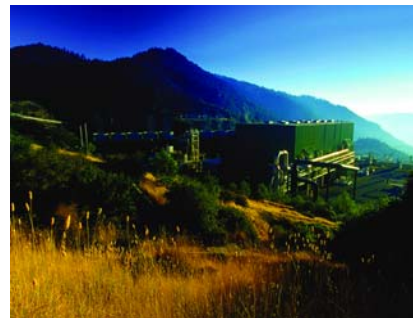
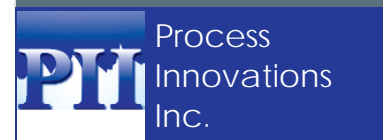




# ProcessPlugins Condition Monitor of Gas Turbine driven Process Gas Compressors



Partner Organizations:



## PROCESS PLUGINS™ Condition Monitor of Gas Turbines driving Process gas Centrifugal Compressors

The following input data is suggested to be available, ideally accommodated with P&ID's where appropriate:

1. Combustion turbine fuel supply flow rate
2. Combustion turbine fuel supply pressure
3. Combustion turbine fuel supply temperature
4. Combustion turbine exhaust temperatures
5. Air compressor inlet temperature
6. Air compressor filter inlet pressure
7. Air compressor filter outlet pressure
8. Air compressor outlet pressure
9. Air compressor outlet temperature
10. Process gas compressor fluid flow rate
11. Process gas compressor inlet pressure
12. Process gas compressor inlet temperature
13. Process gas compressor outlet pressure
14. Process gas compressor outlet temperature
15. Process gas heating value
16. All available gas chromatograph data (i.e. Constituents by percentage)
17. Bearing temperatures
18. Bearing vibrations

Gas constituent data is used to calculate gas density which is used in calculating real time mass flow rates. With heating value, this is used to calculate the fuel energy delivered to the combustion turbine. Turbine efficiency is then calculated as a function of fuel input and total work delivered to the Process gas compressor. The following parameters are calculated and key performance indicators (KPIs) are visually displayed in a real time comparison to manufacturer design curves or data, or to historical data trends:

1. Process gas compressor isentropic (adiabatic) efficiency
2. Process gas compressor polytropic efficiency
3. Air compressor isentropic (adiabatic) efficiency
4. Air compressor polytropic efficiency
5. Combustion turbine work
6. Combustion turbine efficiency
7. Applicable heat exchanger effectiveness

If any component's performance drops substantially below the expected value, then a visual display and PI Notification will communicate this information.

This module includes a complete set of PI Process Book displays and corresponding PI Web Parts displays.

Template  
 description  
 low Creek A  
 low Creek B  
 low Creek C

## Shallow Creek HP Gas Compressor A

### Solar Turbines

A Caterpillar Company

NGP: 94.7 %    NPT: 85.1 %

**SPEED:**

Actual            6,821 RPM  
 Nominal         6,968 RPM  
 Deviation        -147 RPM

**EFFICIENCY:**

Actual            0.823  
 Nominal         0.850  
 Deviation        -0.027

**HORSEPOWER:**

Shaft             2,426 hp

**ISENTROPIC HEAD:**

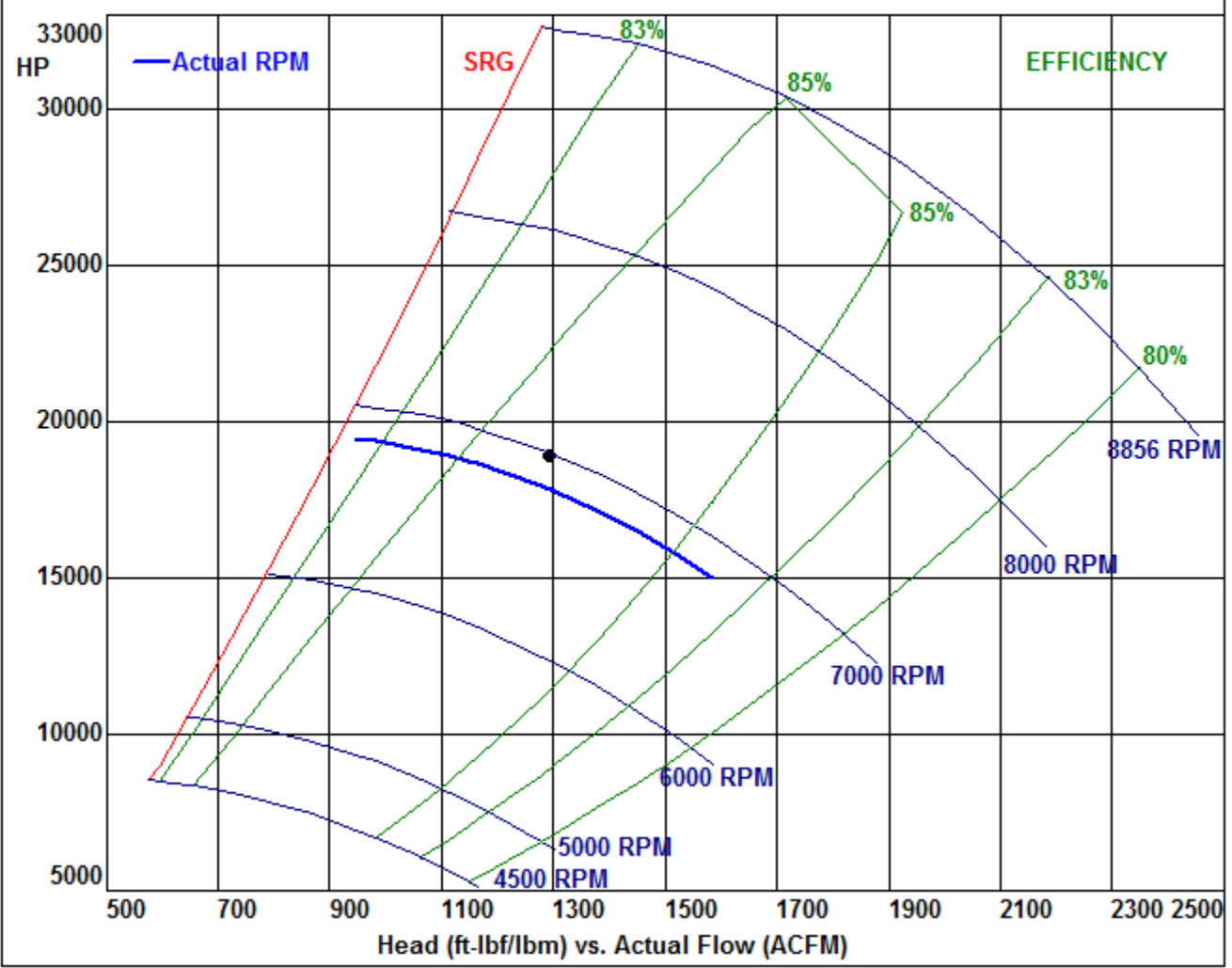
Actual            18,954 ft-lbf/lbm  
 Predicted        18,927 ft-lbf/lbm  
 Deviation        0.14 %

**INLET FLOW:**

Actual            1,292 acfm  
 Standard         115 MMscfd

**SETPOINTS:**

NGP                94.7 %  
 T5                 1,409 °F  
 SoLoNOx T5     1,366 °F  
 Discharge        1,338 psig  
 Flow               145 MMscfd  
 Suction            305 psig



Corporate level summary “drill down” screens make navigation easy via PI Process Book, or Internet Explorer using PI Web Parts.

Flexibility of the OSIsoft AF structure allows for value substitution whenever certain instrumentation may be unavailable. This substitution can take a number of forms including real-time calculation of the expected value based upon surrounding instrumentation, manual input via AF, manual input to a PI tag based on operator rounds, or any combination of manual and calculated inputs.

The Process Plugins™ solution has the capability of monitoring an unlimited number of assets, which could be added by the end user at any time in the future.

## **MORE ABOUT PROCESS PLUGINS™**

OSIsoft’s PI System continues to be the industry standard in data historians, which has been the core of its 21<sup>st</sup> century real-time infrastructure platform. And now this platform comes fully loaded with every feature necessary to support all of your needs for monitoring, modeling, diagnostics, or forecasting without the need for any 3<sup>rd</sup> party software. That’s where the Process Plugins™ package comes in.

Process Plugins™ is not 3<sup>rd</sup> party software. The Process Plugins™ package customizes your OSIsoft platform for your plant. This is the only existing solution if you want:

1. No unnecessarily redundant PI tags
2. No 3<sup>rd</sup> party software
3. One Microsoft certified package with seamless integration of calculations and models
4. Web browser interface capability
5. Ability to drill down into calculations to see (or edit) exactly what they’re doing

Demo - PI System Explorer

File Edit View Go Tools Help

Database Query Date Back Check In New Element New Attribute Search

### Elements

- Environment
- ProcessCompressor
  - Fuel
  - Chromatograph
  - GasCompressor
    - Performance
    - Stage1
    - Stage2
    - Stage3
  - GasTurbine
    - Compressor
      - Efficiency
      - Inlet
      - Outlet
    - Exhaust
      - Flow
      - Temperature
      - TemperatureProfile
    - HeatRate
    - Output
  - SourGas
    - Chromatograph
    - StackEmissionsEPA

### Performance

General Child Elements Attributes Ports Version

Filter

Name	Value
DischargePressureAbs	34.55559 bar
DischargePressureDeviation	-7.381195 %
DischargePressureGage	33.71563 bar
DischargeTemperature	68.10236 °C
ShaftPower	9.856818 kW
ShaftPowerDesign	17.16473 kW
ShaftPowerDeviation	-42.57516 %
Speed	13241 RPM
SuctionMFlow	0.1506883 kg/s
SuctionMFlowDesign	147 lb/min
SuctionPressureAbs	22.87487 bar
SuctionPressureGage	22.03491 bar
SuctionTemperature	34.89045 °C
SuctionVFlow	799.5492 m3/h
SuctionVFlowEng	446.4387 SCFM
V2	18933.51 m3/h
Work	10.29591 kW
WorkDesign	12.27499 kW
WorkDesignGuarantee	90.52604 kW

Group by:  Category

Name: SuctionMFlow

Description:

Configuration Item:

Categories:

UOM: kg/s

Value Type: Single

Value: 0.1506883 kg/s

Data Reference: Formula

Settings...

A=SuctionVFlow;UOM=m3/h;B=..\SourGas|STP\_Density;UOM=kg/m3;[A\*B];UOM=kg/h

Elements

Event Frames

Library

Unit of Measure

MyPI

Notifications

Contacts

SuctionMFlow

The Process Plugins™ package resides primarily within OSIsoft's PI Asset Framework (PI-AF). Your plant customization exists in the form of *elements* which handle most of your basic performance calculations. Using PI System Explorer, system administrators can view, modify, or enhance elements as desired.

## Element Formulas

The screenshot shows a dialog box titled "Formula Configuration:(SuctionMFlow)". It is divided into two main sections: "Parameters" and "Equations".

**Parameters:** This section contains two text boxes. The first contains the formula "A=SuctionVFlow;UOM=m3/h" and the second contains "B=..\SourGas|STP\_Density;UOM=kg/m3". To the right of these boxes are three icons: a yellow star, a grey 'X', and a red 'X'.

**Equations:** This section contains a text box with the formula "A\*B". To the right of this box are four icons: a yellow star, a grey 'X', a red 'X', and two grey arrows pointing up and down.

Below the "Parameters" section is a checkbox labeled "Default Values Allowed" which is currently unchecked.

**Result:** This section includes a "Unit of Measure:" dropdown menu set to "kg/h", and two empty input fields for "Minimum:" and "Maximum:".

At the bottom, there is an "Evaluate" button and a text box displaying the result "503.873968676773 kg/h". Below this are "OK" and "Cancel" buttons.

Fundamental performance calculations exist as formulas within elements.

# Element Templates

The screenshot displays the PPI - PI System Explorer interface. The main window is titled "PPI - PI System Explorer" and features a menu bar (File, Edit, View, Go, Help) and a toolbar with icons for Database, Query Date, Back, Check In, New Element Template, and New Attribute Template. A search bar is located in the top right corner.

The interface is divided into several panes:

- Library:** A list of element templates, with "PPIstmSI\_VTL" selected and highlighted in blue.
- General:** The active tab for the selected element, showing a search bar and a table of attributes.
- Attribute Templates:** A pane for configuring the selected attribute template.
- Ports:** A pane for configuring the selected port.
- Search:** A search bar for finding templates.
- Settings:** A pane for configuring the selected template.

The "Attribute Templates" pane shows a table with the following data:

Name	Description
InputT	Temperature
OutputV	Specific Volume

The "Settings" pane shows the following configuration for the "InputT" attribute:

- Name: InputT
- Description: Temperature
- Configuration Item:
- Categories:
- UOM: °C
- Value Type: Single
- Default Value: 0 °C
- Data Reference: Formula

The "Settings" pane also includes a "Settings..." button and a text area containing the formula: `A=.\ITemperature;UOM=°C;[A]`

The status bar at the bottom of the window displays: "PPIstmSI\_VTL Modified:2/14/2009 5:04:04 PM."

The Process Plugins™ package comes with a complete set of “Drag & Drop” Element Templates for use in PI-AF. Some routines utilize the Process Plugins™ Windows service, which delivers results back to an element.

## Lookup Tables

GasProperties							
General	Table	Define Table	Version				
GasProperties							
	Name	Molecule	MolWeight	HHVdry	LHVdry	SpecHeatRati	SpecHeatCp
	Acetylene	C2H2	26.03728	1488	0	1.232	1.69
	Air	AIR	28.963	0	0	1.4	1.01
	Ammonia	NH4	18.03846	0	0	1.31	2.19
	Argon	Ar	39.948	0	0	1.667	0.52
▶	n-Butane	C4H10	58.123	3392	3131	1.094	1.67
	i-butane	C4H10	58.123	3392	3131	1.094	1.67
	Carbon Dioxide	CO2	44.01	0	0	1.289	0.844
	Carbon Monoxide	CO	28.01	321	321	1.4	1.02
	Chlorine	Cl2	70.906	0	0	1.34	0.48
	Ethane	C2H6	30.07	1789	1636	1.187	1.75
	Ethylene	C2H4	28.05316	1614	1485	1.24	1.53
	Helium	He	4.002602	0	0	1.667	5.19
	Heptanes	C7H16	100.204	5502.5	5100	1.05	0
	Hexanes	C6H14	86.177	4755.9	4403.8	1.06	0
	Hydrogen	H2	2.016	325	273.8	1.405	14.32
	Hydrochloric Acid	HCl	36.46094	0	0	1.41	0.8
	Hydrogen Sulfide	H2S	34.08	647	596	1.32	1.017
	Hydroxyl	OH	17.00734	0	0	1.384	1.76
	Methane	CH4	16.043	1014	913	1.304	2.22
	Methyl Chloride	CH2Cl	49.47958	0	0	1.2	1.005
	Nitric Oxide	NO	30.0061	0	0	1.386	0.995
	Nitrogen	N2	28.013	0	0	1.4	1.04
	Nitrous Oxide	N2O	44.0128	0	0	1.27	0.88
	Oxygen	O2	31.999	0	0	1.395	0.919
	n-Pentane	C5H12	72.15	4200	3884	1.07	0
	i-pentane	C5H12	72.15	4200	3884	1.07	0
	Propane	C3H8	44.097	2573	2367	1.127	1.67
	Propylene	C3H6	42.07974	2383	2192	1.15	1.5
	Sulphur Dioxide	SO2	64.0638	0	0	1.29	0.64

The Process Plugins™ package comes with both industry standard and site specific tables which are used by elements for lookup functions as well as interpolation.

## Data Storage

The screenshot displays the 'PPI - PI System Explorer' application window. The main area is titled 'PPI\_WriteToPI' and shows the 'Attributes' tab. A table lists two attributes: 'Formula' with a value of 6508.577 and 'PIPoint' with a value of 6508.572. The 'PIPoint' attribute is selected, and its configuration is shown in the right-hand pane. The configuration includes the following fields:

- Name: PIPoint
- Description: (empty)
- Configuration Item:
- Categories: (empty)
- UOM: <None>
- Value Type: Single
- Value: 6508.572
- Data Reference: PI Point

Below the configuration fields is a 'Settings...' button and a text area containing the path: \\ProcessPlugins\PPI\_PUMP\_OUT\_U01\_BFP\_A\_0\_OP\_HEAD\_DES;ReadOnly=False. On the left, a tree view shows the hierarchy of elements, with 'PPI\_WriteToPI' selected under 'Performance'. On the right, a search bar and a list of elements are visible, including PPIStmEng\_HPS, PPIStmEng\_HPT, PPIStmEng\_HPX, PPIStmEng\_HsatP, PPIStmEng\_HsatT, PPIStmEng\_HTL, PPIStmEng\_PsatT, PPIStmEng\_SPH, PPIStmEng\_SPT, PPIStmEng\_SPTL, PPIStmEng\_SPX, PPIStmEng\_SsatP, PPIStmEng\_SsatT, PPIStmEng\_TPH, PPIStmEng\_TPS, PPIStmEng\_TsatP, PPIStmEng\_VPH, PPIStmEng\_VPS, PPIStmEng\_VPT, PPIStmEng\_VPTL, PPIStmEng\_VsatP, and PPIStmEng\_VsatT.

Key resultant data generated by Process Plugins™ modules are stored in the OSIsoft PI historian. Process Plugins™ modules do not store redundant or unnecessary data, but only a handful of PI tags for key results.

## Units of Measure

**Unit of Measure**

Search

Class

- Moles
- Partition
- Power**
- Pressure
- Specific Volume
- Temperature
- Temperature (Delta)
- Time
- Velocity
- Viscosity
- Volume
- Volume Flow Rate
- Volumetric Heating Value

Elements

Transfers

Library

**Unit of Measure**

**Power**

Search

Name	Abbrevi...	Class	Canonical	R.
Btu/h	Btu/h	Power	0.29307107017222 W	0...
Cal/s	Cal/s	Power	4.1868 W	4...
HP	HP	Power	745.699871582 W	7...
J/s	J/s	Power	1 W	1...
kBtu/h	kBtu/h	Power	293.07107017222 W	1...
kVA	kVA	Power	1000 W	1...
kVAR	kVAR	Power	1000 W	1...
kW	kW	Power	1000 W	1...
MJ/h	MJ/h	Power	277.777777777778 W	2...
MMBtu/d	MMBtu/d	Power	12211.2945905092 W	4...
MMBtu/h	MMBtu/h	Power	293071.07017222 W	1...
MMBtu/min	MMBtu/min	Power	17584264.2103332 W	6...
MMcal/h	MMcal/h	Power	1163 W	1...
MVA	MVA	Power	1000000 W	1...
MVAR	MVAR	Power	1000000 W	1...
MW	MW	Power	1000000 W	1...
VA	VA	Power	1 W	1...
VAR	VAR	Power	1 W	1...
W	W	Power	1 W	1...

Unit-of-Measure Database on PROCESSPLUGINS (33 Classes, 218 UOMs) Modified:7/2/2008 10:40:56 AM.

The Process Plugins™ package includes a complete set of engineering units utilized by the utility industry for use with the PI AF Unit of Measure (UOM) system. PI-AF automatically performs unit conversions on demand and delivers results in either the U.S. English or S.I. engineering unit systems.



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