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Supporting Operational Availability with PI System and SAP PM connection

Presented by **Réka Erdei**
Gábor Mucsina



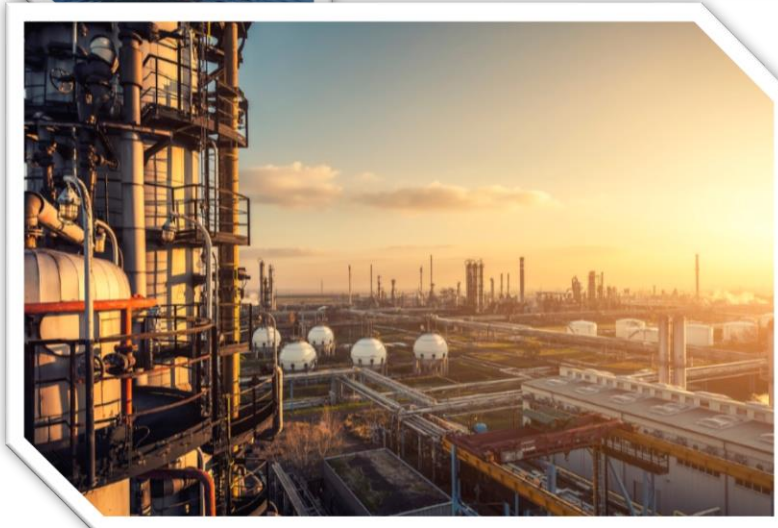
Agenda

- Introduction
- Business Challenge
- Focus on Predictive and Preventive Maintenance
- Implementation Details
 - Corrosion & integrity predicting High Temperature Hydrogen Attack (HTHA)
 - Preventive maintenance aided by the connection of OSIsoft's PI System and SAP PM
- Summary



MOL Group

MOL is an integrated, independent, international oil and gas company, headquartered in Budapest, Hungary with a track record of over 100 years in the industry.



MOL Group in numbers



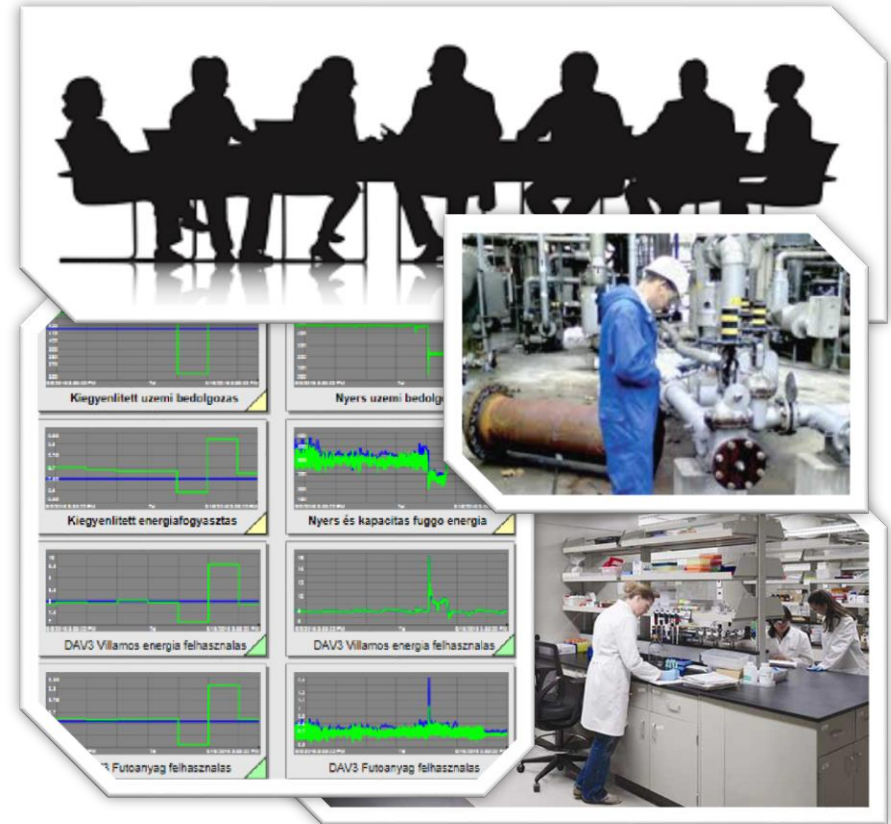
OSIsoft and MOL Hungary



Role of PI System in Danube Refinery

Primary process database and operational intelligence tool

- Production Management
- Reporting
- Operation
- Quality Management
- Maintenance
- Energy Monitoring
- ...



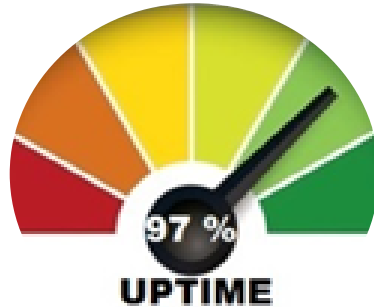
Business Challenge

Reliability and preventive programs

- NxDSP – increase operational excellence
- UPTIME - reliability improvement program (FMEA, LFF, RCFA)
- PSM (Process Safety Management)

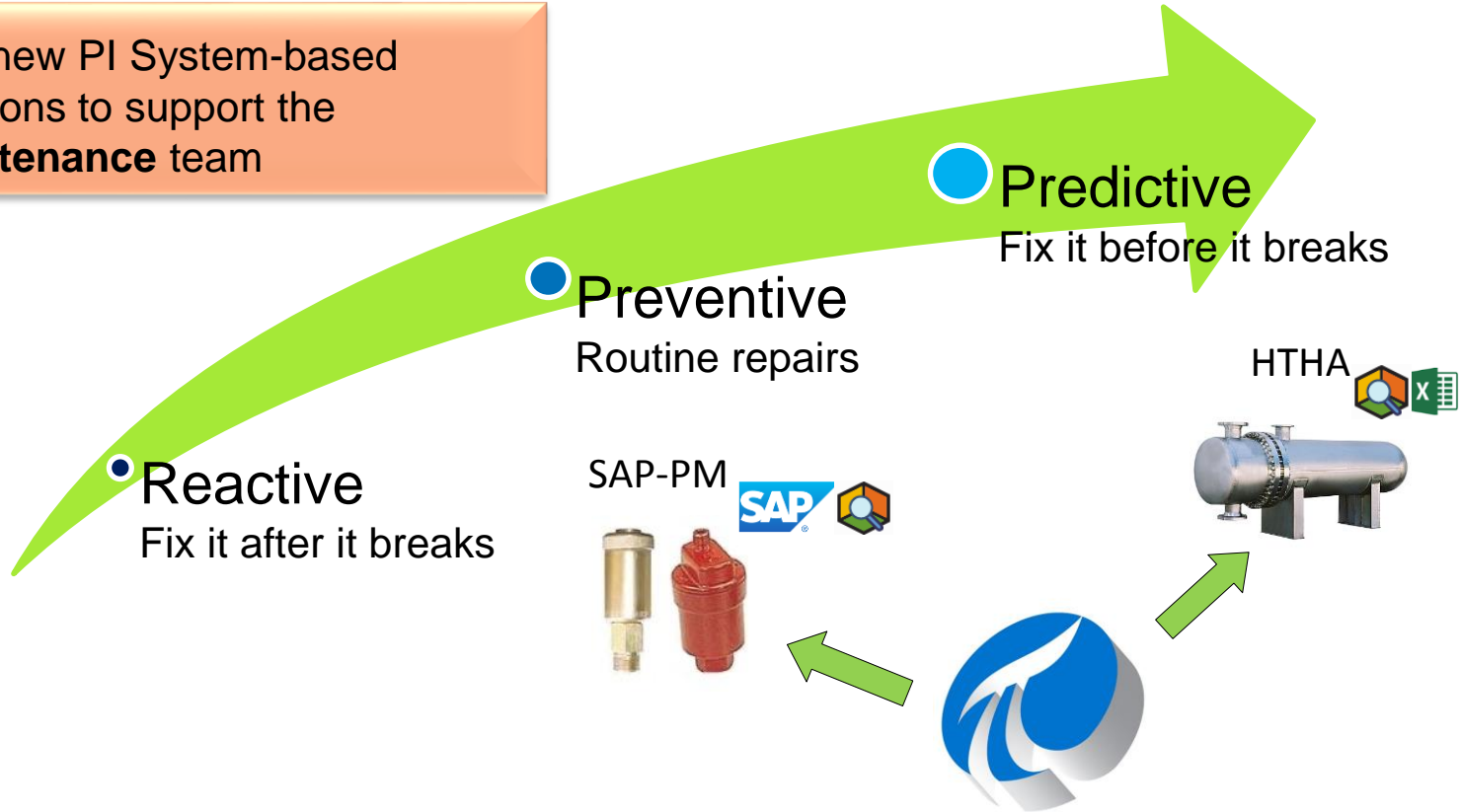
Our goal is to **keep our assets healthy** to avoid unplanned shutdowns

- Avoid harmful process conditions
- Increase the ratio of preventive maintenance



Focus on predictive and preventive maintenance

Two new PI System-based solutions to support the **maintenance** team

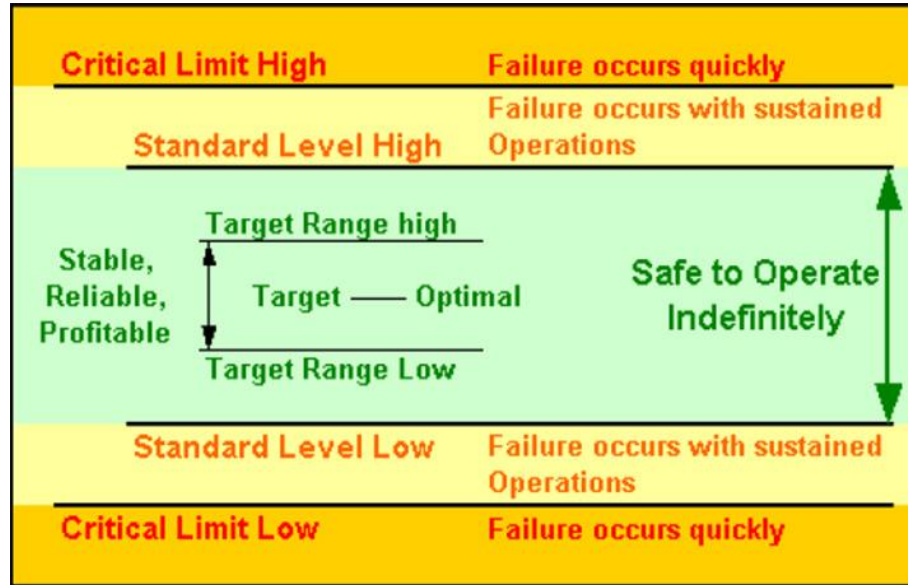




Corrosion & Integrity Predicting High Temperature Hydrogen Attack (HTHA)

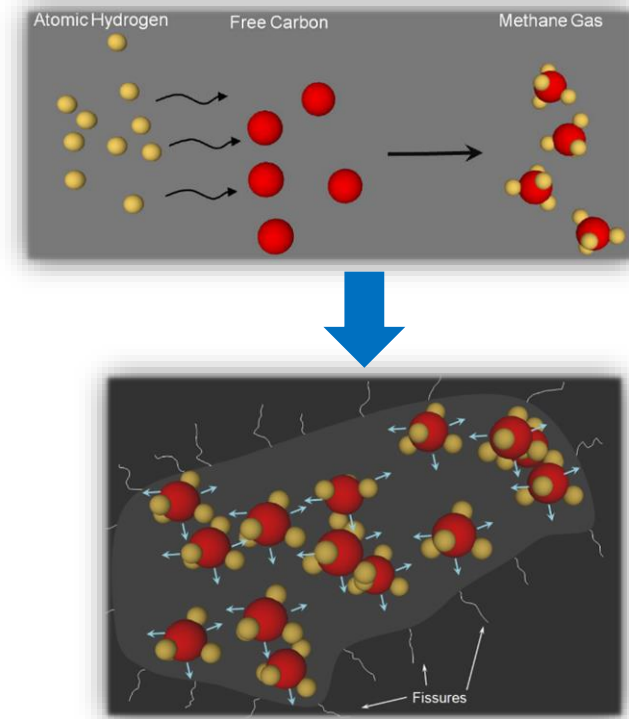
BACKGROUND - IOW

Definition of **Integrity Operating Windows (IOW)**: Established **limits** for **process variables** (parameters) that can **affect the integrity or reliability of the equipment** if the process operation deviates from the established limits for a predetermined length of time.

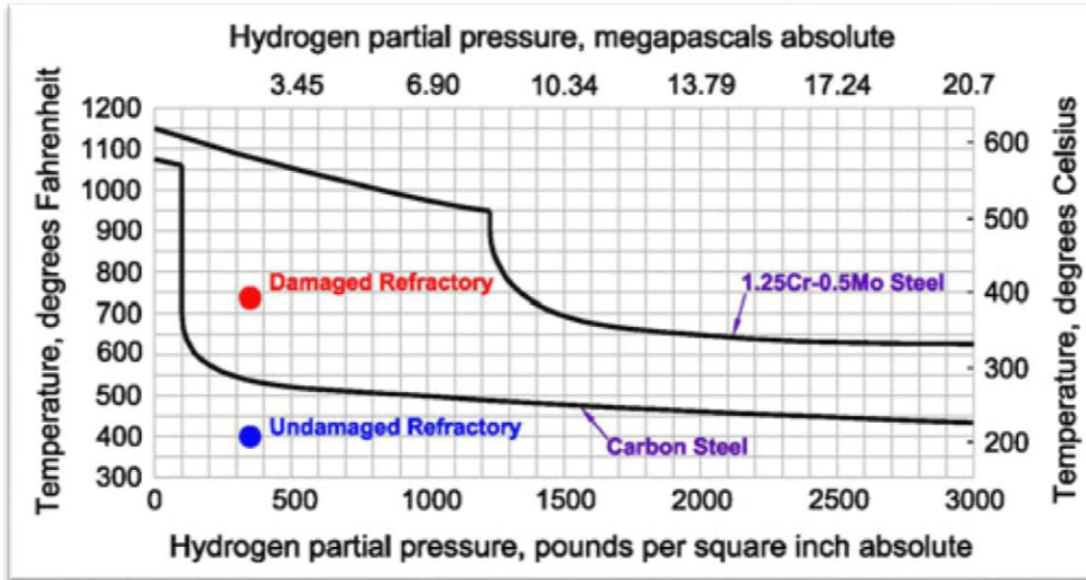


BACKGROUND - HTHA

- Tesoro, Anacortes refinery, 2010
- Fatal injury of seven employees
- Heat exchanger catastrophically ruptured because of an HTHA - high temperature hydrogen attack
 - HTHA occurs when atomic **hydrogen diffuses into the steel walls** of process equipment
 - The hydrogen reacts with carbon in the steel, **producing methane gas**
 - Methane molecules cannot diffuse out of the steel, they **accumulate** inside of the steel, creating **high pressure**, forms **fissures** in steel
 - This reaction **removes carbon** from the steel (decarburization)

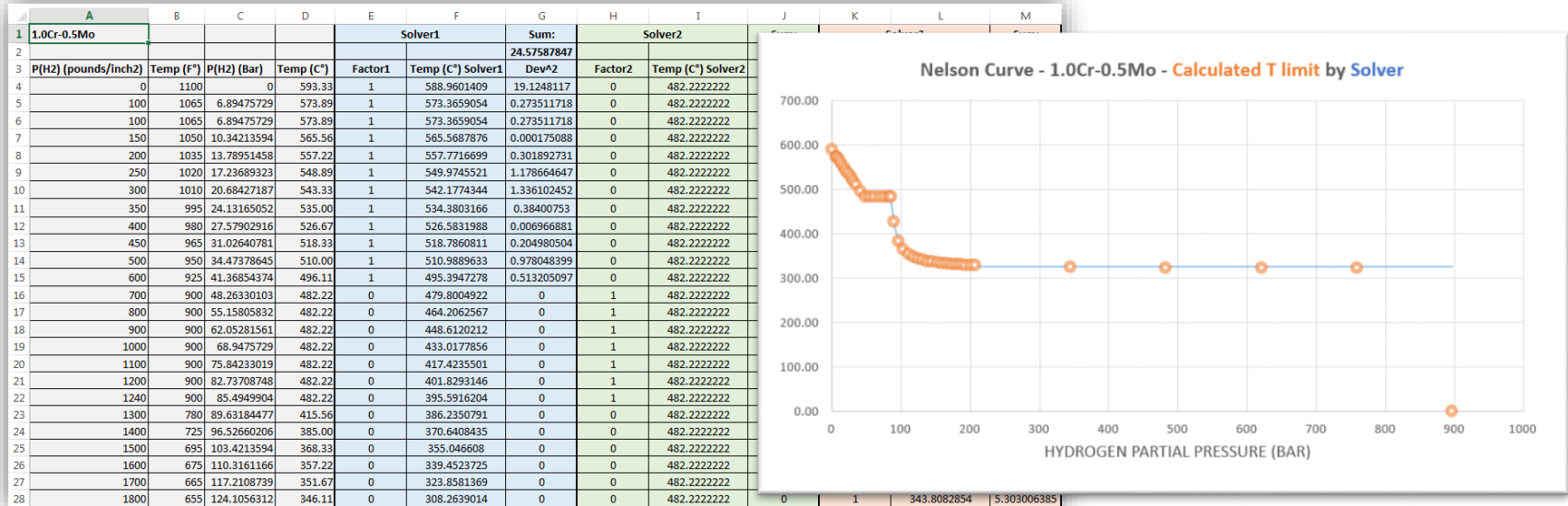


- A **Nelson Curve** is an empiric curve used in production units which shows the permissible **hydrogen partial pressure** and **temperature** for the given **pipe class** (material of construction) to avoid HTHA.



IMPLEMENTATION– Nelson Curves with solver

- Estimate T-p data values from the Nelson curves
- Minimize the squared deviation by the help of Excel Solver
- Tune the Excel Solver parameters to fit better on the points



IMPLEMENTATION– Create the system in Asset Framework (AF)

Challenges

- Suitable attributes structure
- Analyses with ONE general equation
- Nelson curves based on material of construction
- Table contains the constants for table lookup
- Calculate the temperature and pressure limits as well

The screenshot displays the Asset Framework (AF) interface with several panels and a calculation table.

Category: Configuration Parameters

Attribute	Value	Description	Unit	Default
Deviation Action Timeframe	nincs	Beavatkozás időkerete	String	<None>
Functional Location		Műszaki hely	String	<None>
H Limit Pressure FIX	94	Felső határesetek p FIX	Double	<None>
H Limit Temperature FIX	240	Felső határesetek T FIX	Double	<None>
Hydrogen Content Limit	100	Hidrogén tartalom határérték	Double	<None>
Hydrogen Content Limit Table	-	Hidrogén tartalom határérték	String	<None>
Hydrogen Content Measurement	DHDSHQ3600PV.PV	Hidrogén tartalom mérés	String	<None>
Material Type	Carbon Steel	Anyagminőség	IOW Material Types	<None>
Pressure Measurement	DHDSHPH7327.PVA	Nyomás	String	<None>
Unit Operating	1	Üzem működik tag	Int16	PI Point

Category: General Attributes

Attribute	Value	Description	Unit	Default
Block ID	DMCHAB	Üzemcsoport ID	String	String Builder
Desc	Crk. Gáz előmelegítő 103/2 - köpeny	Hosszú leírás	String	String Builder
Name	DHDSHT 1290.PV	Figyelt PI Tag	String	String Builder
Unit ID	DHDS	Üzem ID	String	String Builder

Category: Limit

Attribute	Value	Description	Unit	Default
H Limit Pressure				
H Limit Temperature				

Category: Process Data

Attribute	Value	Description	Unit	Default
Current				
Hydrogen Content				
Pressure				

Category: Results

Attribute	Value	Description	Unit	Default
Exceedance State				
H2 Pressure Limit				
Temperature Limit				

Category: Time Cumulated Data

Attribute	Value	Description	Unit	Default
Exceedance Time				

Analysis Calculation Table

Name	Expression
X	'H2 Partial Pressure'
NelsonTempLimit	'TA' + 'TB'*x + 'TC'*Log(x+'TD') + 'TE'/(x+'TF')
y	'Current'
NelsonPressureLimit	'PA' + 'PB'*y + 'PG'*Exp('PC'*y+'PD') + 'PE'/(y+'PF')

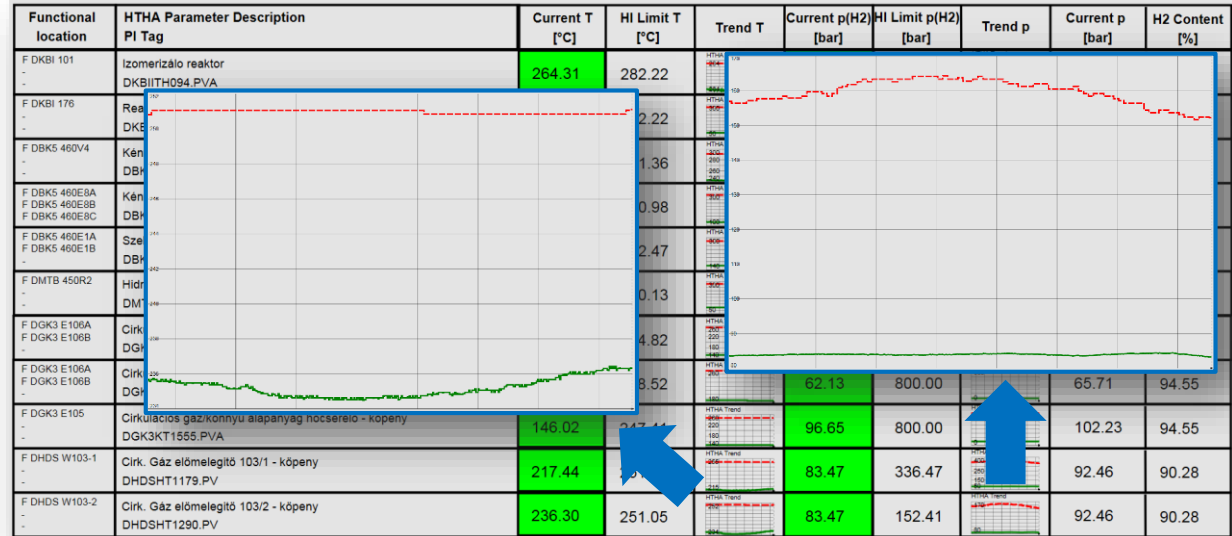
Annotations in the image:

- HI limit calculation**: Points to the 'HI Limit' calculation in the 'Analysis' tab.
- IOW HTHA Exceedance state calculation**: Points to the 'IOW HTHA Exceedance State Calculation' calculation in the 'Analysis' tab.

IMPLEMENTATION– Continuous Monitoring / PI Coresight

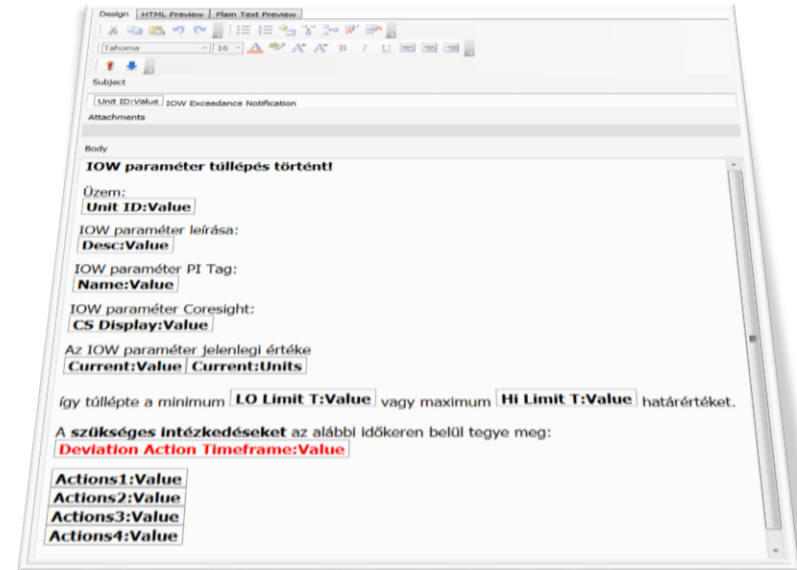
- Support collaboration and decision making
- Visualization management - Multi-state symbol

- Easy to use
- Dynamic limits
- Mini trends

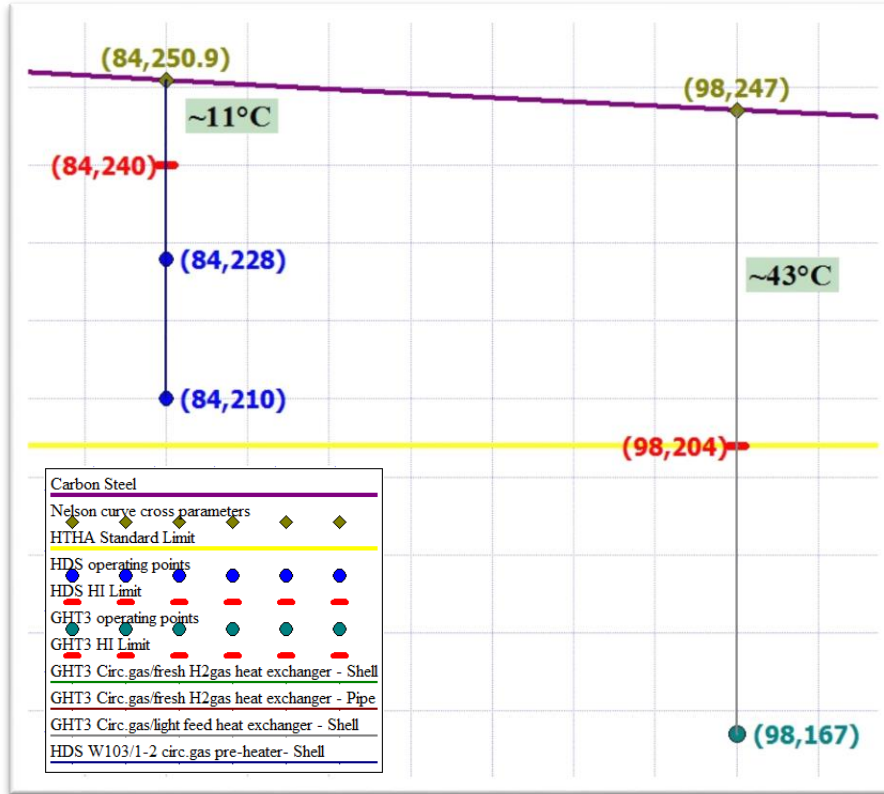


IMPLEMENTATION– Message / PI System Notifications

- Immediate problem solving
- Reduced the alerts by 90%
- E-mails include all of the relevant information
- Link to the PI Coresight display
- Contain the intervention possibilities



Results of Action – Knowledge



- Deeper understanding of the corrosion processes
- Operating points distance from the Nelson Curve
- Collect the corrosion related parameters in one Asset Framework structure

Results of Action - Attitude




- Reduced corrosion → Cost savings
- Changed the material for a better alloy
- Improved the preventive approach
- Better communication between departments
- Maintenance team has a continuous monitoring tool



Preventive Maintenance aided by connecting the PI System and SAP PM



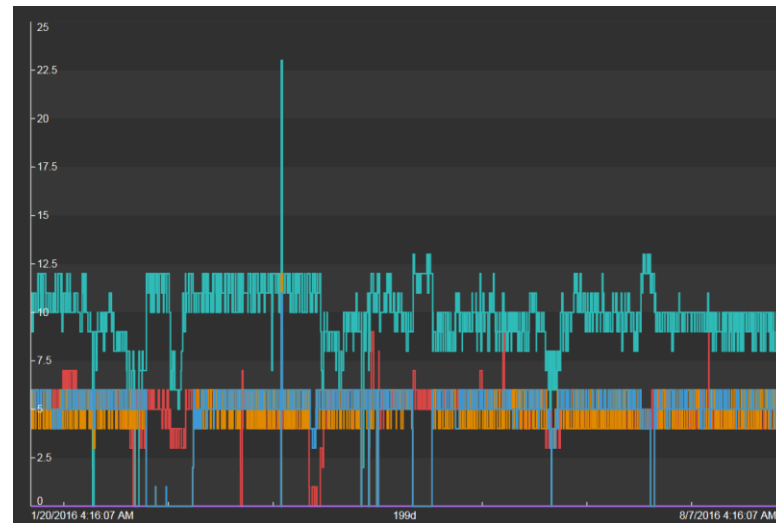
Challenge – Critical Availability Problems

- Hydrogen Production Plants (HPP) are critical units in the refinery
 - Pressure Swing Adsorbers (PSA) are critical equipments in unit operation
 - Cyclic operation – Heavy load on valves (9-10 open-close hourly)
 - **\$1.2 million USD loss in three years due to PSA valve failures**
- 
- UPTIME program: **97% operational availability**



Solution – Preventive Maintenance

- Maintenance Engineering created a preventive maintenance strategy to keep valves in operation
- Problem: Time-based scheduling can not be used
 - Valves in each position are replaced regularly
 - Load on given valve position depends on unit feed
- **Process data (Cycle Number) has to be used to schedule maintenance**



Hourly cycle number of PSA valves

Phase 1 – Separated OSIsoft's PI System and SAP PM

- Aim: test the maintenance strategy
- Criteria:
 - No CAPEX, no IT development
 - Only existing software, tools
- System:
 - Valve cycle count was collected in the PI System
 - Analysis, data evaluation in MS Excel
 - Manual order creation in SAP PM

RFID név	Dátum	Tartalék	Béépítve	Össz-tartalék (nap)	Össz-üzemidő (nap)	RFID mozgás (db)	Pozícióban eltöltött idő (nap)	Megjegyzés
PSA006	2014-08-05	FALSE	TRUE				692	MAINT: 2014-08-05 12:23:10 Béépítve KKV5110E
PSA006	2014-01-28	TRUE	FALSE				189	MAINT: 2014-01-28 12:00:00 Tartalék
PSA006	2013-08-27	FALSE	TRUE				154	MAINT: 2013-08-27 10:06:50Béépítve kkv5103e
PSA006	2011-08-12	TRUE	FALSE				746	MAINT: 2011-08-12 Tartalék
PSA006	2011-03-02	FALSE	TRUE	935	1009	4	163	MAINT: 20110302 KKV-5105F
PSA007	2016-04-20	TRUE	FALSE				68	MAINT: 2016-04-20 09:22:45 Tartalék
PSA007	2014-01-28	FALSE	TRUE				813	MAINT: 2014-01-28 12:00:00 Béépítve KKV5103B
PSA007	2011-08-12	TRUE	FALSE				900	MAINT: 2011-08-12 Tartalék
PSA007	2011-03-02	FALSE	TRUE	968	976	3	163	MAINT: 20110302 KKV-5105B
PSA010	2014-08-05	FALSE	TRUE				692	MAINT: 2014-08-05 12:14:13 Béépítve KKV5110A
PSA010	2014-01-28	TRUE	FALSE				189	MAINT: 2014-01-28 12:00:00 Tartalék
PSA010	2013-08-27	FALSE	TRUE				154	MAINT: 2013-08-27 10:10:05Béépítve kkv5103a
PSA010	2011-08-12	TRUE	FALSE				746	MAINT: 2011-08-12 Tartalék
PSA010	2011-03-02	FALSE	TRUE	935	1009	4	163	MAINT: 20110302 KKV-5110A
PSA011	2014-08-05	FALSE	TRUE				692	MAINT: 2014-08-05 12:24:16 Béépítve KKV5105B
PSA011	2014-01-28	TRUE	FALSE				189	MAINT: 2014-01-28 12:00:00 Tartalék
PSA011	2013-08-27	FALSE	TRUE				154	MAINT: 2013-08-27 10:15:50Béépítve kkv5105b
PSA011	2011-08-12	TRUE	FALSE				746	MAINT: 2011-08-12Tartalék
PSA011	2011-03-02	FALSE	TRUE	935	1009	4	163	MAINT: 20110302 KKV-5105A

HG2 - 2011.03.02 / HG2 2016-01-01 -óta				
Jelenlegi hely	PSA_szelep	Össz-tartalék (nap)	Össz-üzemidő (nap)	
F-D-HG2-KKV5101A	PSA098	277	770	
F-D-HG2-KKV5101B	PSA026	264	1680	
F-D-HG2-KKV5101C	PSA073	319	1462	
F-D-HG2-KKV5101D	PSA029	264	1680	
F-D-HG2-KKV5101E	PSA077	250	1531	
F-D-HG2-KKV5101F	PSA071	250	1531	
F-D-HG2-KKV5102A	PSA067	133	1665	
F-D-HG2-KKV5102B	PSA069	133	1665	
F-D-HG2-KKV5102C	PSA097	116	1665	
F-D-HG2-KKV5102D	PSA093	169	1612	
F-D-HG2-KKV5102E	PSA087	116	1665	
F-D-HG2-KKV5102F	PSA076	356	1425	
F-D-HG2-KKV5103A	PSA066	354	1571	

Phase 2 – Connection of OSIsoft's PI System and SAP PM

- Aim: robust IT system to support preventive maintenance strategies
- Criteria:
 - Support the scheduling of PSA valve maintenance
 - **Flexibility and scalability** (further strategies expected)
 - **Integrated solution** (utilization of existing softwares)
- Tools:
 - PI System → Main process database + Real-time analysis
 - SAP PM → Equipment database + Maintenance management tool
- Missing component: Connection between systems

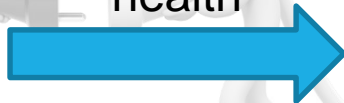
Architecture – Roles of components

PI Server

- Process database
- Online analysis of process information
- Calculation of asset health
 - Asset condition
 - Running hours
 - Performance
- User Interface
 - PI Coresight
 - PI DataLink

Connection (WebLogic)

Calculated asset
health



Maintenance
related information

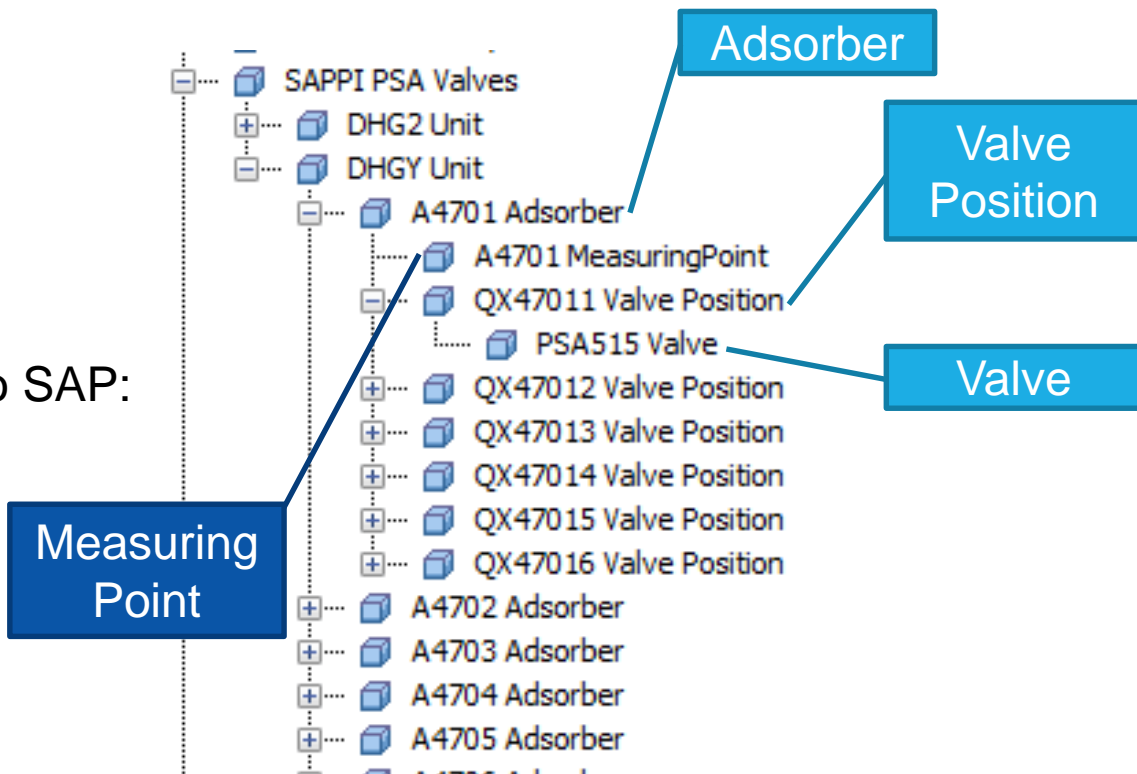


SAP PM

- Maintenance database
- Management of maintenance processes
- Creation of work orders or notifications
- Trigger maintenance strategies based on asset health

AF Structure

- Structure for calculation:
 - Adsorber
 - Valve positions
 - Valves
- Structure for moving data into SAP:
 - Adsorber
 - Measuring Points



AF Calculation 1.

- Calculation steps:
 1. Cycle number of valve positions (PI Points)
 2. Cycle number of valves (read the attribute from the current parent)
 3. Preventive maintenance state of valves (based on valve cycle number and last repair time)
 4. Two aggregation steps (one with formula data reference, one with Roll Up analysis)
 5. Collecting results to move data into SAP Measuring Points

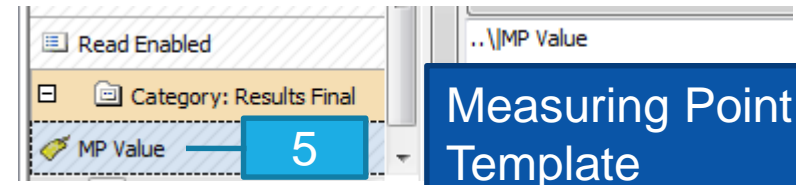
Valve Template		
Filter	Name	Value
Category: Auxiliary Attributes		
	Element GUID	24f27f94-704d-11e6-b8e1-54ee75770d4f
	Tag Identifier	PSA515_24f27f94-704d-11e6-b8e1-54ee75770d4f
Category: Error Handling		
	Number of Equipments in Position	1 count
Category: Identity		
	Equipment Name	PSA515
	Functional Location - FL1-2	F DHGY
	Functional Location - FL4	A4701
	Functional Location - FL5	QX47011
Category: Manual Data Entry		
	First Installation	2016-01-01 12:00:00 AM
	Last Check	2016-01-01 12:00:00 AM
	Last Positioner Change	2016-01-01 12:00:00 AM
Category: Parent Attribute		
	PSA Position Cycle Number	0
Category: Process Data		
	PSA Equipment Cycle Number - Hourly	0
Category: Results Auxiliary		
	Cycle Number 1 - Last Check	12959.309024162 count
	Cycle Number 2 - Last Positioner Change	12959.3090208308 count
	Running Hours - Total	5012 h
Category: Results Final		
	Preventive Condition Description	Normál állapot
	Preventive Condition ID	0 count
	Remaining Cycles	187040 count
	Remaining Hours	30028 h

1. - 2.

3.

AF Calculation 2.

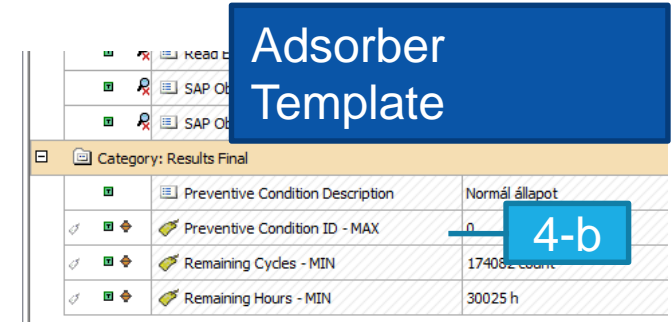
- Calculation steps:
 - Cycle number of valve positions (PI Points)
 - Cycle number of valves (read the attribute from the current parent)
 - Preventive maintenance state of valves (based on valve cycle number and last repair time)
 - Two aggregation steps (one with formula data reference, one with Roll Up analysis)
 - Collecting results to move data into SAP Measuring Points



This screenshot shows the configuration for a Measuring Point Template. The 'Read Enabled' checkbox is checked. The 'Category' is set to 'Results Final'. The 'MP Value' field is highlighted with a blue box containing the number 5.

Read Enabled	..\\MP Value
Category: Results Final	
MP Value	5

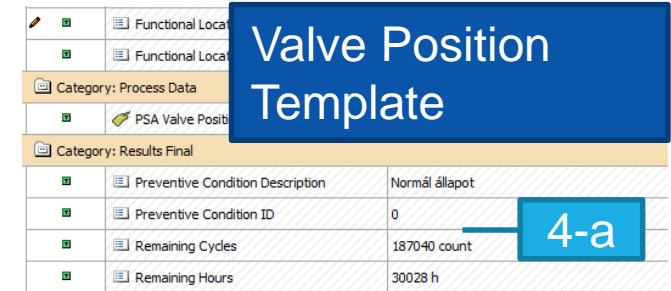
Measuring Point Template



This screenshot shows the configuration for an Adsorber Template. The 'Category' is set to 'Results Final'. The 'Preventive Condition ID - MAX' field is highlighted with a blue box containing the text '4-b'.

Preventive Condition Description	Normál állapot
Preventive Condition ID - MAX	0
Remaining Cycles - MIN	174082 count
Remaining Hours - MIN	30025 h

Adsorber Template



This screenshot shows the configuration for a Valve Position Template. The 'Category' is set to 'Results Final'. The 'Preventive Condition ID' field is highlighted with a blue box containing the text '4-a'.

Preventive Condition Description	Normál állapot
Preventive Condition ID	0
Remaining Cycles	187040 count
Remaining Hours	30028 h

Valve Position Template

PI System-SAP Connection

- Collect data from elements with Measuring Point template
 - PI OLEDB Enterprise
 - AF linked table
- Expose these data to the WebLogic middleware (Linux+Java)
 - PI JDBC did not fit into our existing environment
 - WebLogic reads through PI Web API

```
--***** Object: View SAPPI_MeasuringPoint_Results Script Date: 2016
SELECT *
FROM [Maintenance].[DataT].[SAPPI_MeasuringPoint_Results]
```

		SAP MP ID	SAP MP Type	SAP MP Unit of Measure	SAP Parent Object ID
1	#	TemporaryMPID_26	Szamlalo		F DHG2 V310
2	#	Tempo			
3	#	Tempo			

Help pages: [PI Web API Help](#) > [Table](#) > [GetData](#)

```
{
  "Columns": {
    "ElementName": "String",
    "ElementGUID": "Guid",
    "SAP MP ID": "String",
    "SAP MP Type": "String",
    "SAP MP Unit of Measure": "String",
    "SAP Parent Object ID": "String",
    "SAP Parent Object Type": "String",
    "Read Enabled": "Int32",
    "Error Code": "Int32",
    "Last Calculation Time": "DateTime",
    "MP Value": "Double"
  },
  "Rows": [
    {
      "ElementName": "V310 MeasuringPoint",
      "ElementGUID": "ff2bdec9-72d2-11e6-84e4-54ee75770d4f",
      "SAP MP ID": "TemporaryMPID_26",
      "SAP MP Type": "Szamlalo",
      "SAP MP Unit of Measure": "",
      "SAP Parent Object ID": "F DHG2 V310",
      "SAP Parent Object Type": "Functional Location",
      "Read Enabled": 1,
      "Error Code": 0,
      "Last Calculation Time": "2016-09-06T09:20:00Z",
      "MP Value": 0.0
    },
  ]
}
```


Asset Policy – SAP PM

- Maintenance management
→ Asset policy
- Asset policy:
 - Where to do?
 - What to do?
 - When to do?
- SAP PM covers these functionalities
 - Technical database
 - Task lists
 - SAP maintenance plan based on measuring points (with data from PI System)

The screenshot displays the SAP PM 'Technical Database' (Műszaki hely - st) interface. It shows a hierarchical structure of maintenance tasks for a specific measuring point (F DMK1 103-2). The tasks are organized into a tree view, with the selected task being 'F DMK1 103-2_FFE' (FFE-SZÜRLET-OLDÓSZERES ALAPANYAG). Below the tree, a detailed task list is shown, including columns for 'Műv. A...', 'Munkah.', 'Gyár', 'Vez.', 'Művelet megnevezése', 'H.', 'Munka', 'E.', 'Sz.', 'Tartam', 'E.', 'S', '%', 'S.feld.elo', 'T...', 'Telj', 'MintaKcs', and 'S'. The task list includes various maintenance activities such as 'Munkakezdés feltételeinek biztosítása', 'Műszaki előkészítés', 'Projekt irányítás', 'Adminisztráció', 'Műszaki ellenőrzés', 'Álvány építése', 'Motor vill.hálóról történő', 'Szétszerelés, javítás', 'Összeszerelés, beállítás', 'Motor vill.en.hálóra történő', 'Beüzemelésnél résztvevők', and 'Dokumentáció készítése'.

Technical Database

Műszaki hely F DMK1 103-2 Érv. kezd. 16.09.08
MH Megnevezés SZÜRLET-OLDÓSZERES ALAPANYAG

F DMK1 103-2 SZÜRLET-OLDÓSZERES ALAPANYAG

F DMK1 103-2_FFE FFE-SZÜRLET-OLDÓSZERES ALAPANYAG

30073949 Csiller 20000289
30106732 Tengelykapcsoló
30106732 PM-500

Berendezésterv módosítása: műveletáttekintés

Berendezés 30073949 Csiller
Tervcsoport 15057 Csiller állapotfelmérés 12 tengely TCsSz 1

Általános műveletáttekintés

Műv. A...	Munkah.	Gyár	Vez.	Művelet megnevezése	H.	Munka	E.	Sz.	Tartam	E.	S	%	S.feld.elo	T...	Telj	MintaKcs	S
0010	PSBGKCSE	HBSB	PM02	Munkakezdés feltételeinek biztosítása	✓	2,5	H	1	2,5	H	1	100		1		PM-NORM	
0020	PSBMUEK	HBSB	PM02	Műszaki előkészítés			H	1		H	1			1			
0030	PSBPRV	HBSB	PM02	Projekt irányítás													
0040	PSBADM	HBSB	PM02	Adminisztráció													
0050	PSBMUE	HBSB	PM02	Műszaki ellenőrzés													
0100	PSBSAL	HBSB	PM13	Álvány építése													
0110	PSBVAL	HBSB	PM13	Motor vill.hálóról történő													
0140	PSBGKCSE	HBSB	PM02	Szétszerelés, javítás													
0220	PSBGKCSE	HBSB	PM02	Összeszerelés, beállítás													
0250	PSBVAL	HBSB	PM13	Motor vill.en.hálóra történő													
0260	PSBSAL	HBSB	PM13	Beüzemelésnél résztvevők													
0270	PSBGKCSE	HBSB	PM02	Beüzemelésnél résztvevők													
0280	PSBGKCSE	HBSB	PM02	Dokumentáció készítése													

Task Lists

Maintenance Plan

TMK-terv módosítása: műveletáttekintés

TMK-terv 101000

TMK-terv feje

TMK-terv ciklusai TMK-terv ütemezési paraméterei TMK-terv kiegészítő adatai

Ciklus	E...	TMK-ciklus szövege	Számláló	Megnevezés
15000H			82	MOL_TF04_CSILLER_P

Tétel Objektumlista - tétel Telephely - tétel Felhasználókövetés - tétel

TMK-tétel 2606 PREV_Csiller állapotfelmérés_F DMK1

Hivatkozási objektum

Műszaki hely F DMK1 103-2_FFE FFE-SZÜRLET-OLDÓSZERES ALAPANYAG
Berendezés 30073949 Csiller

Tervezésadatok

Tervező gyár HBSB MOL Nyrt. Száhlomb - nemCH Tervezőcsoport

Expected Results

- Contribution in strategic operational availability program (UPTIME) goal: **97% Operational Availability**
- Preventive maintenance strategies in operation (e.g. PSA valves, Furnace tubes)
 - Estimated reduction of unplanned shutdowns caused by these equipments: **10-15 %**
 - Saving due to increased operational reliability of these equipments: **\$230,000/year**
- Flexible, scalable system
 - **Further assets to be involved in preventive maintenance**



Next Steps

- Short-term
 - System roll out for other assets
- Mid- and long-term
 - System roll out for other assets
 - Utilization of advanced analytic possibilities (SAP HANA, PI Integrator for Business Analytics)
- Identification of further possibilities to utilize process data in maintenance



Reliability can be increased significantly with the PI System

COMPANY and GOAL

MOL operates thousands of assets, therefore reliability is a key factor in success; asset availability is a pillar of our efficiency programs.



CHALLENGE

Challenging strategic operational availability goals (97%)

- This level of OA can not be achieved with reactive maintenance
- Critical PSA valve failures have to be prevented

SOLUTION

PI Server-based solution to support operational awareness and preventive maintenance

- Integrity Operating Windows (IOW) and HTHA implementation in PI Server to avoid corrosive, harmful situations
- Connection of PI Server and SAP PM to support preventive maintenance

RESULTS

Effective tools for maintenance engineers to keep asset healthy

- Less corrosive process conditions
- Longer asset life
- Increased availability of PSA valves (\$230,000/year)
- Flexible architecture for further preventive strategies

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Questions

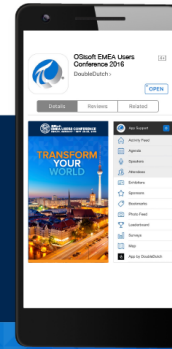
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감사합니다

谢谢

Danke

Merci

Gracias

Thank You

Köszönöm

ありがとう

Спасибо

Obrigado

„In God we trust; all others bring data.”

W. E. Deming



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