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Leveraging the PI System for Gas Turbine Remote Monitoring & Diagnostics

Presented by WOOD GROUP **Wood Group GTS**

Wood Group GTS
Keep on turning

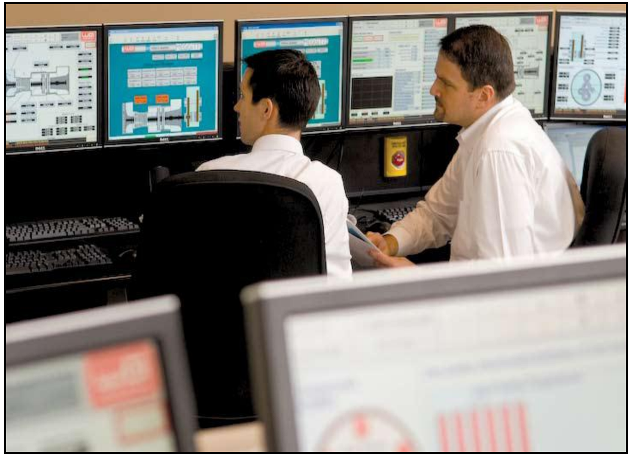
Dave Olsheski – Engineering Manager

Bill Maulsby – Sr. Project Engineer

Monitoring, Diagnostics & Performance

Wood Group GTS Loveland, CO USA

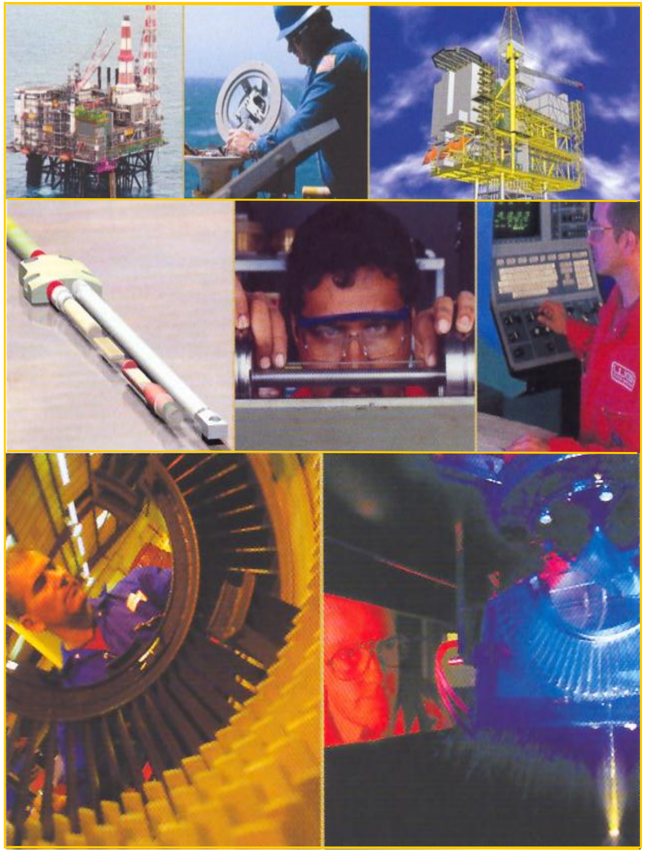
Wood Group GTS is a leading independent service provider for gas turbines in the global oil & gas and power generation industries



TransCanada Turbines – The Independent Alternative

Rolls Wood Group – Repair & Overhaul Expertise

Wood Group – Pratt & Whitney – A United Technologies Company



Established in 1961, John Wood Group PLC, **"Wood Group"**, employs over **33,000** people in **55** countries worldwide and generates over **$5.5B** in annual sales.

WG GTS is an Independent Service Provider for:

- Power Plant Operations & Maintenance (O&M)
- Field Service
- Repair & Overhaul
- Engineering, Procurement & Construction (EPC)
- Parts Supply
- Control Retrofits

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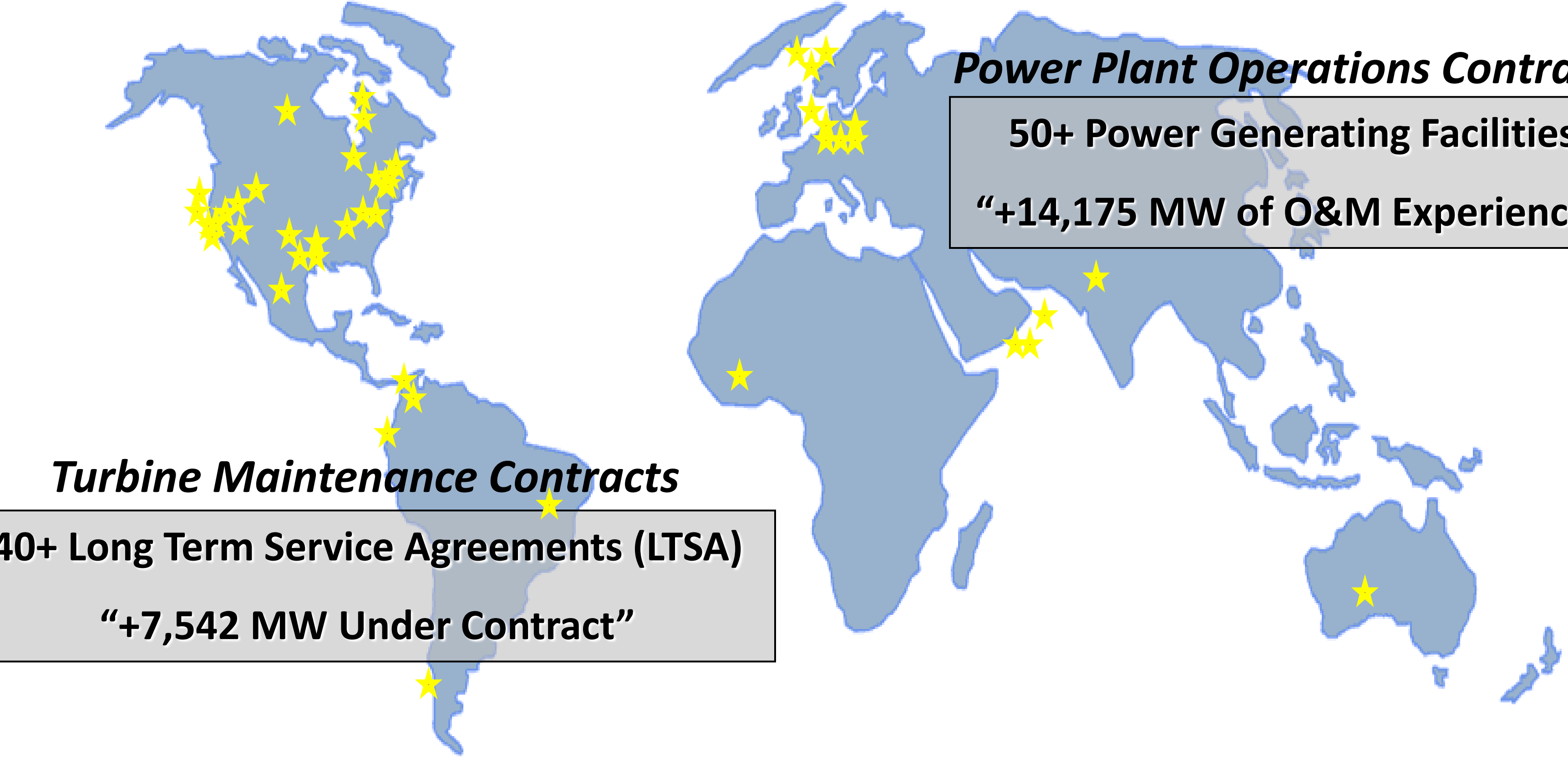
Long-Term Contractual Asset Portfolio
"Diverse Gas Turbine Technology and Geographical Locations"



Power Plant Operations Contracts

50+ Power Generating Facilities

"+14,175 MW of O&M Experience"

Turbine Maintenance Contracts

40+ Long Term Service Agreements (LTSA)

"+7,542 MW Under Contract"

Wood Group GTS Remote Monitoring & Diagnostics

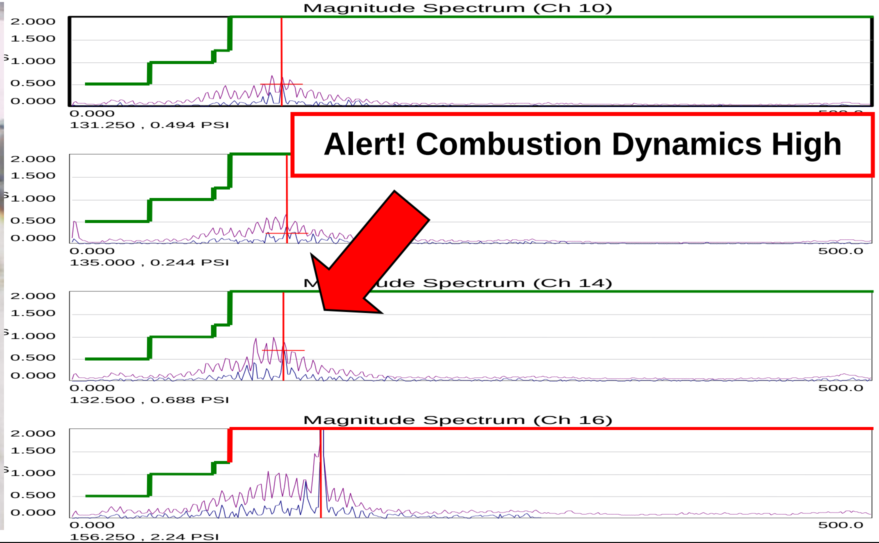
Leverage IT Technology to Provide World-Class Remote Engineering Service & Support

Allow Real-Time Wood Group Engineering Interface With Global Service Asset Fleet

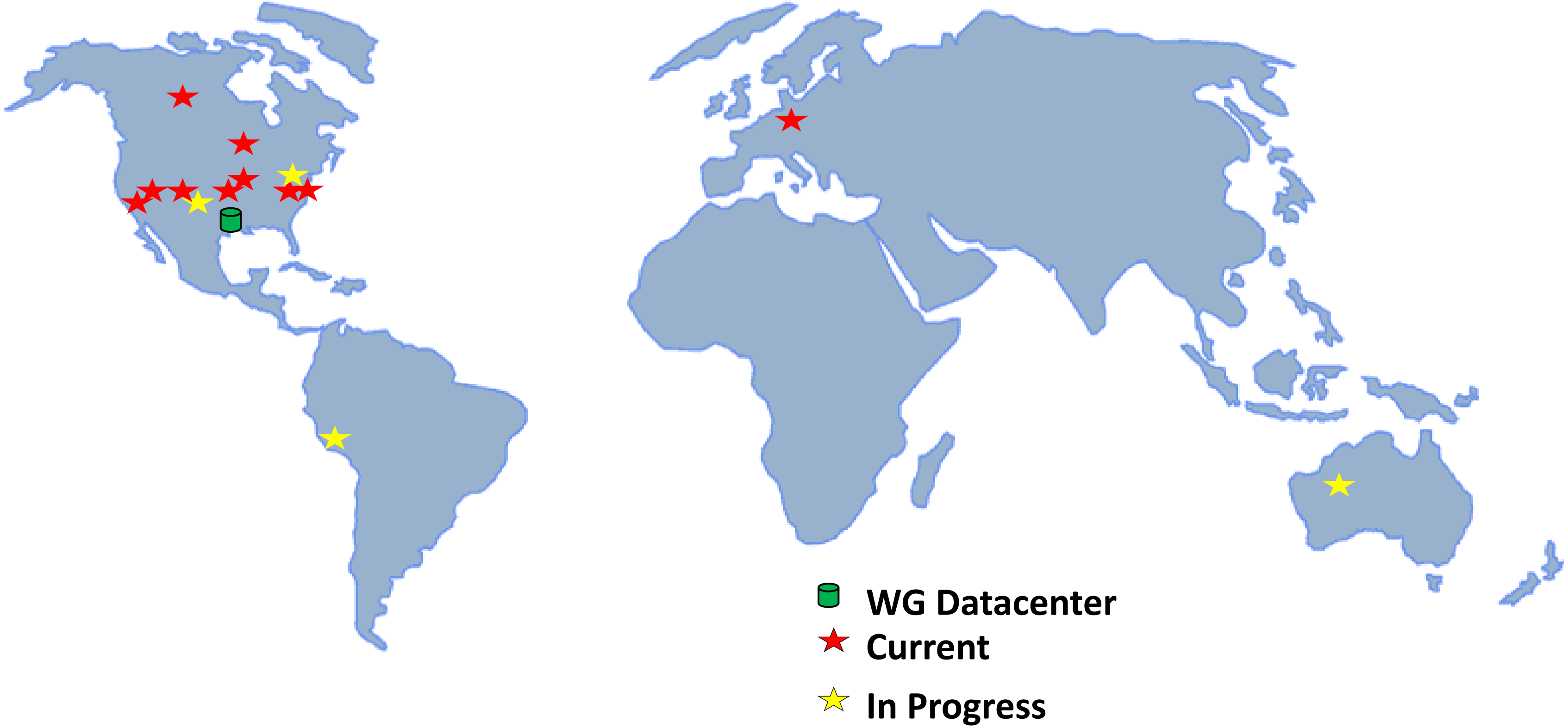
Enhance All Wood Group GTS Contractual Service Offerings (O&M, LTSA)

Avoid This….

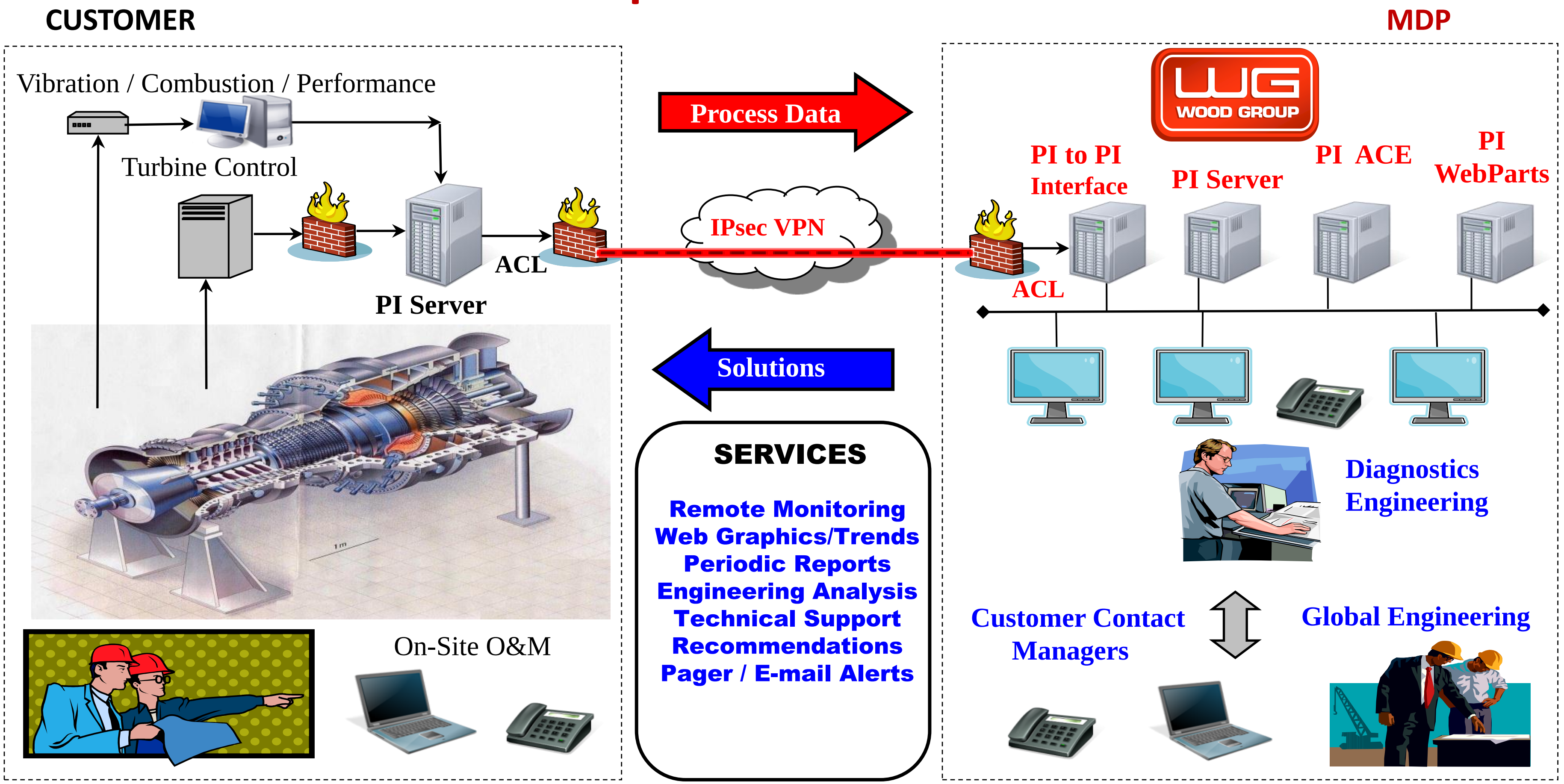
By Utilizing This!



Wood Group GTS MDnet Sites



Wood Group GTS MDP Environment



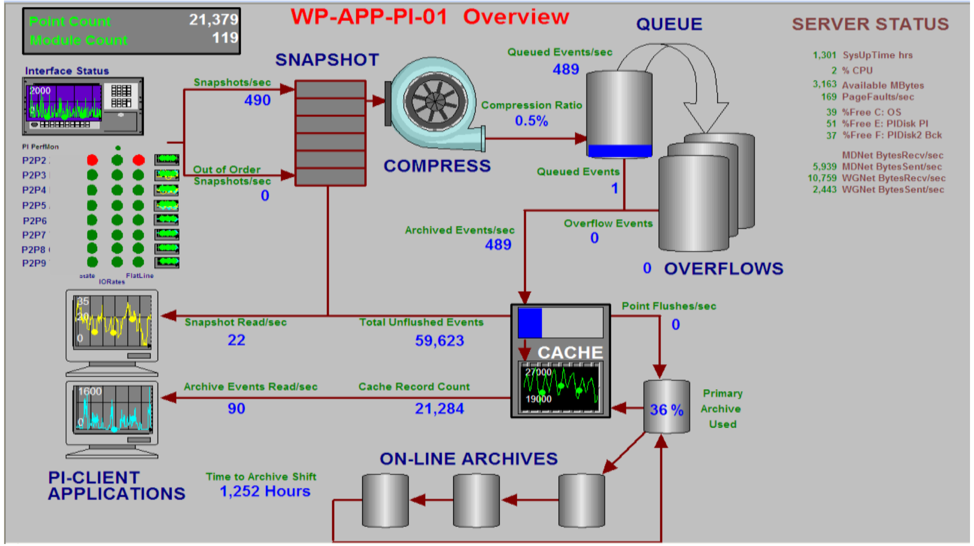
Wood Group GTS MDP Infrastructure

Virtual Machine Environment:

- Supportable, Scalable, Reliable, Cost Effective
- 4GB, 2 cpu 3.0GHz, 400 GB current arcs, Windows Server
- PI to PI, PI Server, PIANO, PIWP on SharePoint, PI Server client nodes

PI Server Environment:

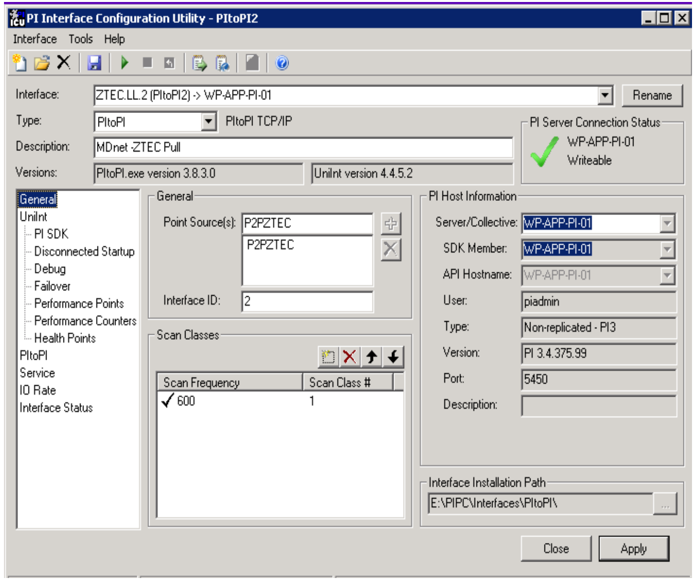
- 50K tags → ?
- 4GB archives, 15 day shift.
- Low Compression, High Arc Read/Sec
- Move to PI 2010 with AF & MCN



Wood Group GTS MDP Infrastructure

PI to PI Interface:

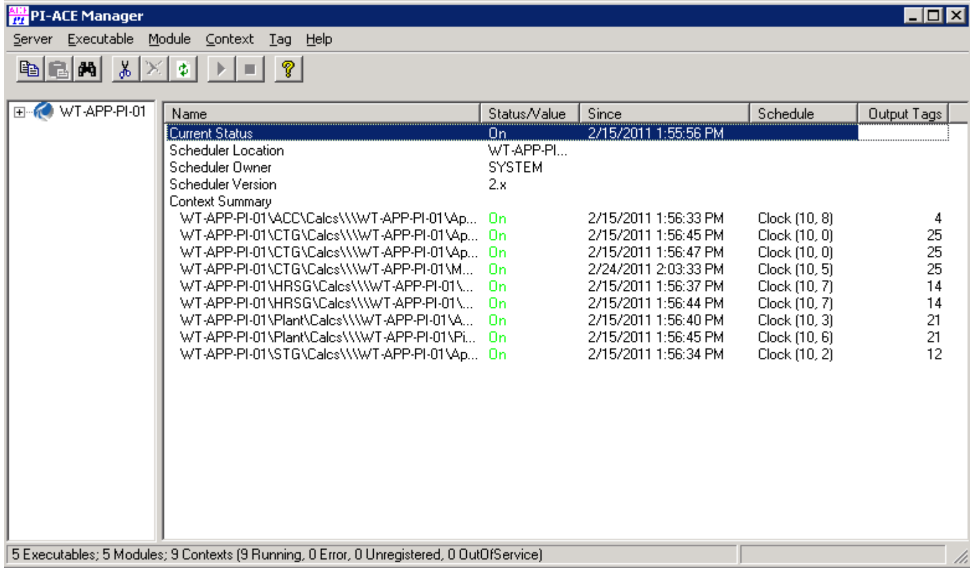
- Read Only, Pull
- Replicate Arcs → /HROnly
  - … 96 hr. recovery
  - … no snapshot, IST events
  - … Arc replace
- Scan Frequency f(# events, latency)
  - …Collect 4-5K tags/site
  - … IORates 4-6K events/min steady state
  - … 100-200 msec latency
  - … Set scan interval 10 – 15 minutes
  - … See completion 2 – 12 minutes



Wood Group GTS MDP Infrastructure

PI ACE:

- Performance calculations & predictive models
- Clock scheduled
- Logic to process PI to PI scan “batches”
- Backfill reprocessing logic
- PI MDB aliases & properties (Migrate to PI AF)
- PI ACE Contexts using common code
- Additional code instances for scalability

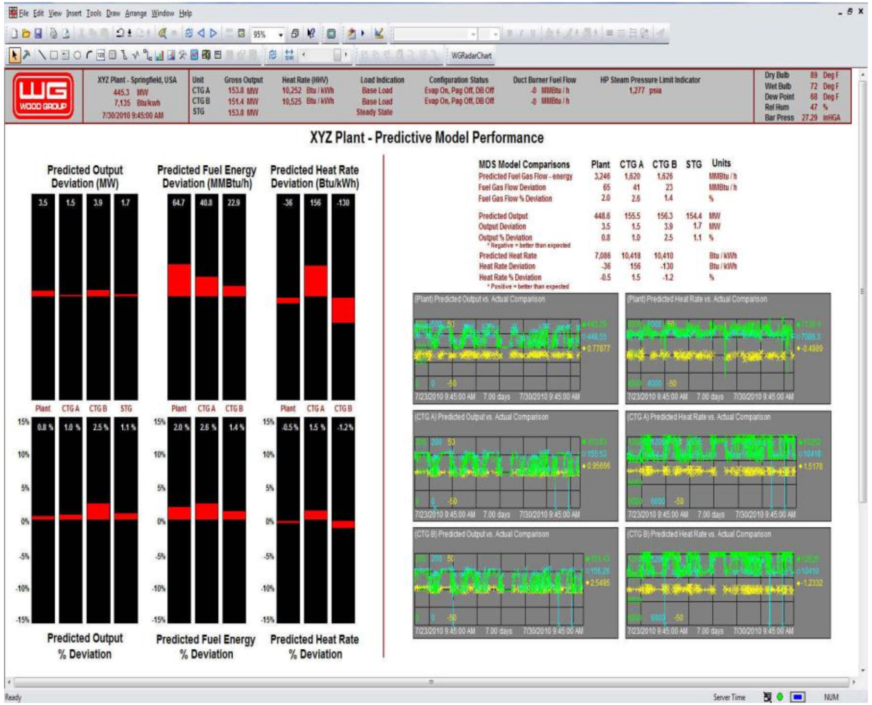


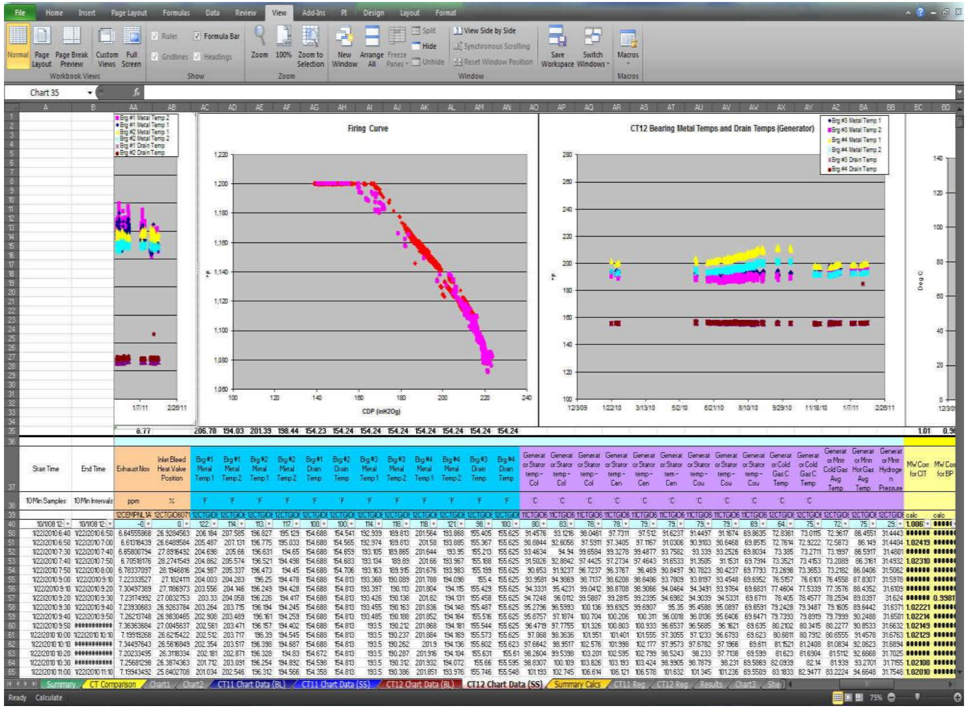
Alerts:

- Exception emails to BlackBerry
- Turbine performance & MDP infrastructure alerts
- Expand use with PI System 2010 migration

Wood Group GTS MDP Infrastructure

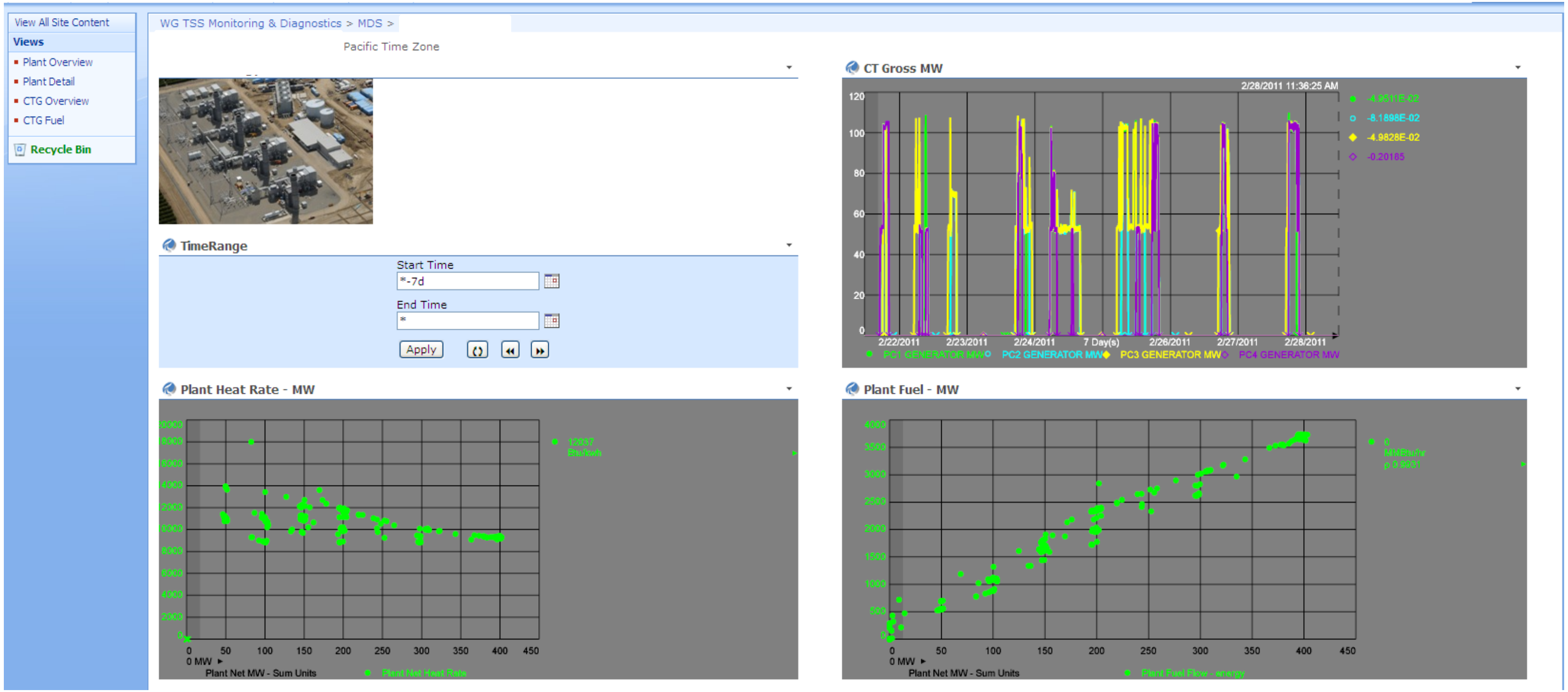
PI Clients: Traditional





Wood Group GTS MDP Infrastructure

PI Clients: PI WebParts



Wood Group GTS MDP Process Solutions

Interpretation, Contextualization and Recommendation Driving Action

- Infrastructure and Application investment has no ROI if there is not a responsible party and/or process to utilize the information

- Automation can make resources more efficient, but ultimately someone must interpret the information and make sound recommendations

- Proper recommendations that are acted upon and translated into actionable improvements result in improved asset profitability

People Must Utilize the Information and Act

Diagnostic Algorithms Convert Process Data to Equipment Information

Wood Group RM&D utilizes (3) Major Categories of Diagnostics to effectively Monitor Equipment Health

(1) Process Variable Monitoring
(2) Thermal Performance Metrics
(3) Equipment Modelling

Effective Deployment Considerations

Applications – Scalability, Features/Functions, Configuration
Process Data – Collection Resolution, Averaging, Normalization
Resources – Effective Combination of Software and Power Plant Engineers

PROCESS VARIABLE MONITORING

Turbine readings are monitored against known limits and relationships
Basic linear and 2nd order functions are utilized

- Typically employed at LOL to Base Load, steady state averaging
- Alarm limits are set below Turbine Control System alarm set-point(s)
- Automation is employed to generate alarms

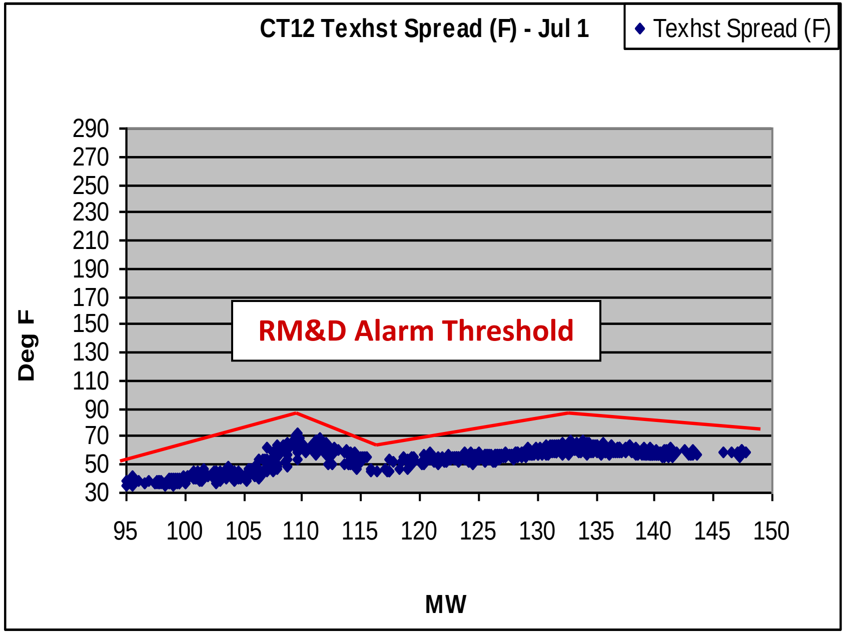
Examples

- Predicted Fuel Consumption (Fuel vs. Load)
- Exhaust Temperature Spread (Texhst vs. Load)
- DLN Combustion Dynamics (if CDMS data applicable / available)
- Bearing Monitoring (Vibration vs. Load, Bearing Metal & Oil Temps)
- Turbine Wheelspace Temperatures (Temps vs. Load)

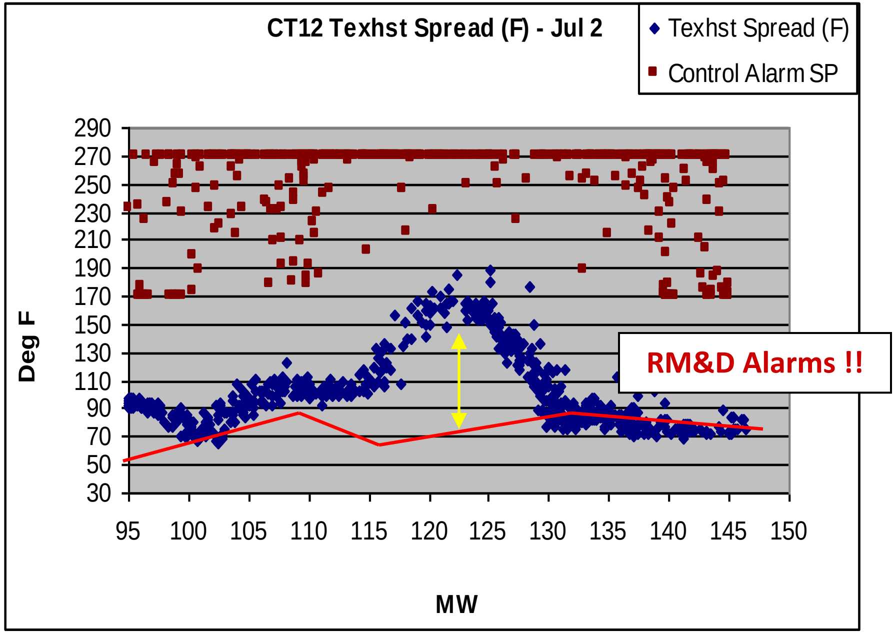
RM&D utilized for early identification of component failure

Unit Cycled July 1 - July 2. Noted Step Change in Texhst Spread +100F

July 1 - Load vs. Texhst Spread



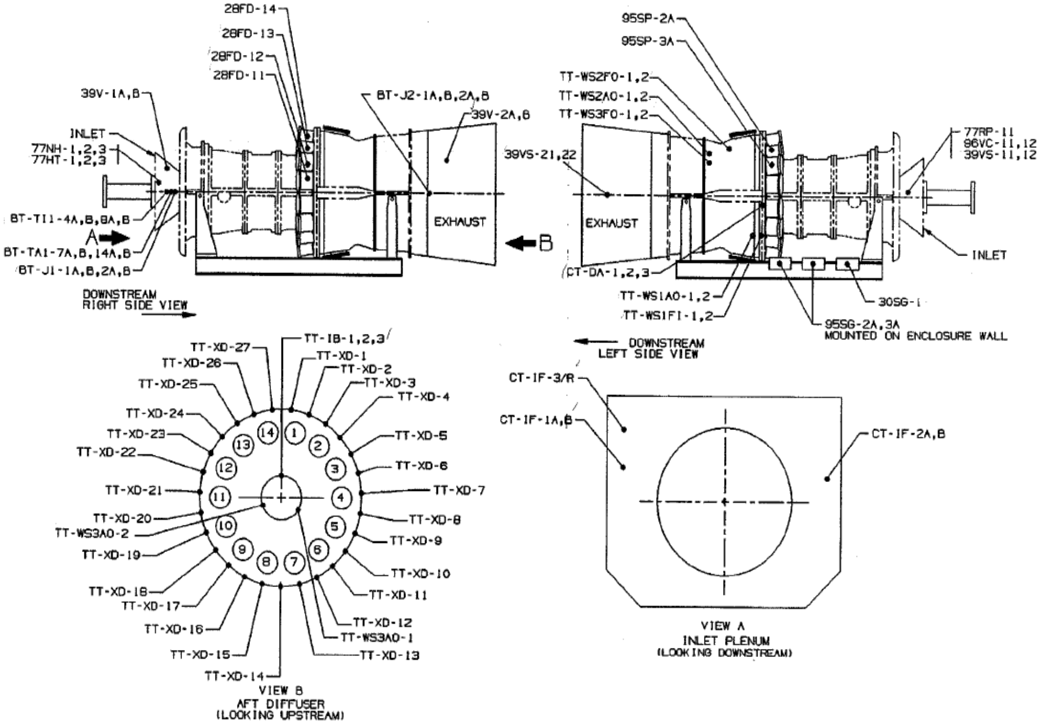
July 2 - Load vs. Texhst Spread



RM&D utilized for early identification of component failure

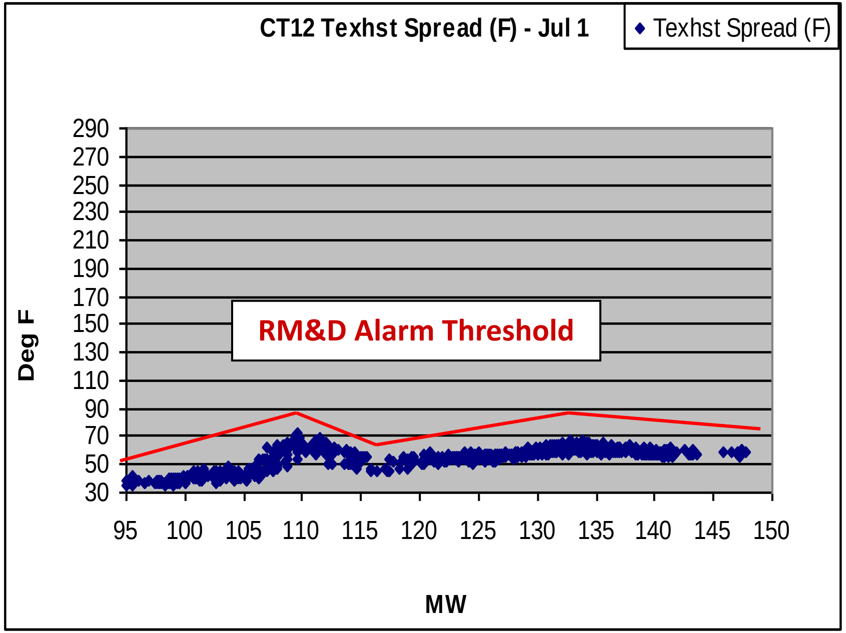
Understand Your Equipment and Associated Instrumentation

Critical Correlation between Exhaust Temperature Profile and Upstream Combustor Health



Approaches for Effective Process Variable Monitoring

Load vs. Texhst Spread



- ✓ Understand Your Process & Criticality
- ✓ Plot Relationships & Identify Anomalies
- ✓ Generate Alarm Limits / Benchmarks
- ✓ Data Processing - No Transients, Averaging
- ✓ Utilize Automation for Alarming
- ✓ Contextualize - Instrumentation or Real ?
- ✓ Respond Appropriately

THERMAL PERFORMANCE METRICS

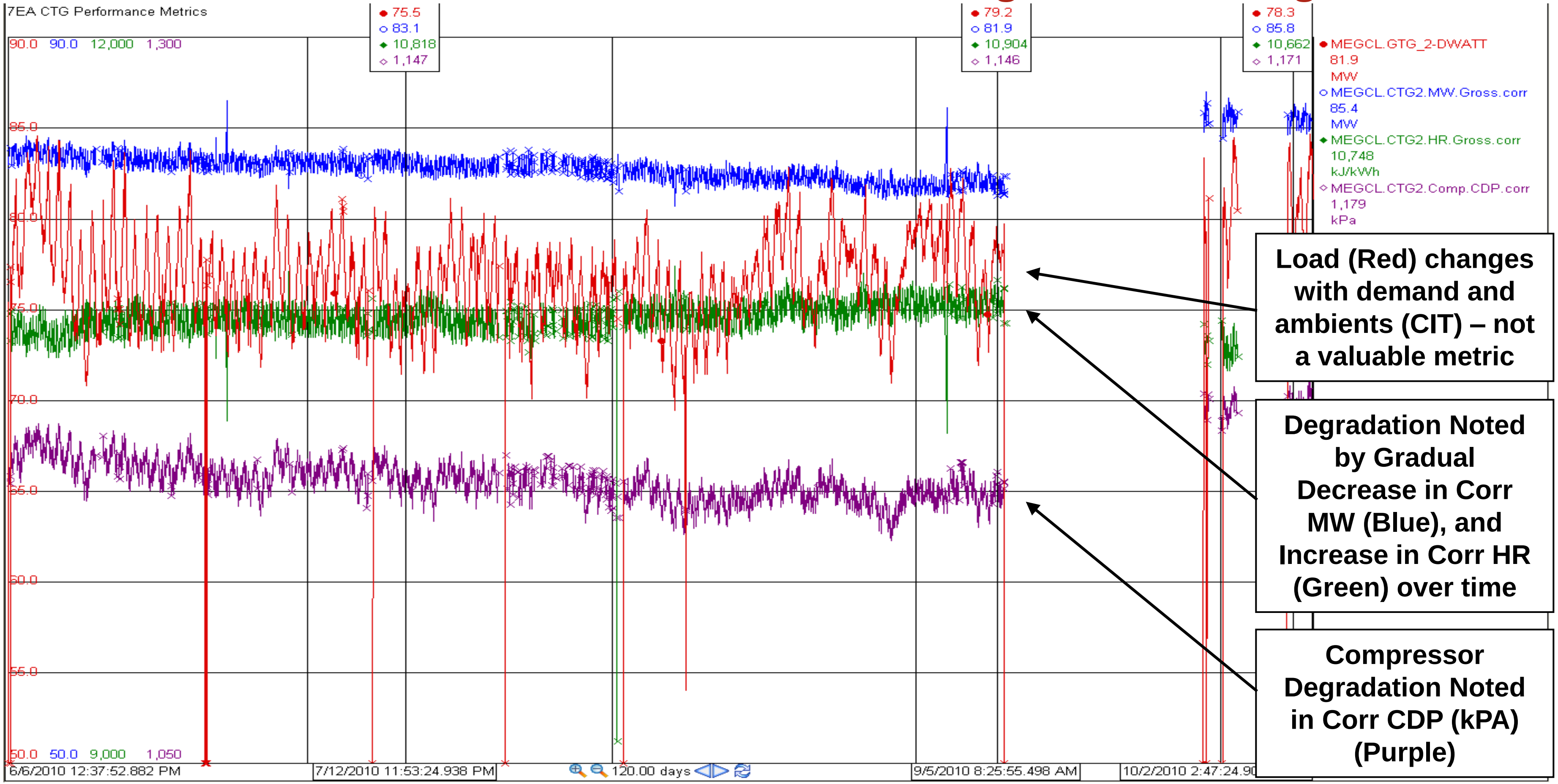
Thermal performance metrics are applicable at base load, or load normalized
Plant / Unit-specific correction curves provide the most accurate calculations

- Typically employed at Base Load, steady state averaging
- Calculations are based on correction curves and known thermodynamic principals
- Automation is employed to generate alarms

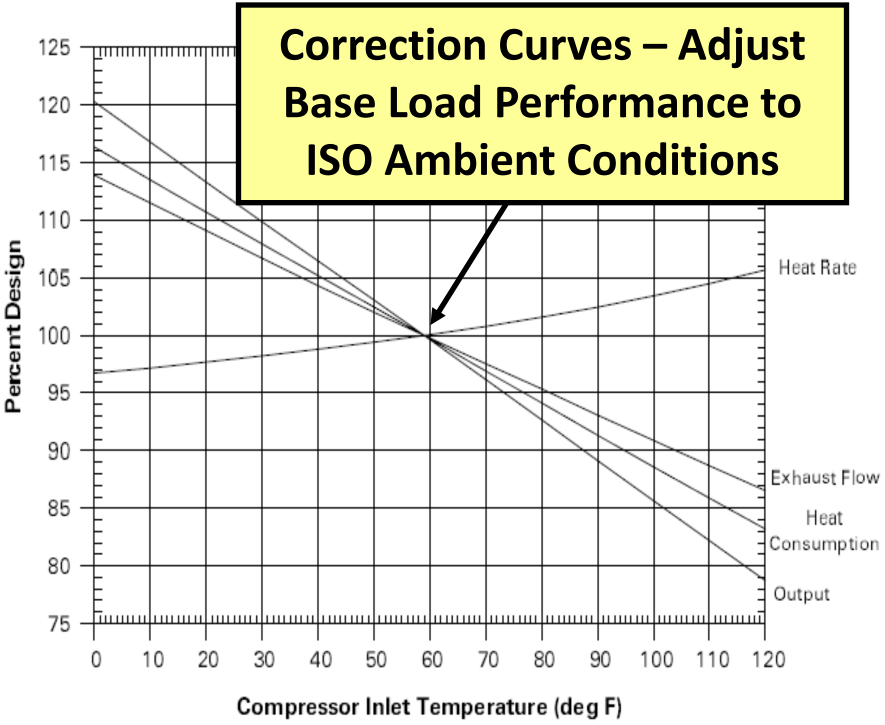
Examples

- Plant / Unit Corrected Output (MW) – Steam Adjusted for Cogen Applications
- Plant / Unit Corrected Heat Rate - Steam Adjusted for Cogen Applications
- CT Compressor Efficiency
- Corrected CDP, Corrected Texhst
- CT Inlet Cooling Effectiveness

Thermal Performance Metrics Utilized for Degradation Management

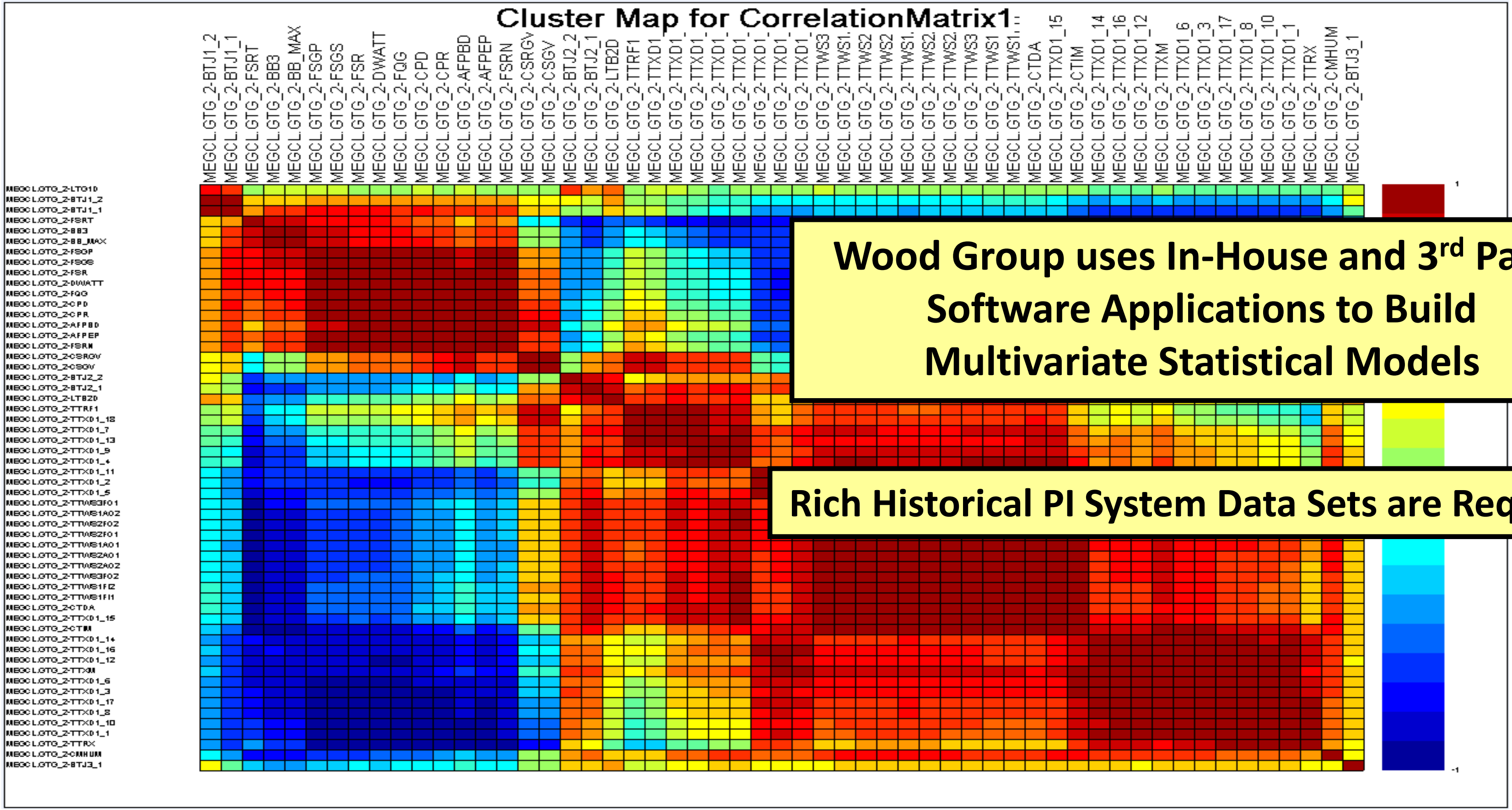


Approaches for Effective Thermal Performance Monitoring



- ✓ Understand Your Process & Criticality
- ✓ Obtain or Generate Correction Curves
- ✓ Deploy Calculations - ACE or Other
- ✓ Data Processing - No Transients, Averaging, Base Load Filtering
- ✓ Utilize Automation for Alarming
- ✓ Contextualize – Are results realistic?
- ✓ Respond Appropriately

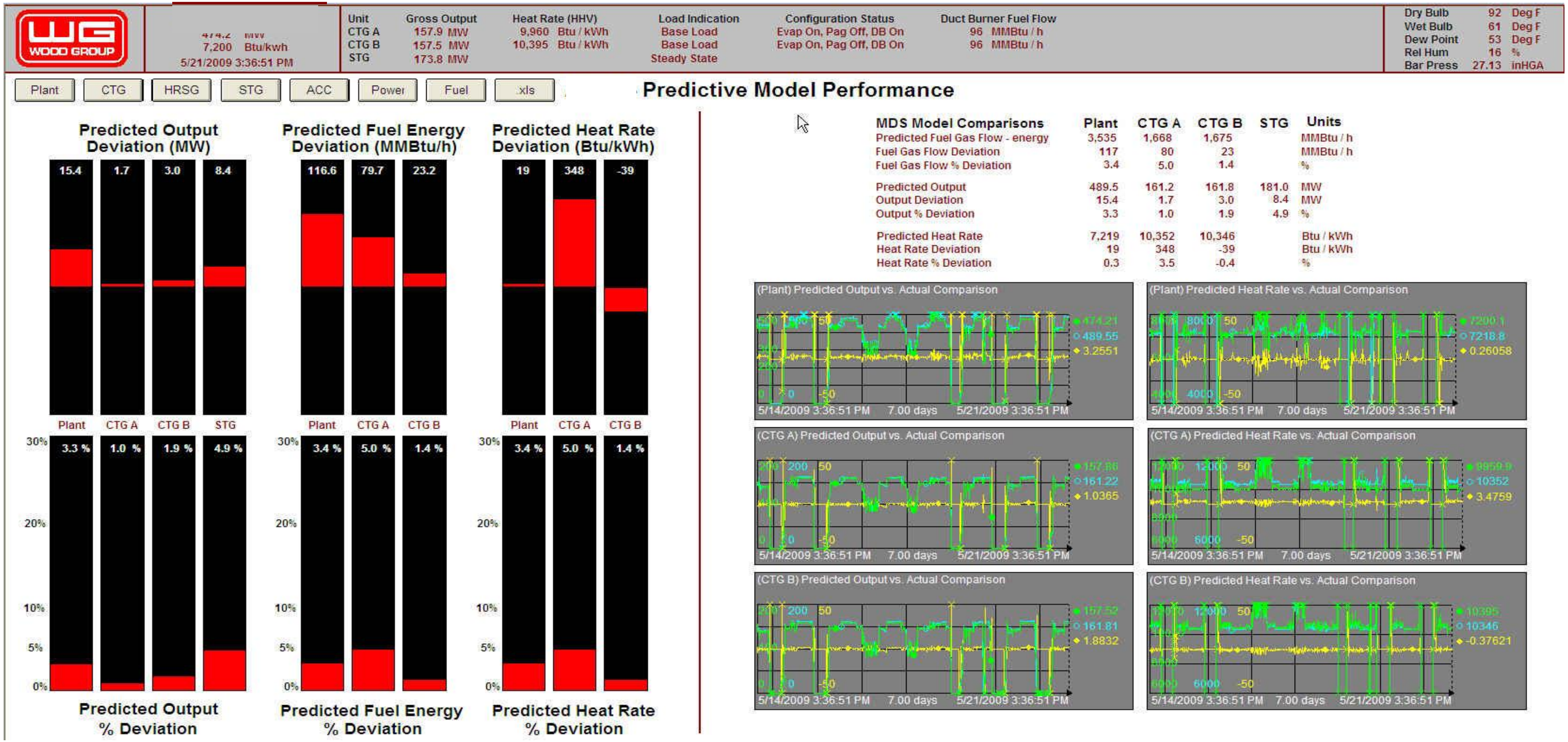
Advanced Statistical Models Provide Identification of Subtle Changes in Process Data



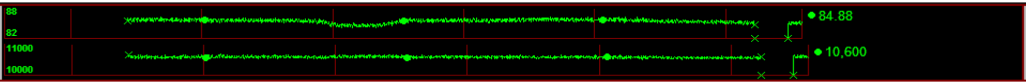
Wood Group uses In-House and 3rd Party Software Applications to Build Multivariate Statistical Models

Rich Historical PI System Data Sets are Required

Combined Cycle Plant Modelling Utilized for Monitoring and Dispatch Optimization



7EA Sample Display	Gross Output	Total Starts 36 Counts
12/6/2009 2:00:00 PM	96.3 MW	Fired Hours 1,449 Hours
Load Indication	Heat Rate (LHV)	Peak Fired Hrs 0 Hours
Base Load	10,288 kJ/kWh	Emergency Trips 13 Counts



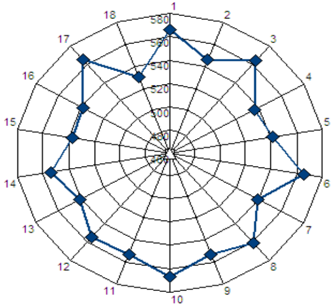
CTG Summary | CTG Alarms | CT Other | Generator

CTG Performance Summary

Measured Parameter			Units
Load	DWATT	96.3	MW
Load Ref - MK V	L90PSEL	85.0	MW
FSR Load	FSRN	88.5	%
FSR Temp	FSRT	84.2	%
Turbine Speed	TNH_RPM	3,600	rpm
Fuel Gas Flow	FQG	6.0	kg/s
Fuel Gas Temp	FTG	44.4	Deg C
Fuel Gas Pressure	FPG1	2,455	kPa
Inlet DP	AFPCS	56.7	mmWC
Cmprsr Inlet Pressure	AFPAP	968	mbar
Cmprsr Inlet Temp Max	CTIM	-15.8	Deg C
Cmprsr Inlet Specific Hum	CMHUM	0.60	g/kg
Cmprsr Inlet Dew Point	ITDP	2253.27	Deg C
IGV Postion	CSGV	84.0	DegA
IGV Ref	CSRGV	84.0	DegA
IBH Valve Position	CSBHX	7.7	%
IBH Valve Ref	CSRIH	0.0	%
IBH % Cmp Flow Dmd	CSRBH	255.0	%
Bleed Heat Enabled	L69BHEN	On	
DLN Bleed Heat Enabled	L83BHEN	On	
Cmprsr Discharge Press	CPD	1,250	kPa
Cmprsr Pressure Ratio	CPR	14.0	n/a
Cmprsr Discharge Temp	CTDA	319	Deg C
Exhaust Temp Median	TTXM	524	Deg C
Exhaust Temp Ref	TTRX	524	Deg C
Combustor Spread 1	TTXSP1	25	Deg C
Combustor Spread 2	TTXSP2	19	Deg C
Combustor Spread 3	TTXSP3	17	Deg C
Allowable Temp Spread	TTXSPL	51	Deg C
Exhaust DP	AFPEP	297.0	mmWC
Fuel System			
Fuel Gas Intrstg Press	FPG2	2,139	kPA
Fuel Gas SRV Press Ref	FPRG	2,142	kPA
SRV Feedback	FSGR	51.87	%
Primary CV Feedback	FSGP	77.10	%
Secondary CV Feedback	FSGS	41.56	%
% Fuel to Primary Nozzles	FSRXS	81.75	%
Fuel Split - % to Prim	FSRXSR	81.75	%
Fuel Transfer Setpoint	FSRXT	0.00	%
Fuel Transfer Dmd	FSRXTL	0.00	%

Calculated Performance		Units
Fuel Gas Flow - mass	21,495	kg/h
Fuel Gas Flow - volume	29,235	Nm3/h
Fuel Gas Flow - energy	991	GJ/h
Gross Heat Rate - LHV	10,288	kJ/kWh
Compressor Pressure Ratio	14.0	n/a
Compressor Efficiency	86.4	%
Compressor Temp Delta	334	Deg C
Compressor Disch Pressure Corr	1168.2	kPa
Corrected Output	84.9	MW
Corrected Heat Rate	10,600	kJ/kWh
Corrected Exhaust Temp	545	Deg C
Predicted Fuel Gas Flow - Energy	979	GJ/h
Fuel Gas Flow Deviation	12	GJ/h
Fuel Gas Flow % Deviation	1.2	%
Exhaust Temp Deviation	-0.2	Deg C
Comb Spread 1 Deviation	-2.0	Deg C
Comb Spread 2 Deviation	-8.3	Deg C
Comb Spread 3 Deviation	-9.6	Deg C

Exhaust Temp Profile



Measured Parameter			Units
Vibration			
Max Vibration	BB Max	153	mm/s
Turb Brg #1A -Vibration	BB1	55	mm/s
Turb Brg #1B - Vibration	BB2	62	mm/s
Turb Brg #2 - Vibration	BB3	154	mm/s
Turb Brg #3A - Vibration	BB4	127	mm/s
Turb Brg #3B - Vibration	BB5	132	mm/s
Gen Brg #4A - Vibration	BB10	43	mm/s
Gen Brg #4B - Vibration	BB11	40	mm/s
Gen Brg #5 - Vibration	BB12	136	mm/s
Bearing Metal & Oil Temps			
Turb Brg 1-1 - Mtl Temp	BTJ1-1	86	Deg C
Turb Brg 1-2 - Mtl Temp	BTJ1-2	85	Deg C
Turb Brg #1 - Drain Temp	LTB1D	62	Deg C
Turb Brg 2-1 - Mtl Temp	BTJ2-1	87	Deg C
Turb Brg 2-2 - Mtl Temp	BTJ2-2	83	Deg C
Turb Brg #2 - Drain Temp	LTB2D	76	Deg C
Turb Brg 3-1 - Mtl Temp	BTJ3-1	77	Deg C
Turb Brg 3-2 - Mtl Temp	BTJ3-2	112	Deg C
Turb Brg #3 - Drain Temp	LTB3D	69	Deg C
Gen Brg 1-1 - Mtl Temp	BTGJ1-1	80	Deg C
Gen Brg 1-2 - Mtl Temp	BTGJ1-2	79	Deg C
Gen Brg #1 - Drain Temp	LTG1D	79	Deg C
Gen Brg 2-1 - Mtl Temp	BTGJ2-1	81	Deg C
Gen Brg 2-2 - Mtl Temp	BTGJ2-2	99	Deg C
Gen Brg #2 - Drain Temp	LTG2D	79	Deg C
Thrust Brg 1-1 - Active Side	BTTA1_1	71	Deg C
Thrust Brg 1-2 - Active Side	BTTA1_2	74	Deg C
Thrust Brg 2-1 - Inactive Side	BTTI1_1	65	Deg C
Thrust Brg 2-2 - Inactive Side	BTTI1_2	64	Deg C
Bearing Oil Supply Temp	LTTH1	55	Deg C
Generator - Mechanical			
DTGSF1	DTGSF1	90	Deg C
DTGSF2	DTGSF2	91	Deg C
DTGSF3	DTGSF3	91	Deg C
DTGSA4	DTGSA4	90	Deg C
DTGSA5	DTGSA5	90	Deg C
DTGSA6	DTGSA6	90	Deg C
DTGGC10	DTGGC10	40	Deg C
DTGGC11	DTGGC11	39	Deg C
DTGGH18	DTGGH18	70	Deg C
DTGGH19	DTGGH19	69	Deg C

Measured Parameter			Units
Cmprsr Discharge Temp1	CTDA1	319	Deg C
Cmprsr Discharge Temp2	CTDA2	317	Deg C
Cmprsr Discharge Temp3	CTDA3	319	Deg C
Whlspc Stg 1 Fwd Inner 1	TTWS1FI1	353	Deg C
Whlspc Stg 1 Fwd Inner 2	TTWS1FI2	353	Deg C
Whlspc Stg 1 Aft Outer 1	TTWS1AO1	407	Deg C
Whlspc Stg 1 Aft Outer 2	TTWS1AO2	403	Deg C
Whlspc Stg 2 Fwd Outer 1	TTWS2FO1	390	Deg C
Whlspc Stg 2 Fwd Outer2	TTWS2FO2	391	Deg C
Whlspc Stg 2 Aft Outer 1	TTWS2AO1	353	Deg C
Whlspc Stg 2 Aft Outer 2	TTWS2AO2	349	Deg C
Whlspc Stg 3 Fwd Outer 1	TTWS3FO1	391	Deg C
Whlspc Stg 3 Fwd Outer2	TTWS3FO2	397	Deg C
Whlspc Stg 3 Aft Outer 1	TTWS3AO1	232	Deg C
Whlspc Stg 3 Aft Outer 2	TTWS3AO2	220	Deg C
Inner Barrel Temp	TTIB1	176	Deg C
Exhaust Temp 1	TTXD1_1	521	Deg C
Exhaust Temp 2	TTXD1_2	534	Deg C
Exhaust Temp 3	TTXD1_3	520	Deg C
Exhaust Temp 4	TTXD1_4	549	Deg C
Exhaust Temp 5	TTXD1_5	509	Deg C
Exhaust Temp 6	TTXD1_6	525	Deg C
Exhaust Temp 7	TTXD1_7	536	Deg C
Exhaust Temp 8	TTXD1_8	510	Deg C
Exhaust Temp 9	TTXD1_9	544	Deg C
Exhaust Temp 10	TTXD1_10	516	Deg C
Exhaust Temp 11	TTXD1_11	522	Deg C
Exhaust Temp 12	TTXD1_12	534	Deg C
Exhaust Temp 13	TTXD1_13	522	Deg C
Exhaust Temp 14	TTXD1_14	502	Deg C
Exhaust Temp 15	TTXD1_15	533	Deg C
Exhaust Temp 16	TTXD1_16	508	Deg C
Exhaust Temp 17	TTXD1_17	528	Deg C
Exhaust Temp 18	TTXD1_18	524	Deg C
Flame Detectors			
Flame - Ch 1	L28FDA	Off	
Flame - Ch 2	L28FDB	Off	
Flame - Ch 3	L28FDC	Off	
Flame - Ch 4	L28FDD	Off	
Flame - Ch 5	L28FDE	On	
Flame - Ch 6	L28FDF	On	
Flame - Ch 7	L28FDG	On	
Flame - Ch 8	L28FDH	On	

Thank you

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