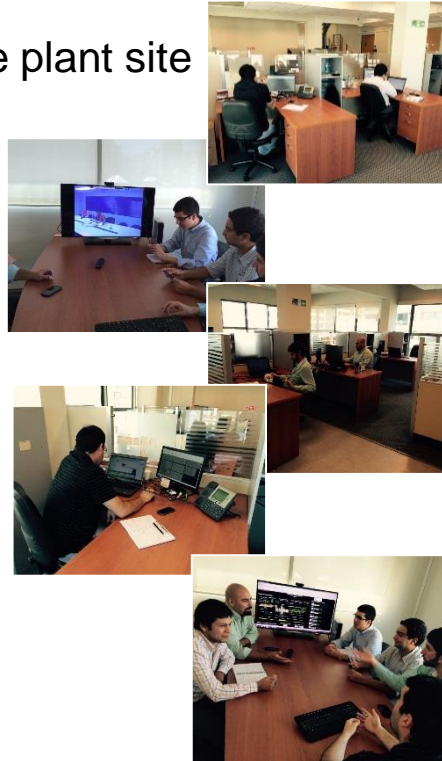
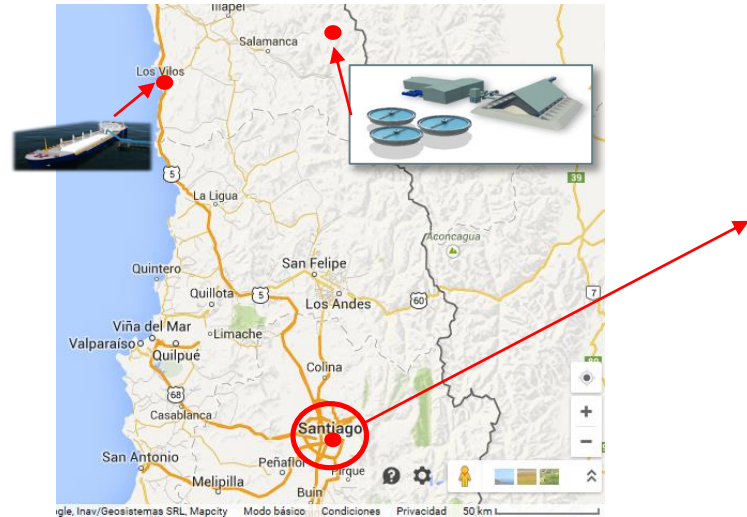
Process Analysis

Process evaluation (APC and control system performance)

Plant Model (Asset Framework)

SCAPIE Remote Site

- A “pilot” initiative
- Goal: move critical activities from the plant site



- ✓ DCS engineering and support
- ✓ ACS engineering and support
- ✓ PI-PIMS engineering and support
- ✓ Operational Intelligence support and development

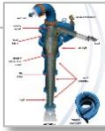
An initiative to learn, test and develop:

- ✓ coordination and management procedures
- ✓ base technologies
- ✓ team building

SCAPIE Engineering Remote Site

- ✓ PI System and DCS (control) teams working together at the same site
- ✓ Up and running since the last quarter of 2014
- ✓ Services provided by the remote team has been not affected
- ✓ People learn very fast how to work remotely
- ✓ An excellent case for a precise evaluation of the multiple possibilities for remote operations management and consequently, its implementation, i.e.: remote control?, remote operations management?, remote process engineering?, remote reliability engineering?.
- ✓ Many components that have to be evaluated in its own merit since the time, investments and change management differs a lot.
- ✓ PI System as a **key enabler for change**,but starting from a reliable infrastructure and trusted data

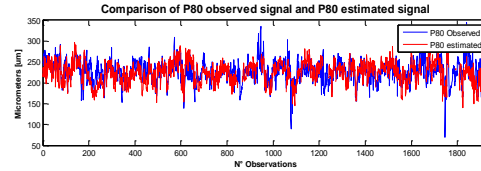
P80 Model



Overall Objective

To design and implement an online adaptive model

- ✓ capable of estimating the hydro cyclones overflow P80 coming from the ball mill at the output of each hydro cyclone battery for implementing ball milling APC strategies
- ✓ capable to incorporate real-time information of the process and to adapt model parameters.
- ✓ combining empirical and phenomenological knowledge




	P80 Estimated	P80 Observed
Mean	227,22	224,51
Sigma	22,26	26,10

Excellent performance of the model as compared with the Lab Data

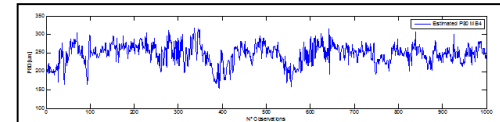
Role of the PI System

- ✓ source of the “experimental data”, use of the history for the model development and testing.
- ✓ model running on PI ACE and Asset Framework (AF), future: move the model to the APC platform.

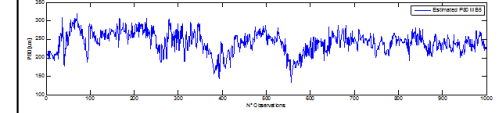
- ✓  Use of multivariable process analysis tools to identify the most influencing factors for the model development.



P80 BM 1



P80 BM 2



Process Analysis, example case 1

Objective

Obtain Grindability (Powell) curves for a SAG Mill

Conventional methods: *a time and cost consuming set of experiments*

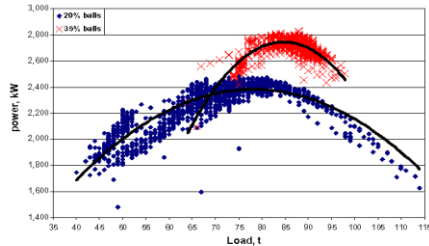
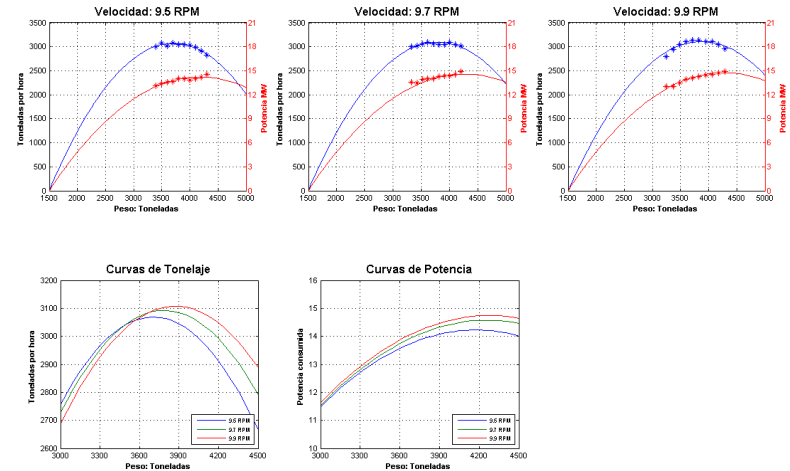


Fig. 2. Power-load curve based on operating data (Powell et al., 2001).

Role of the PI System

- ✓ Use the PI Server as the BIG DATA repository
- ✓ The PI System repository represents almost all the feasible operational conditions
- ✓ Reveal the knowledge that is embedded in the operational history

The results, using the history in PI



Some results

- ✓ (re) Tuning of the APC parameters, new operational points were founded with a much better energy consumption ratio.
- ✓ Implement an online SAG monitoring cockpit (future), by comparing the actual operational points with the expected ideal ones.
- ✓ Same, for the APC performance evaluation.

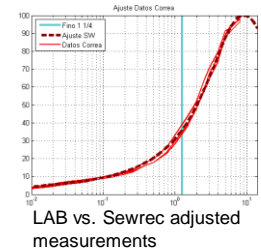
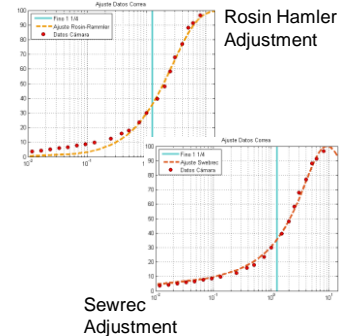
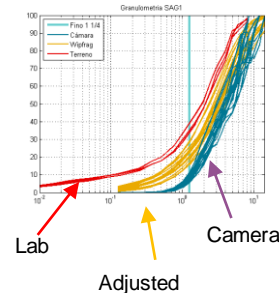
Process Analysis, example case 2

✓ PI System as a “daily tool” for the process analysis engineers

The problem 1 Difference between the ores size distribution as measured by the online analyzer (image analysis) and the lab results.

Find Analysis of the historical data using different adjustment methodologies showed that SEWREC distribution showed a much better fit than the previously used Rosin-Ramler.

Deploy Past measurements were adjusted, with the study results it was possible to correct previous balances and studies

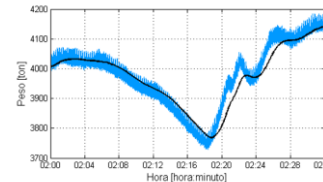


The problem 2 The signal from the SAG Mill load cell need to be filtered to eliminate noise that may affect the control.

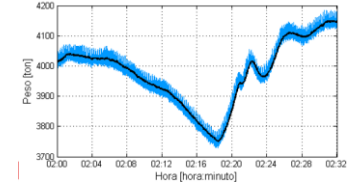
Find Analysis of the historical data showed that the existing filter added a delay of about **40** seconds. Several new filtering methodologies were investigated :moving averages, IIR, others, looking for a better compromise between Filtering and its inherent Delay.

Deploy Filtering techniques are being tested, the selected one will be moved to the APC.

Delay decrease in a critical signal will improve APC performance and its responsiveness.



Load Cell: original Signal and Filtered (existing filter)



Same, using different filtering techniques

Process evaluation use case

✓ PI System as a monitoring system for critical assets

The problem APC and process control systems are a critical asset, its performance directly affect (and somehow determines) the performance of the operation.

As any other asset, it is necessary to online evaluate its behavior and “health” towards the assurance of its availability, use and expected performance.

Evaluation needs the processing of online and historical (BIG) data

Find Several “test” methods were compared using historical data.

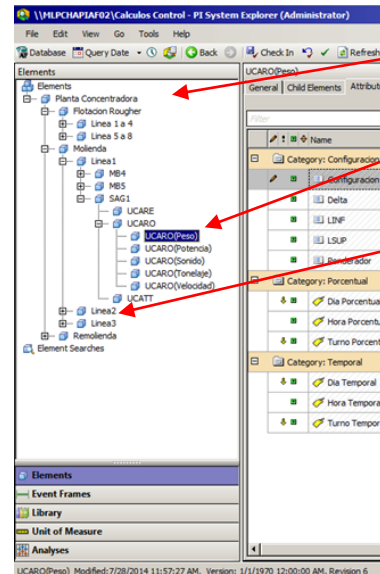
Tests were compared with known problems and its operational behavior.

A final set of tests and KPI were selected

Deploy Using PI ACE (Test evaluation) and AF (Monitoring Model) two systems were implemented:

1. APC KPI’s
2. Control loop evaluation

System 1: APC KPI’s	
UCATT	Utilization time
UCARE	Utilization time (considering equipment restrictions and op. state)
UCARO	Utilization time (considering operational limits restrictions)



AF model follow the processing flow
For every major equipment the KPI’s are calculated.

KPI’s can be assigned to a “specific controlled variable.”

Roll ups are defined to evaluate aggregated KPI’s for “operational lines”

Calculations are being made @ 1 H

The automated system replaced a lot of spreadsheets and ad-hoc analysis, by providing elaborated and timely information for the process control engineers.

UCARE and UCARO are an extraordinary source of information about the behavior and “working logic” of the APC. Integration with Event Frames will provide indeed a deeper knowledge (future)

Process evaluation, control loop performance evaluation

The problem

Provide a simple monitoring system for the detection of performance problems in the control loops, with a special focus on the measuring instruments, the actuators (valves, principally) and controller tuning.

Main users: process control engineers and maintenance people.

Find

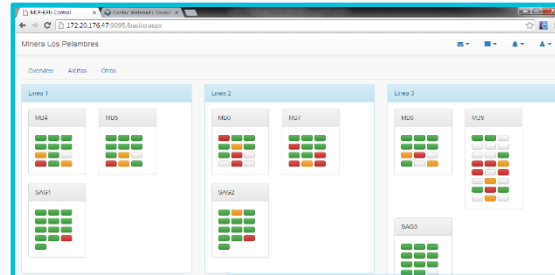
Analysis of the historical data using different KPI's to determine a selection of the most suitable.

Stablish a set of simple roll up rules allowing for a fast diagnostics of the loop problem most probable cause.

Deploy

KPI calculations running in PI ACE, configuration in AF.
Configuration consisting on:

- the KPI assignment to each loop as well as its parameters.
- the selection of the applicable rules



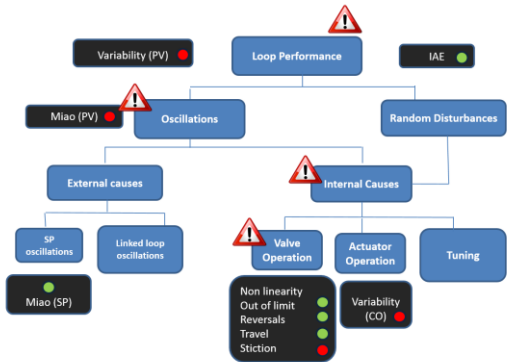
Overview

Detail summary

Lazo	Instrumento	Alerta	Acción
MB4	FIC1301(SP)	Lazo agua MB4 (cascada lazo % solido)	Revisar actuator
MB5	FIC1501(SP)	Lazo agua MB5 (cascada lazo % solido)	Revisar actuator
SAG1	BWSAG1WEIGHT(SP)	Lazo Peso	Revisar actuator
MB6	DIT2343	Instrumento % Sólido (Lazo % Sólido MB6)	Reparar instrumento de medición
MB6	320HCPP103(PV)	Instrumento Velocidad bomba (Lazo bomba MB6)	Reparar instrumento de medición
MB6	320HCPP103(SP)	Lazo bomba MB6 (cascada lazo presión)	Revisar instrumento de medición PV
MB7	FIT2542	Instrumento Flujo volumetrico MB7	Reparar instrumento de medición
MB7	KS-DIT2543MAX	Lazo %Sólido MB7	Revisar actuator
MB7	FIC2501(SP)	Lazo agua MB7 (cascada lazo % solido)	Revisar actuator

Process evaluation, example case, Control Loop Evaluation (cont.)

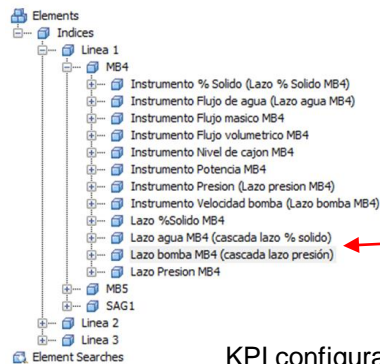
BM4 Water flow control loop



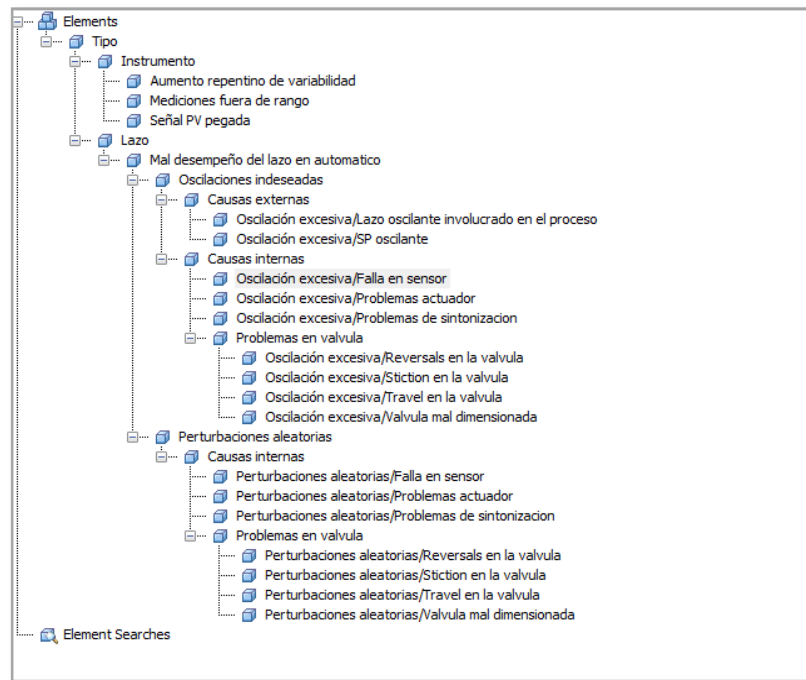
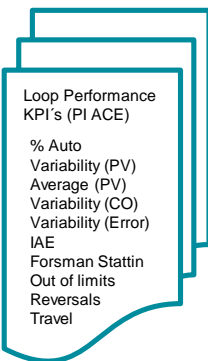
Diagnostic rules “roll-up” configuration for loops, instruments and valves



One or more KPI are assigned to a Loop, an instrument, an actuator (ex.: a valve)



KPI configuration



For every KPI a threshold is defined

ExceptionTime over/under threshold is calculated

Analysis rules are evaluated using the exception times

The core: reliable data, meaningful contexts

The problem As the PI System evolved to a mission critical system, data quality, availability and uniqueness becomes also critical.

Need for a close management of a selected set of data.

Find A structured analysis of the available data, validation needs, aggregated calculations and KPI's.
A methodology was used for the selection of the "core variables", as a validation criteria, the list was compared with all the actual reports, verifying if any value on these could be derived from the "core variables"

Deploy Develop an AF model for the core variables.
Establish dedicated procedures for the quality assurance of the "core data" as well as for the AF model.

Re-engineer the actual reports and dashboards
Almost an immediate value by the Coresight users.

Level 1

Related with the main function of the Line, Process, Major Eq.

Most of the times these variables have a "program"

Ex.: Throughput, Inventories, MatBalance values.

Efficacy

Level 2

How the function is being (was) done.

Most of the times these variables have a Target.

Ex.: Ratios, Consumptions, Operational Adjustments.

Efficiency

Level 3

Provides an insight about how the Main Function as well as the execution was done.

Most of the times these variables have limits.

Op. Control

Plant Model (core variables)

ARCHIVO INICIO INSERTAR DISEÑO DE PÁGINA FÓRMULAS DATOS REVISAR VISTA

Portapapeles Fuente Alineación Número Estilos Celdas

Normal Buena Incorrecto Neutral

Calculo Celda de co... Celda vincul... Entrada

Insertar Eliminar Formato Autosuma Rellenar Ordenar y filtrar Buscar y Modificar

Portapapeles Fuente Alineación Número Estilos Celdas

Normal Buena Incorrecto Neutral

Calculo Celda de co... Celda vincul... Entrada

Insertar Eliminar Formato Autosuma Rellenar Ordenar y filtrar Buscar y Modificar

Level 1 2 3 R.Time Hour Shift Day MTD YTD Prog.

		Nombre de la Variable			Nivel Variable			Tipos Variable									
		Etapa	Corriente	Variable	VN1	VN2	VN3	Unidad	Variable Tiempo Real	Hora	Turno	Dia	ACC Mes	ACCY	Program	Co	
3	Proceso	Subproceso / Etapa															
4	Mina	Mina	Mineral Movido	Maza	X			ton	KPI-1-MINA_Mov(Actual)			X	X	X	X		
5			Mineral	Flujo	X			TMH	KPI-1-MINA_Min_Trans(Actual)			X	X	X	X		
6			Operación	Tiempo		X		hr	X			X	X	X	X		
7			Alimentación	SPC													
8			Pre Chancado			X			KPI-1-MINA_Pre_Chanc(Actual)								
9			Mineral	Razon Esteril - Mineral					X								
10			Disponibles	Cantidad		X	X	%	100-DSP0001_DP1CH			X	X	X	X		
11			Palas	Uso					100-DSP0002_DP1CH			X	X	X	X		
12			Disponibles	Cantidad		X	X	TPH	100-WI0004_DP1CH			X	X	X	X		
13			Camiones	Disponibles		X	X	%	100-DSP0003_DP1CH			X	X	X	X		
14			Camiones	Uso		X	X	%	100-DSP0004_DP1CH			X	X	X	X		
15				Cantidad		X	X	TPH	100-WI0005_DP1CH			X	X	X	X		
16																	
17																	
18																	
19																	
20																	
21																	
22			Chancado	Porcentaje Duro	X			ton			X	X	X	X	X		
23			Humedad			X		%									
24			Alimentación SPP														
25			Mineral Alimentación	Duraza		X	X										
26			Mineral Alimentación	Litología		X	X										
27			Mineral Alimentación	Especies		X	X										
28			Feeder 5	Velocidad		X	X	%	P5-DW_220_50								
29			Feeder 5	Estado		X	X	%	P5-D_3_02_50								
30			Feeder 6	Velocidad		X	X	%	P5-DW_235_50								
31			Feeder 6	Estado		X	X	%	P5-D_14_03_50								
32			Feeder 7	Velocidad		X	X	%	P5-DW_235_50								
33			Feeder 7	Estado		X	X	%	P5-D_16_02_50								
34			Feeder 8	Velocidad		X	X	%	P5-DW_235_50								
35			Feeder 8	Estado		X	X	%	P5-D_18_02_50								
36			Alimentación Mineral	Pesómetro	X			ton	MN-WI0108	110-WQ0108_MDB		MN-WI0108_BLD	MN-WI0108_ACM_BLD	MN-WI0108_ACY_BLD	X		
37			Operación	Tiempo				hr	110-HISPPCR001AH			MN-HISPPCR001AH_BLD	MN-HISPPCR001AH_ACM_BLD	MN-HISPPCR001AH_ACY_BLD	X		
38			Chancado	IEE		X		KWh/Ton	IEECHANC								
39			Accionamiento	Potencia		X	X	KW	MN-JICR001								
40			Accionamiento	Estado		X			MN-HISPPCR001AR	MN-HISPPCR001AH		MN-HISPPCR001AH_BLD	MN-HISPPCR001AH_ACM_BLD	MN-HISPPCR001AH_ACY_BLD			
41			Accionamiento	Potencia		X	X	KW	MN-JICV001A								
42			Alimentación SPM	Pesómetro		X	X	TPH	MN-WI0108								
43			Operación	Tiempo		X	X	hr	MN-WI0108								

A rigorous convention for descriptor's naming
process/Eq. & stream & variable

823
824
825
826

ShipLoad

Future directions

- ✓ Continue empowering the users in the “first line” of the operation decisions.
- ✓ Enhance and further development of dedicated OI applications:
 - Equipment performance
 - Energy
 - Reliability
 - Consumables
- ✓ Operations portal
- ✓ Complete (PI System) coverage of the mine data
 - Consumables stocks
 - FMS (down times, eq. health, production data)
 - Log Book
 - SKF (condition monitoring)
 - CMMS
 - Shovels and Drillers eq. heal
- ✓ Enhance and empower the remote site

Final remarks

- ✓ 1st. Line Operations Managers, engineers and analysts possess a challenge (and a huge opportunity) to add value.
- ✓ PI System as a core technology to support the daily work and added value applications for the 1st line.
- ✓ PI System as a core technology for implementing different organizational structures, not only a remote site but the support of the extended operational excellence ecosystem.

Acknowledgements:

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