



REGIONAL HAZE FOUR-FACTOR ANALYSIS
NMED FOLLOW-UP LETTER RESPONSE
Xcel Energy, Cunningham Station

Prepared By:

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1. RESPONSES TO THE NMED

The NMED posed the following questions regarding the emissions control options Enterprise presented for the two (2) turbines and two (2) boilers located at the Xcel Energy Cunningham Station.

COMBUSTION TURBINES

1. *Provide the details regarding Good Combustion Practices (GCP) and the routine maintenance schedule and procedures that are currently used to mitigate NO_x emissions that are employed as the base case.*

Response: Xcel Energy implements robust Good Combustion Practice which are detailed in a Good Combustion Practices Manual that has been developed specifically for the Cunningham Station facility. This document is provided with this submission.

2. *Can documentation be obtained from Siemens to support the claim that there are no commercially available dry low NO_x (DLN) burners that would provide lower emissions than those already installed on the combustion turbines?*

Response: Correspondence from Dan Johnson (Siemens Energy) is attached in Appendix A confirming that DLN and ULN upgrades are not commercially available for the Siemens D5A turbines installed at the Cunningham Station.

3. *Provide documentation with details from Xcel engineers that steam injection may not be implemented on the combustion turbines.*

Response: An email from Siemens is attached in Appendix A discussing the fact that steam injection is not available for these units. The reasons include physical limitations in the combustion chamber and cost, among others. Moreover, Siemens stated that steam injection has not been installed on these units. In addition to the technical barriers the technology has not been commercially demonstrated and is therefore not considered to be a viable control option for the Turbines at the Cunningham Station

4. *Although the analysis indicates that selective catalytic reduction (SCR) may be considered a technically feasible control option, if space and temperature limitations can be overcome, please provide additional discussion on the possible space limitations; the potential significant technical and financial challenges associated with elevated exhaust temperature from the simple cycle turbines; and the drawbacks from employing this technology on peaking units when compared to continuous operation of combined-cycle units.*

Response: As discussed in the original submission, Xcel considered space limitations and determined that there is enough space to install the SCRs. While exhaust temperature may present some issues, if needed Xcel could install a hot side SCR, which is suggested by Siemens in the email attachment to number 3, above. Specific cost and performance factors were not considered for a hot side SCR as the EPA cost estimate manual and generic AP-42 control efficiencies were used to evaluate the cost effectiveness of these units.

INDUSTRIAL BOILERS

5. Provide the details regarding GCP and the routine maintenance schedule and procedures that are currently used to mitigate NOX emissions and are employed as the base case.

Response: Per the above response, please see the Good Combustion Practices manual for Cunningham Station.

6. Please provide additional detail on the reasons why the three levels of combustion burners on Boiler Unit 1 cannot be modified to include the overfire air technique currently employed on Unit 2.

Response: Unit 1 is a much smaller boiler than unit 2. Overfired air involves removing the top layer of burners and replacing them with air registers. If this modification were implemented, there would not be enough burners to operate the unit. The Unit would need to be redesigned and rebuilt to add another burner layer, with air registers installed at the top. The locations of the burners would change and would require a redesign and rebuild of the piping and ductwork for air and gas delivery. Alternatively, the boiler itself could be completely redesigned and rebuilt to accommodate the implementation of overfire air. However, as stated in the Guidelines for BART determinations Under the Regional Haze Rule, the general types of modifications that shall be considered under this analysis include the implementation of lower emitting processes or practices and add-on controls. Moreover, the guidance states that this analysis shall not be considered as a “requirement to redesign the source when considering available control alternatives.”¹ Therefore, neither of these options to accommodate overfire air are a viable option.

7. There are other NOX reduction technologies that may be applicable to the Cunningham Station’s boilers. Please include a discussion on the technical feasibility on the following technologies:

a. ECOTUBE;

Response: The ECOTUBE technology is a combination of SCR and overfire air technology. Since overfire air controls cannot be implemented on Unit 1, this would not be feasible on that unit, as well. Moreover, since overfire air is currently installed on Unit 2 and we have evaluated SCR controls for that unit, it is not clear that there would be any additional benefit from this control.

The Eastern Research Group prepared a report for the Clean Air Strategic Alliance on Control technologies for the Electricity Framework.² () The report noted that this technology had not been commercially demonstrated on demonstrated on large boilers. The technology was therefore excluded from the analysis. The Navajo Generating Station in Tempe, AZ conducted a BART analysis for the previous Regional Haze Rule Planning period. The ECOTUBE technology was eliminated from consideration using this same reasoning. This determination was submitted to and accepted by WRAP. This technology will not be considered further by Xcel for use on the boilers operating at Cunningham Station.

b. LoTOx;

Response: LoTOx technology is a relatively recent technology that to this point has not been widely used. While the Manufacturer, Linde, LLC, states that the technology is commercially available, no technical documentation could be found to demonstrate robust commercial use of

¹ 40 CFR 51 Appendix Y Section IV.D.1.5

² Electricity Framework 5 Year Review – Control Technologies Review, ERG No. 3689.00.001.001, Prepared for Clean Air Strategic Alliance by Eastern Research Group (2009)
<http://www.assembly.ab.ca/lao/library/egovdocs/2009/ca6/casa/173276.pdf>

the technology. Very limited information exists on this technology: this control technology was not found in the RBLC and no discussions on this control were included in AP-42, the EPA Cost Guidance Manual, Alternative Control Techniques Document, or any other government agency or third-party organization documents.

c. *natural gas reburn;*

Response: Natural gas reburning is a synonym for overfire air burning. This technique is currently implemented on Unit 2 and cannot be implemented on Unit 1, as discussed in the response to question 2, above.

d. *NO_xStarTM and NO_xStar PlusTM;*

Response: In the Electricity Framework 5 Year Review³, the NO_xStar and NO_xStar Plus technology was also reported as not being commercially demonstrated on large boilers. According to the EPA Cost Manual Section 1.2.6, the NO_x control efficiency of these units at a minimum have only been demonstrated to be 45% but the cost is high; the manual states that the cost of a NO_xStar unit is approximately \$60 to \$75 per kW. Unit 1 and 2 have rating of 82 MW and 234 MW, respectively, yielding approximate costs of \$6.15 million and \$17.55 million. While SCR units have total capital costs of \$11.11 and \$21.98 million, they provide a much higher NO_x control efficiency of 80%. Because this technology is not widely used, has not been commercially demonstrated on large boilers, and would not be cost effective, the unit is not being considered as a viable option.

e. *regenerative SCR (RSCR);*

Response: No literature was found to be available on regenerative SCRs. It is noted that SCR catalyst elements may be regenerated, but it is not clear how this differs significantly from a standard SCR.

f. *selective non-catalytic combustion*

Response: Selective non-catalytic reduction techniques have relatively poor performance compared to SCRs; AP-42 Section 1.4.4 states a NO_x control efficiency of 24%. Additionally, the unit was not identified as a control that has been implemented in the last 10 years in the RBLC. For this reason, the control was not considered.

Although the unit is somewhat cheaper than a SCR, Xcel does not believe this would demonstrate that this technology would be more cost effective. According to the EPA Air Pollution Control Technology Fact Sheet for SNCR units the cost estimates for the units would be as follows:

Costs from the "Air Pollution Control Technology Fact Sheet" for Selective Non-Catalytic Reduction	
Capital Cost (\$/MW)	\$ 25,000
O&M Cost (\$/MW)	\$ 5,000
Other Annualized Costs (\$/MW/yr)	\$ 1,000

³ Ibid.

	Unit 1	Unit 2	Notes
Boiler Rating (MW)	82	234	
Capital Cost	\$ 2,050,000	\$ 5,850,000	
O&M Cost	\$ 410,000	\$ 1,170,000	
Lifetime Annualized Costs	\$ 1,640,000	\$ 4,680,000	SNCR lifetime is assumed to be 20 years
Total Cost	\$ 4,100,000	\$ 11,700,000	Capital, O&M, and other annualized costs
Annualized TCI	\$ 343,085.25	\$ 979,048.16	Amortized over 20 years w/ 5.5% interest
Baseline Emissions (tpy)	142.50	588.90	2016 emission inventory data
Control Efficiency (%)	24%	24%	AP-42 Section 1.4.4
Tons Controlled (tpy)	34.20	141.34	Control efficiency * baseline emissions
Cost Per Ton (\$/ton)	\$10,031.73	\$6,927.10	Annualized TCI / tons controlled

Based on the above cost information, the SNCR technology is slightly less cost effective than SCR technology. Xcel does not anticipate that there are any site-specific environmental or non-air impacts from this control technology.

COST OF COMPLIANCE

1. *Please provide copies of all vendor quotes used for determining the cost of compliance and copies of electronic spreadsheets used to calculate cost effectiveness.*

Response: A vendor quote of the water injection quote is provided in Appendix A. Additional cost associated with the installation and operation of water injection were calculated using the EPA Cost Manual. SCR equipment costs are calculated using the EPA Cost Manual spreadsheets. Other installation costs associated with this unit were estimated by Xcel. Documentation of all these costs are included in an electronic spreadsheet.

2. *Provide a vendor quote to refine the cost effectiveness estimates for installation of SCR units on the boilers.*

Response: With the understanding that vendor quotes were not required to estimate equipment cost and in accordance with guidance from the NMED (as provided on the Regional Haze website), the EPA Cost Manual Spreadsheets were used to estimate the costs of SCR units for the boilers. The electronic spreadsheet is attached with the EPA cost spreadsheets included.

APPENDIX A: VENDOR DOCUMENTATION

From: [Johnson, Dan](#)
To: [Taylor, Douglas B](#)
Subject: Siemens Mature D-Frame Units
Date: Thursday, February 06, 2020 11:17:52 AM

CAUTION EXTERNAL SENDER: Stop and consider before you click links or open attachments.

Report suspicious email using the 'Report Phishing/Spam' button in Outlook.

Doug,

Siemens Energy does not provide an ULN upgrade for mature D-Frame gas turbines. The technology is only available for F-Frame and newer gas turbines.

Kind Regards,
Dan Johnson
Siemens Energy
Power Systems Sales
469-900-7841



From: [Johnson, Dan](#)
To: [Taylor, Douglas B](#)
Subject: RE: Question about power augmentation steam injection
Date: Tuesday, January 14, 2020 2:26:53 PM

CAUTION EXTERNAL SENDER: Stop and consider before you click links or open attachments.

Report suspicious email using the 'Report Phishing/Spam' button in Outlook.

Doug,

The Cheng cycle seems to be something new to the market. A few data points from their web page:

- Not possible to get a 50-90% MW increase. Shaft limit prevents it, even on a hot day. Not certain if Xcel can utilize a rate increase without NSR?
- It's doubtful that the generator would accept that power increase, either, so – new generator required = \$\$\$\$\$.
- It is doubtful that a GT will accept the “massive” amount of steam that Cheng describes without serious consideration of dynamics/flame stability. Could be more a hindrance than a benefit if just for emissions reduction.
- We do not agree with the efficiency increase promised without a HRSG driven steam turbine.
- Can't tell how much make-up water will be consumed to make the massive amounts of steam. It could be quite a bit which would get expensive.
- Even if the Cheng cycle could be economically implemented on a GT, the Isophase bus duct, GSUT or T&D in the yard would likely be the next bottleneck.

Before doing any thermodynamics, the feasibility is low. The concept is interesting, but sketchy at the same time and the website is scant on details.

Success seems more likely if used on a new unit installation so that all BOP could be sized correctly.

Siemens has not installed steam injected on D5A DLN units.

In order for to do steam injection a HRSG is necessary and site engineering and construction would be expensive. In Siemens opinion, Cunningham should look at a hot SCR.

Dan

From: Taylor, Douglas B <douglas.b.taylor@xcelenergy.com>
Sent: Monday, January 13, 2020 11:20 AM
To: Johnson, Dan (GP SPG RNA PSS MW) <danny.johnson@siemens.com>
Subject: Question about power augmentation steam injection

Dan,

Were the original Westinghouse 501 D5A units we have at Cunningham set up to do steam injection as an option? I know we did wet compression on these units, but NMED is asking questions about options to improve NOx control. I already told them that Siemens doesn't offer DLN for these units.

I saw an after market offering from Cheng Power Systems call the Cheng Cycle, which uses a small single pressure HRSG to generate steam for this, and they say they have retro-fitted a D5A with this. I'm very leery of even talking to them about this. I was thinking the F machines had a steam injection port but I thought the D5A did not. Please advise.

Thanks,
Doug

Douglas B. Taylor

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Project Manager E&C

790 South Buchanan St. 5th Floor Amarillo, Texas 79101

P: 806-378-2118 **C:** 806-676-5509 **F:** 806-378-2152

E: douglas.b.taylor@xcelenergy.com

SIEMENS

April 2, 2008

Steve Niehaus
XCEL Cunningham Station
PO Box 1650
Hobbs, NM 88240

Subject: DA02-08061 – Xcel Cunningham - W501D5A Fuel Gas Pilot Water Injection

Dear Mr.Niehaus:

Siemens Power Generation Inc. (Siemens) is pleased to provide the following information to Xcel Energy for the Fuel Gas Pilot Water Injection Modification upgrade for your Cunningham units.

This Customer Informational Letter is being provided for discussion and analysis purposes only. It is not intended to be a binding offer to sell the products described within this letter. No guarantees or warranties of any kind are provided with this information.

Fuel Gas Pilot Water Injection Upgrade Overview

Our top priority at Siemens Power Generation is to provide outstanding, responsive service solutions to help you improve your operating plant competitiveness and profitably.

As part of our ongoing commitment to meet the changing requirements of your operating assets, we offer the latest technology to help enhance your operating plant capability and flexibility. One of Siemens' modernization products is Fuel Gas Pilot Water Injection (FGPWI).

FGPWI can be used as a NOx reduction method. It accomplishes this by providing ~10 to 15 gallons per minute of de-mineralized water to the fourteen (14) fuel oil pilot nozzles through a ring manifold. The addition of water cools the pilot flame temperature, effectively reducing Thermal NOx production. The application of FGPWI could reduce NOx emissions for this plant by 3-4 ppmvd resulting in a NOx level around and below 15 ppmvd@15% O2. In addition, FGPWI could result in a slight increase in power output.

Fuel Gas Pilot Water Injection Upgrade Major Material Scope of Supply:

The reference FGPWI Upgrade for Cunningham D5A's will require some additional hardware. The following major hardware is identified below, however, a site-specific evaluation would be performed to determine final configuration prior to submittal of a firm offering.

- Fuel Gas Pilot Water Injection Skid
- Dual Fuel Pilot Nozzles
- Piping and Heat Tracing
- Miscellaneous Electrical Equipment such as breakers, local panel, etc.

Siemens Power Generation Inc.

8600 N. Royal Ln. Suite 100
Irving, TX 75063

Siemens Confidential

- Interconnect piping and remote isolation valves for the skid de-mineralized water supply and return.
- Fuel Gas Pilot Water Injection Ring Manifold around the gas turbine.

Control Integration (WDPF Systems)

The following upgrades to the control system are required for compatibility with the FGPWI Modification Upgrade:

- Control system modification for FGPWI system operation

System Interface Requirements (to be provided by Xcel Energy):

- Supply and return of de-mineralized water to the inlet of the FGPWI skid
- FGPWI skid foundation (Siemens can upon request submit scope adder)
- Water flow rate up to 14 gallons per minute
- Water supply nominal temperature of 60°F to 100°F
- Water supply pressure of 30 to 100 psig
- Water supply to be within 20 ft of pump skid

Assumptions / Caveats / Exclusions

- It is assumed the units are operating at a standard W501D5A standard per Siemens specification.
- A foundation would be required for the FGPWI Skid as part of the customer scope of supply.
 - Foundation to be located within twenty (20) feet of de-mineralized water source.
- Heat tracing and insulation outside gas turbine enclosure is not included in scope of supply.
- The pilot water injection can only be initiated above 70% load conditions and will be automatically shut off once the engine drops below 70% load.
- Fuel gas must meet Siemens specification 21T0306.
- De-mineralized water must meet Siemens specification 22T1523.
- It is assumed that the current control system is a WDPF.
- It is assumed that the current control system will have sufficient physical space and memory to support the upgrade. The control system will need to be evaluated by Siemens and if additional hardware requirements are identified, it will involve additional scope
- Any hazardous material and waste removal not in Siemens scope
- It is assumed this outage is within a current HGP or Major outage

Estimated Price

The estimated price for one (1) Fuel Gas Pilot Water Injection System Modification Upgrade, as defined in the above material scope of supply, is **\$1,575,000.00** (One million-five hundred Seventy-

Five thousand US dollars). A site-specific evaluation would be required in order to accurately determine final configuration prior to submittal of a firm quote.

Delivery & Lead Time

The total hardware delivery time for the Fuel Gas Pilot Water Injection System Modification Upgrade is estimated at 40 weeks after acceptance of a purchase order.

Upgrade requires a hot gas path outage (HGP) for installation or subject to availability to the unit and all hardware being on site, it is estimated that the outage for this upgrade will require 8 working days per unit. Estimate is based on a 1-12-6-shift arrangement (1 shift per day, 12 hours per shift, and 7 days per week) for the duration of the outage. Estimate is subject to number of craft available, productivity of craft, access to workspace, availability of materials and integration into all site work

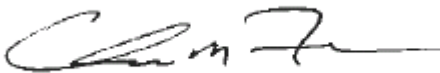
Proprietary Information

This document contains information proprietary to Siemens Power Generation Inc. Xcel Energy's acceptance of this information letter is an acknowledgment of a confidential relationship between Xcel Energy and Siemens Power Generation Inc. with respect to the information letter. Siemens Power Generation Inc. requires this letter to be returned or destroyed when no longer required. Siemens Power Generation Inc. also requires that neither this document nor any information obtained therefrom is to be reproduced, transmitted, disclosed or used otherwise in whole or in part without the written authorization of Siemens Power Generation Inc.

In order to satisfy Xcel Energy's needs, please review this letter and provide us timely feedback. We look forward to discussing the upgrade in more detail and supporting Xcel Energy in all your current and future needs.

Thank you for considering Siemens Power Generation Inc. for your needs at Xcel Energy. Please feel free to contact your local Siemens sales representative if you have any questions.

Best regards,



C. Michael Furrow
Account Manager

cc: Don Templeman – Siemens
Tony Hoffmeier – Siemens
Sandra Johnson – Siemens

APPENDIX B: HYSPLIT MODELING ANALYSIS

Xcel Energy's Cunningham Station was identified as a facility that may potentially have an impact on visibility at the Carlsbad Caverns National Park. The NMED used a Q/d analysis of all the major sources in New Mexico to make this determination, where "Q" is the facilities emission rate of NO_x and SO₂ and "d" is the distance of the facility to a national park. There are several disadvantages to evaluating facility impact in this manner. The methodology does not take into consideration the plethora of minor sources with a much closer proximity to the Class I area. Additionally, the driving factor of a facility's relative impact on a Class I area is the prevailing meteorological conditions in the region.

The Cunningham Station is located 69.3 miles away from the Carlsbad Caverns Class I area at a wind vector of 58 degrees (northeast). The wind roses reported in Figures 1 and 2 below show that the prevailing wind direction in Carlsbad are bi modal blowing mostly from the SE and NW and the wind in Hobbs, NM blow mostly from the south. The wind climatology of these locations does not favor pollutant transport from the Cunningham Station to the Carlsbad Cavern Class I area.

It is understood, however that pollutants are not transport in a straight line and that, over an extended period of time, while unlikely, it is plausible that pollutants emitted by the Cunningham Station could be transported to the Carlsbad Caverns. To evaluate this transport, HYSPLIT modeling has been employed. The results of this modeling are discussed in this Appendix.

Figure 1. 2015 Wind Rose of Wind Speed vs. Wind Direction in Carlsbad, NM.

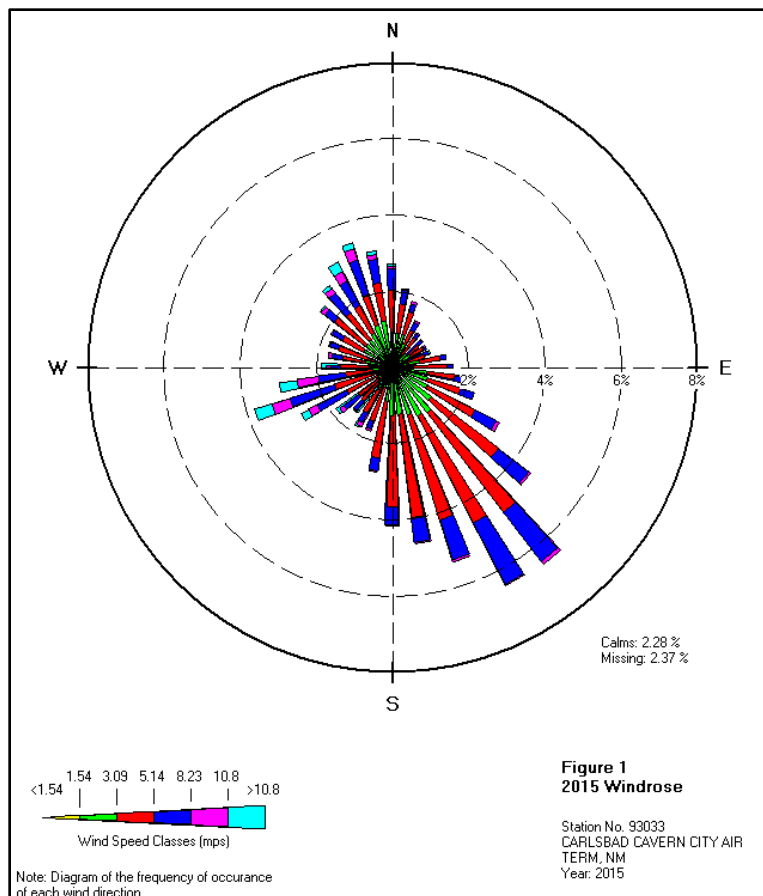
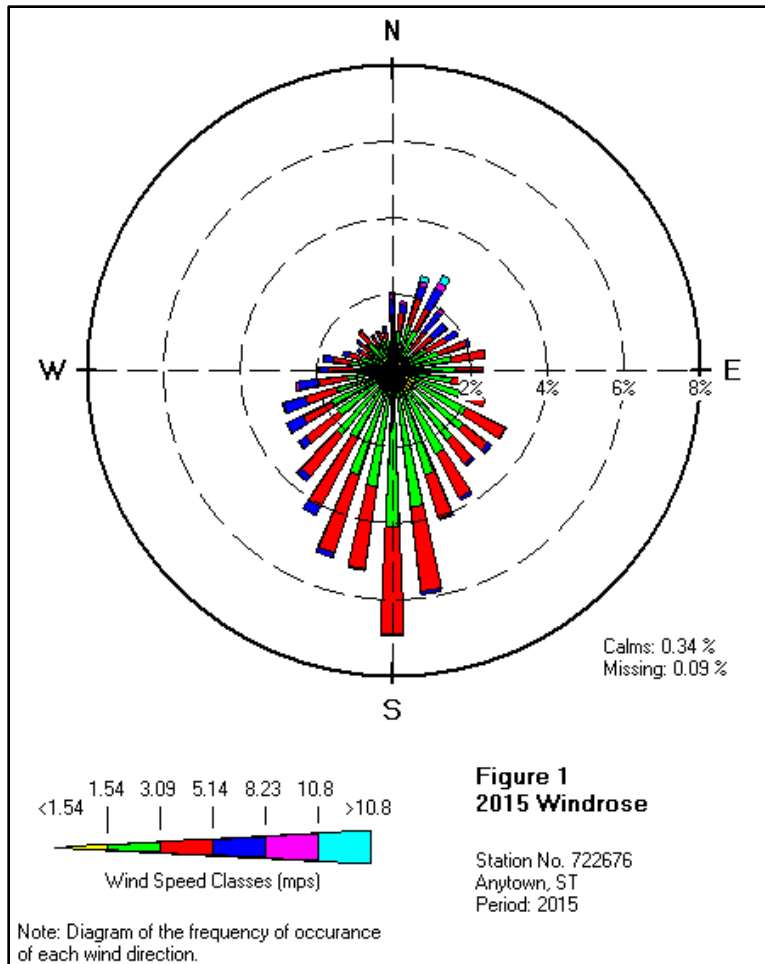


Figure 2. 2015 Wind Rose of Wind Speed vs. Wind Direction in Hobbs, NM.



HYSPLIT MODEL - OVERVIEW

HYSPLIT is a hybrid model using both the Lagrangian approach, which uses a moving frame of reference for the advection and diffusion calculations as the trajectories or air parcels move from their initial location, and the Eulerian methodology, which uses a fixed three-dimensional grid as a frame of reference to compute pollutant air concentrations. The dispersion of a hypothetical pollutant is calculated by assuming either puff or particle dispersion. The back-trajectory analysis utilized applies a particle model, where a fixed number of particles are advected about the model domain by the mean wind field and spread by a turbulent component. The model's default configuration assumes a 3-dimensional particle distribution (horizontal and vertical).

HYSPLIT MODEL - PROCEDURE

There are two HYSPLIT modeling techniques available: dispersion Modeling, which models the concentration of dispersed pollutants in a plume, or trajectory modeling which calculates the mean transport of pollution along a finite path. Using the trajectory modeling tool, back-trajectories were calculated every hour starting January 1, 2014, and ending December 31, 2018. The location modeled was the site of the Carlsbad Caverns IMPROVE monitor (32.1783°N, 104.4406°W).

There are several options available for meteorological datasets. In order to resolve topographic features and mesoscale meteorological phenomena, the 12 km NAMM meteorological dataset was used.

The following protocol was implemented:

- A five-year look-back period (2014 through 2018) was modeled;
- The model was run for each hour of each day (i.e., 24 runs per day);
- A 48 hour back-trajectory was calculated for each of the 24 runs to capture the transport of pollutants from all nearby sources to the Carlsbad Caverns National Park. The model calculated the back-trajectories in 1-hour time steps; and
- The sigma height option was used, with an initial target height of 0.5 sigma which represents half the height of the boundary layer. This height is considered to be representative of the mean ground level ambient air, since the boundary layer is well-mixed/homogenous.

Based on the availability of meteorological data, the HYSPLIT model was able to calculate back-trajectories for 43,753 hours out of 43,824 hours (99.84%). The back-trajectories were then synthesized in a single plot that displays the frequency that trajectories pass through a grid cell. A 0.1° (approximately 10 km) grid cell network was generated using the “trajfreq” executable file that NOAA has included with their suite of HYSPLIT software. For each grid cell (i,j) in the modeling domain, the frequency (F) is calculated using the following equation:

$$F_{i,j} = 100 \sum T_{i,j} / N \quad (\text{equation 1})$$

Where T is the number of trajectories that intersect a grid cell (i,j) and N is the total number of trajectories analyzed (47,353).

To generate a figure from this data, the “conplot” executable was used, which allows the user to select the contour levels, colors, map projection and output format. Figure 3 shows the frequency plot for the Carlsbad Caverns Class I area.

Figure 3. A HYSPLIT back trajectory frequency plot for 2014 to 2018 for the Carlsbad Caverns National Park.

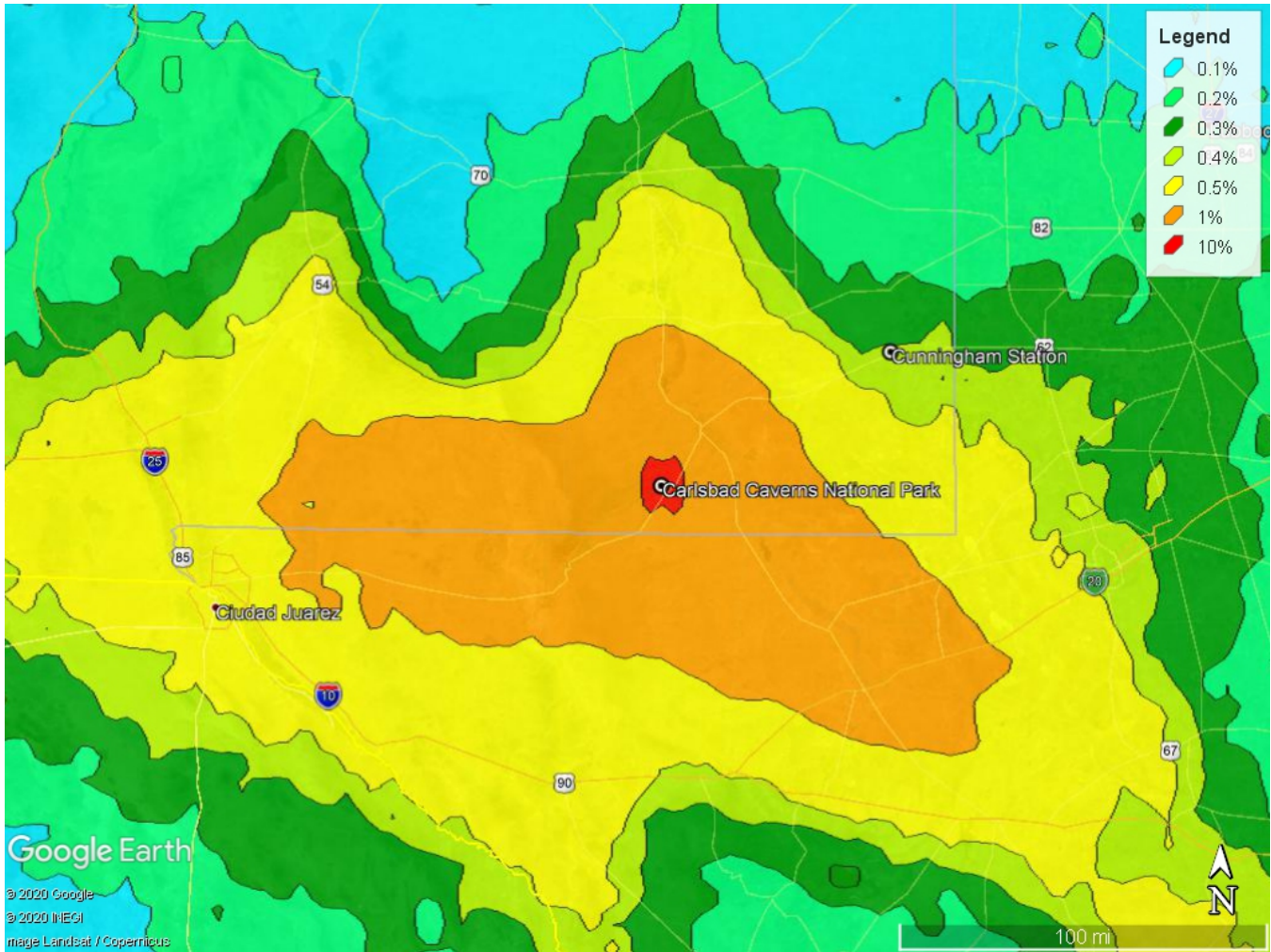


Figure 3 shows that ambient air at Cunningham Station only passes through the grid cell where the Carlsbad Caverns IMPROVE monitor is located with a frequency of approximately 0.4% or 175 hours out of the 43,753 hours that were modeled. While the costs effectiveness of controls alone would preclude the Cunningham Station from implementing any control technologies, this modeling demonstrates that such modifications would not have an impact on visibility at the Carlsbad Caverns.

APPENDIX C: GOOD COMBUSTION PRACTICES MANUAL

Cunningham Station
13 miles west of Hobbs on Carlsbad Hwy
Hobbs, NM 88240

Xcel Energy - SPS

Cunningham Station

Good Combustion Practices Manual

Steam Turbines 1 & 2

Combustion Turbines 3 & 4

Revision 4

Cunningham Generating Station

Good Combustion Practices Handbook

Revision History

<u>Rev #</u>	<u>Date Issued</u>	<u>Reason for revision</u>	<u>Pages</u>
0	4 / 30 / 2011	Internal Review and approval	All
1	5 / 1 / 2012	Incorporation of steam units	All
2	10 / 22 / 2013	Clarification	11, 12, 16
3	12 / 15 / 2014	Revise OEM Maintenance guide to reflect upgrade on unit 4 hardware components	Appendix A
4	12 / 20 / 2018	Revision to applicable OEM Maintenance guide and miscellaneous updates	Appendix A

Rev #	Title	Effective Date	Written by
4	Table of Contents	12/20/2018	<i>Steven Nichols</i>

Cunningham Generating Station

Good Combustion Practices Handbook

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 - 2.2. Emissions Minimization Plan
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 - 3.2. Good Combustion Practices
 - 3.2.1. Stable Operations
 - 3.2.2. Fuel / Air Ratio
 - 3.2.3. Combustion Hardware Maintenance
 - 3.2.4. Start-up and Shutdown

Appendices

- A. Siemens Combustion Turbine Maintenance Schedule
- B. Combustion Turbine Emissions Tuning Reports (sample)
- C. Combustion Turbine Unit Operating Hours and Start Summary (sample)
- D. Combustion Turbine Maintenance Deviation Records
- E. Combustion Turbine Operator Log Sheet

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Cunningham Generating Station

Good Combustion Practices Handbook

1.0 General Plant Information

The Cunningham generating Station consists of four medium sized electrical generating units. Two of these units have turbines powered by steam produced by natural gas fired boilers. The other two units are driven by direct combustion fired turbines. The two steam powered units are classified as load following units. That is they are usually connected to the Xcel Energy transmission system all of the time, but their output varies according to energy demand on the system. Therefore, these units seldom start, but run the vast majority of the time. The two combustion turbine driven units are classified as peaking units. That means they are started and run only when electrical demand is high. Therefore these two units see a lot of start-up and shut down cycles, but relatively few operating hours.

The complex nature of this facility, with its variety of different types of generating units requires several highly skilled people to properly operate this equipment at all times. These employees rigorously train for years to be able to operate this plant in a safe and environmentally aware manner. A significant portion of that training is devoted to environmental issues, including the awareness of permitted emissions and how their actions directly impact the results.

This plant is located in southeastern New Mexico, approximately 12 miles west of the city of Hobbs. Cooling water for the steam turbines is obtained from a series of deep water wells. This water is in continuous use, except for what is lost due to evaporation or blow down. Blow down is the process in which a portion of the water is sent to a holding pond and replaced with fresh water to help maintain the proper water chemistry. The water in this holding pond is then used by a local farmer for irrigation so that maximum utilization of every drop is achieved.

2.0 Steam Turbine Units 1 & 2

2.1 General Information

Unit # 1

Unit #1 at Cunningham consists of a natural circulation boiler designed and built by Combustion Engineering and is capable of providing up to 625,000 pounds per hour of superheated steam to the turbine generator. This steam is routed through pipes and

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4	Steam Turbines	12/20/2018	<i>Steven Nichols</i>

Cunningham Generating Station

Good Combustion Practices Handbook

Steam Turbine Units 1 & 2

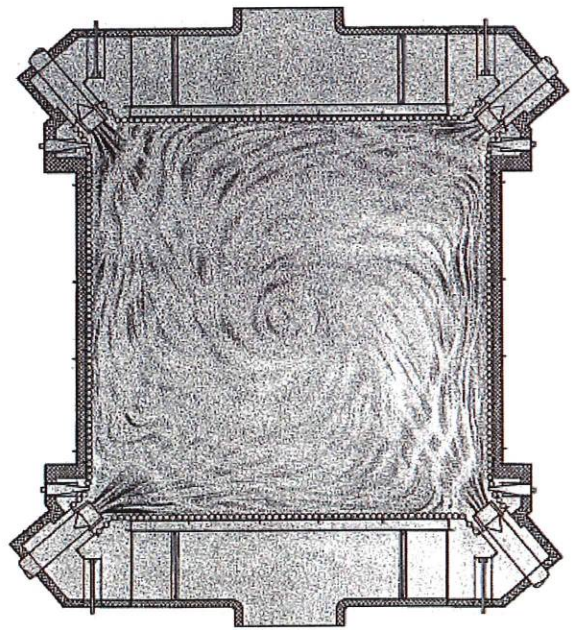
control valves to a General electric steam turbine. This steam passes through the turbine, causing it to rotate. This mechanical rotation is in turn converted to electrical energy by the directly connected generator.

Unit # 2

Unit #2 at Cunningham consists of a natural circulation boiler designed and built by Combustion Engineering and is capable of providing up to 1,400,000 pounds per hour of superheated steam to the turbine generator. This steam is routed through pipes and control valves to a General electric steam turbine. This steam passes through the turbine, causing it to rotate. This mechanical rotation is in turn converted to electrical energy by the directly connected generator. The primary differences in the two boilers, besides their physical size, are that unit 2 reheats the steam from the turbine to provide.

Boilers

Both boilers are natural circulation, tangential fired boilers. The natural circulation refers to the fact that the water circulates through the boiler based on the difference in density of the water, with cold water sinking down to the bottom of the boiler where it is heated and rises. Tangential firing refers to the fact that the burners are located in the corners of the boiler and are aimed in a circular pattern similar to that shown to the right. The boilers convert water into steam by burning natural gas. The automated control system is designed to maintain the proper air flow for good combustion at all times. In addition the operator is trained to monitor the combustion process by keeping an eye on the air flow, as well as by monitoring the flame itself by use of a high temperature video camera. If something should happen to the automatic control functions, the plant operator is fully capable of manually controlling the fuel air ratio for proper combustion.



PLAN VIEW
TANGENTIALLY FIRED FURNACE

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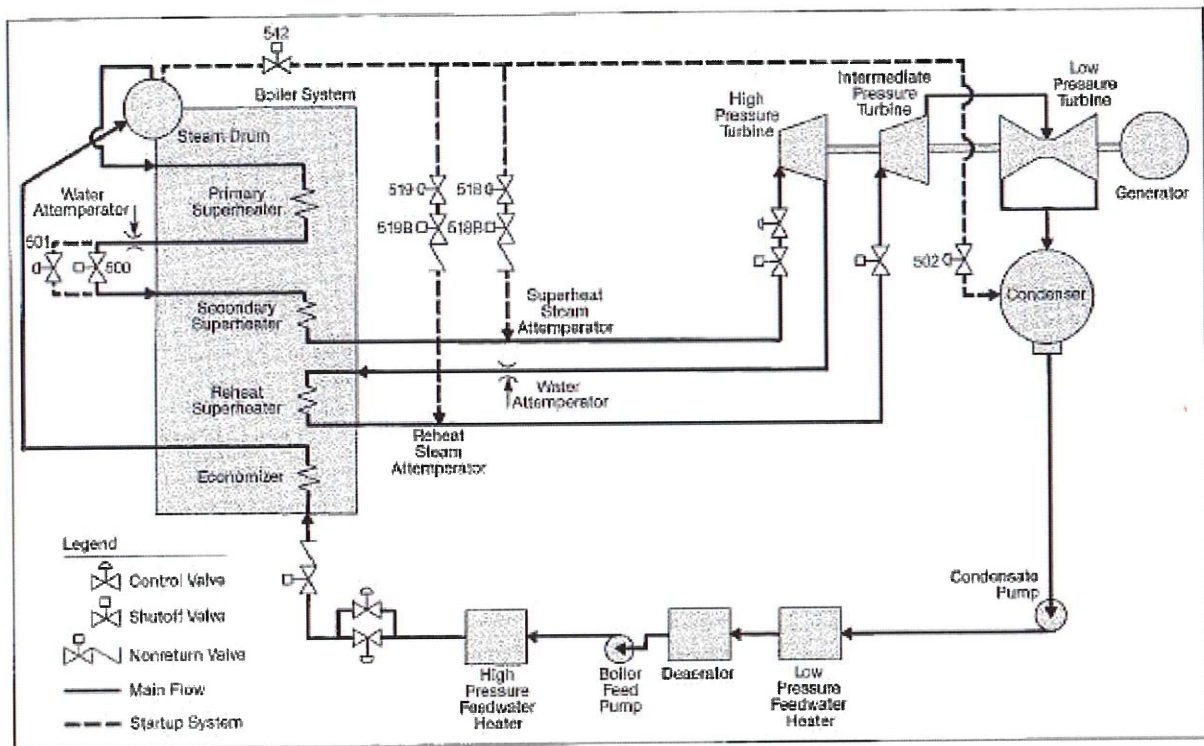
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Steam Turbine Units 1 & 2

In addition, there are a number of both audible and visual alarms that will alert the operator to any abnormal condition that may need to be addressed

A typical diagram of a steam turbine driven generator is shown on the next page. It should be noted that this is a standard depiction and does not represent the actual cycle on either of the Cunningham units. It does however come closest to depicting unit 2 which does have a reheat style turbine, whereas unit 1 does not.



2.2 Emissions Minimization Plan

Generally, emissions during the startup of units 1 and 2 are achieved without having an exceedance. The CEMs required under 40 CFR 75 (Acid Rain CEMs) confirms this. On those occasions when the applicable standards have been exceeded at facilities, this information is reported to NMED. Shutdowns are usually not problematic. If a malfunction were to occur resulting in exceedance of permitted emission limits, operators would attempt to minimize emissions by the following methods:

- ◆ Control the fan speed to ensure that excess air volumes are correct for optimum combustion

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Steam Turbine Units 1 & 2

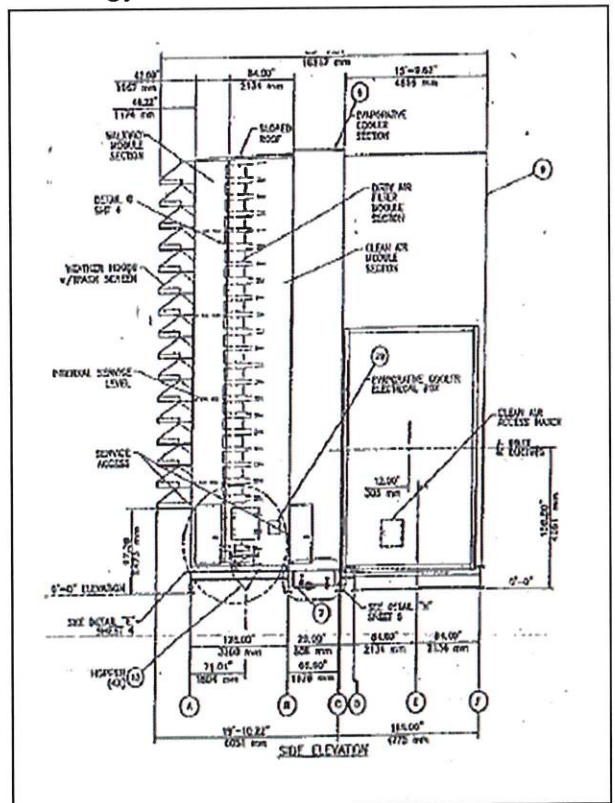
- ◆ Control the unit load (usually by decreasing it) to ensure that good combustion practices are being followed.
- ◆ Controlling the “ramp rate”, which is the speed at which the boiler changes load as it increases during startup or decreases during shutdown. Slowing down the ramp rate allows more time for the boiler to normalize at load points before moving on to the next load in the sequence.
- ◆ Control the fuel flow to ensure that the flame properties and fireball temperatures are optimized.

3.0 Combustion Turbine Units 3 & 4

3.1 Combustion Turbine General Information

In order to meet the growing electrical demand in southwestern New Mexico, Southwestern Public Service Company was granted permission to build 2 new 100 MW (nominal capacity) combustion turbines. These turbines were purchased and installed with the latest state of the art combustion technology. In order to obtain maximum performance from these new units, they were also purchased with evaporative coolers, and a power augmentation system known as wet compression.

The evaporative cooler system is installed in an integrated enclosure along with the inlet air filtration system. The inlet air filter is designed to remove fine solid particulate from the air. These particles can be removed from the filters by a puffer system. The puffer system works by blowing compressed air from the back side of the filter, thus blowing off any accumulated air borne particles. The evaporative cooler system consists of two pumps that take purified water from a collection trough at the bottom of the filter house. The pumps discharge this water into a series of headers



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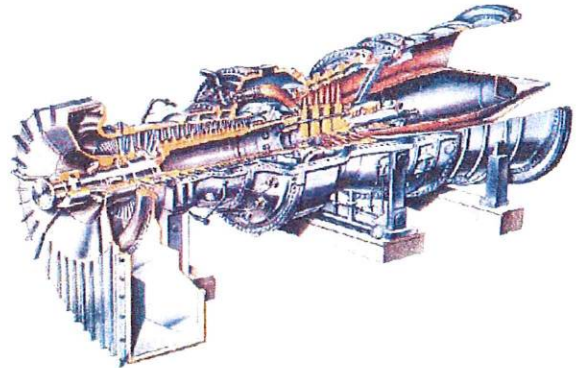
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Combustion Turbine Units 3 & 4

that allows the water to cascade over a special water resistant media in fine droplets. This media is similar in appearance to the corrugated cardboard used to make boxes. The air going to the turbine passes through this media, and absorbs the fine water droplets. This decreases the air temperature to the wet bulb temperature. This lower air temperature allows the compressor section of the turbine to be more efficient, causing an increase in the amount of power that can be generated.

The power augmentation system consists of a pump that supplies medium pressure water to a series of fine spray nozzles. These nozzles are located past the evaporative cooler and before the inlet to the turbine. The spray nozzles are intended to create a fine mist, similar to naturally occurring fog. This mist is sucked into the turbine by the compressor, and as it flows downstream is vaporized by the increasing air temperature. This vaporization of water inside the compresses greatly increases the mass flow through the turbine, resulting in a significant power output. Due to the natural cooling effect incurred in the compressor inlet, neither wet compression, nor evaporative cooling can be used at ambient temperatures below 60 degrees Fahrenheit.

The turbine itself consists of an eighteen stage compressor, which takes ambient air and compresses it to approximately 200 psig and 750 degrees Fahrenheit. This air is used both for combustion and for turbine cooling. The compressor is mated to a four stage turbine. The turbine uses the expansion of the compressed air along with the combusted fuel to drive an electric generator.



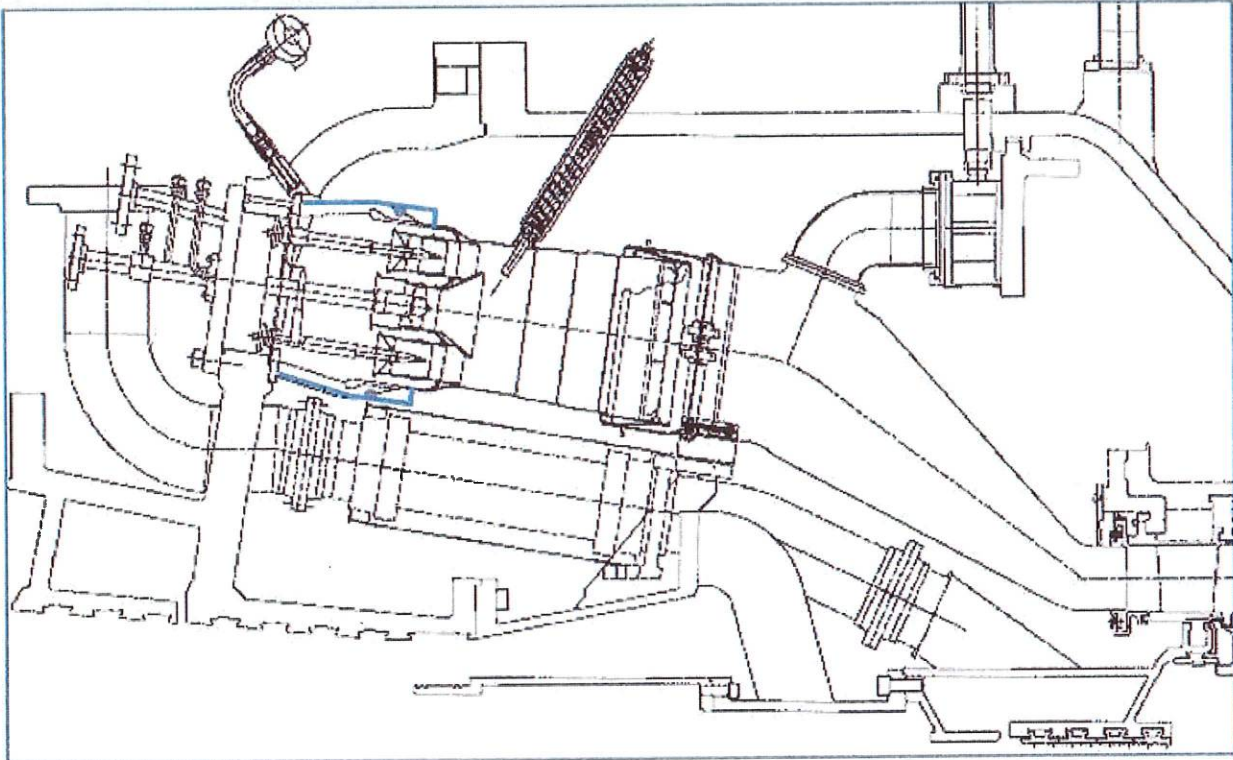
The turbine is equipped with the latest state of the art combustion technology for this type of engine. It has what the manufacture calls a type K (4 stage) combustion system in the diagram on the next page.

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Combustion Turbine Units 3 & 4



This combustor consists of a multi stage burner configuration for fuel control and both variable inlet guide vanes and combustor bypass valves for air flow control. Combustion temperatures are limited to design values by both blade path temperature control and exhaust temperature control. Individual combustor performance is monitored by the blade path temperature spread. This spread is monitored both by the turbine control system and the unit operator to ensure a healthy combustor

The variable inlet guide vanes are a modulating air flow control vane. The position of these vanes vary with unit load, and are automatically adjusted by the turbine control system. The actual desired position of these vanes is determined during emissions tuning, and is adjusted at that time. These vanes are controlled by a hydraulically operated ram. To help ensure proper positioning of these vanes, position is continuously monitored by redundant control devices.

The combustor bypass valve is normally closed, or close to it, during normal steady state operation. This valve is used to bypass some air around the combustor during start-up and shutdown and other upset conditions to ensure the fuel air ratio is

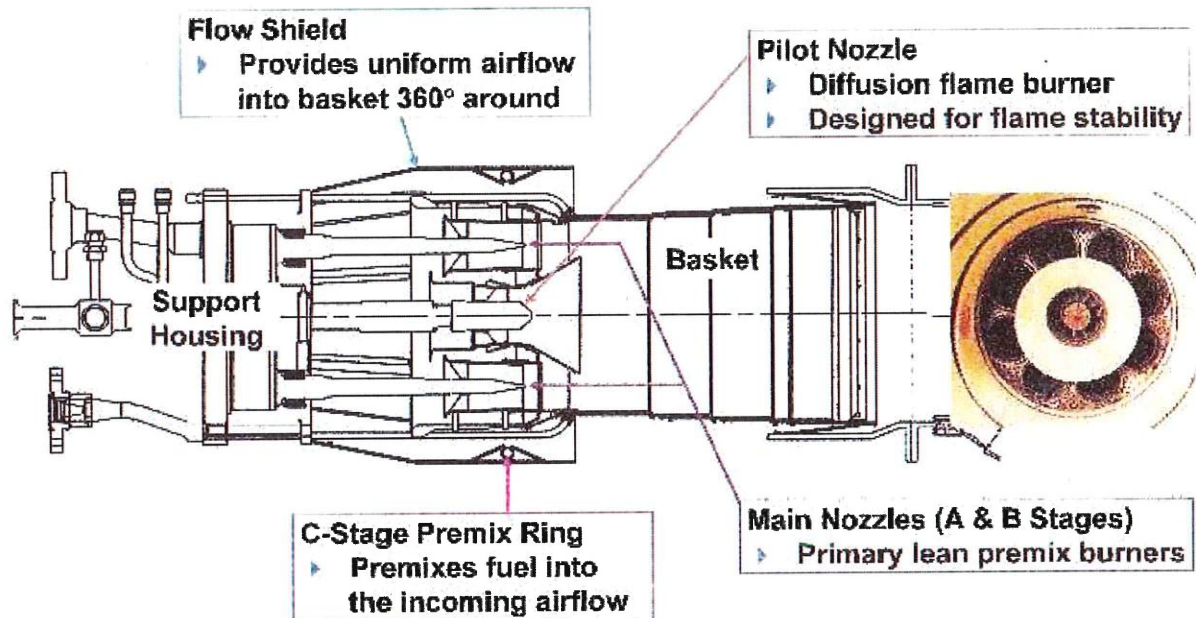
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high enough to sustain the upset condition. The further open this valve is, the more air is bypassed around the combustor, making a richer fuel / air ratio.



The burner itself is a four stage burner. Three of the four stages are lean premixed style burners, in which air is mixed with the fuel prior to its being combusted. A detailed view of the burner is shown below. A description of how the various stages interact and when they come into play is contained in the start-up and shutdown section of this plan.

The Pilot Nozzle is designed for flame stability. It uses a rich fuel-air ratio to provide stable ignition to lean pre-mix burners (stages A & B). After start up, the fuel to the pilot nozzles is reduced, reducing NOx formation. Pilot nozzles have swirler blades to mix combustion air before the fuel is added at the pilot burner tip.

The A&B stages are the primary fuel stages and are designed as lean premix burners. Fuel injection is regulated to match combustion air supply for uniform and lean fuel/air mix. The combustion air is premixed with swirlers around each burner tip for

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uniform, very lean, fuel air mix before reaching the pilot flame ignition source. During normal operation these burners consume roughly 85% of the total fuel.

The Stage C fuel is injected into the flow shield located around perimeter of the burner basket. Combustion air is forced through the annular (pre-mix) ring past stage C nozzles, which pre-mixes fuel/air giving a lean mix below flammability limits. The premixed fuel & air is admitted through holes in the combustor housing behind nozzles and swirlers, then proceeds through burners and a transition piece into the first row of the turbine.

All four stages of fuel nozzles must be periodically removed, cleaned, inspected, and returned to their original condition periodically. The schedule for this maintenance is dictated by the component design, and is based on either hours of operation or number of starts, depending on how the unit is operated. The turbines at Cunningham perform this routine maintenance based on the number of equivalent starts. Additional details are contained in the Siemens maintenance guide (Appendix A)

The following photos are typical of the combustion hardware actually installed at Cunningham, and is shown in a “like new” condition. These photos are included to show what the actual parts look like to help develop a better understanding of their function.



A freshly restored basket

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A restored transition shown, with the combustor bypass valve connection



A combustor bypass valve shown as full open during a routine inspection of the combustion hardware.



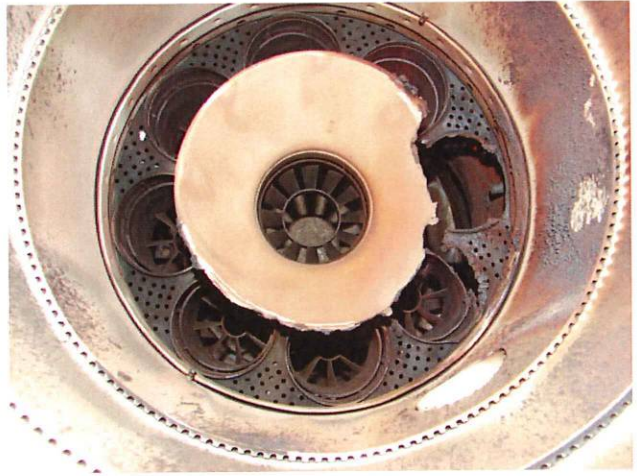
The next few photos represent hardware that is in need of maintenance. It should be noted that the photos are relatively typical of normal wear and tear.

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A combustor basket damaged from a broken "C" stage fuel line



Fuel nozzles showing the pilot nozzle (center) and the A and B stage nozzles



Typical fuel nozzle wear (pilot nozzle at center)



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3.2 Good Combustion Practices

Good combustion practices are an essential part of gas turbine operations. Everything from parts life to power output is dependent upon a healthy combustion process. The turbine control system is designed to continuously monitor and correct minor combustion instabilities. One particularly useful indicator of good combustion health is the blade path temperature spread. This is the temperature difference between the hottest and coldest places in the turbine exhaust. Improper combustion will show up as either a higher or lower temperature depending on what is wrong with the process. For example, a partially blocked fuel nozzle will manifest itself with a lower temperature output. Therefore, if blade path temperature monitoring were to indicate a low temperature, it may be an indication of a blocked fuel nozzle. However, a detailed technical evaluation must be immediately conducted to evaluate what is actually causing the temperature deviation.

In addition to emissions related issues from improper combustion, poor combustion will have a direct impact on turbine hot gas components. For example, operating with a blocked or partially blocked fuel nozzle can adversely affect the temperature profile through a transition, leading to high temperature spots both within the transition and the row one vanes causing premature failure. Thermal stresses on the turbine blades are also of extremely detrimental affect, causing the turbine blade to be continuously subjected to high temperature deviations.

The other critical parameter to proper combustion is the maintenance of a correct fuel to air ratio. Combustion can actually occur over a fairly wide range of fuel air ratios, and as such has little impact on the turbine operation itself, other than in limiting power output by not having correct air flows. However, even a very minor fluctuation in fuel air ratios can cause a significant emissions change due to the extremely sensitive nature of the dry low NOx combustion process. Consequently that is also a critical parameter to be monitored.

The turbine control system actually does an excellent job in monitoring and controlling these parameters. In fact in early 2011 the Cunningham combustion turbines were upgraded to be able to continuously tune fuel parameters to minimize NOx. Following this retrofit, the fuel supply values will be continuously optimized for NOx limitations, as shown in the control diagram on the following page. However, computers, no matter how sophisticated they may be, can only be one aspect of an overall good

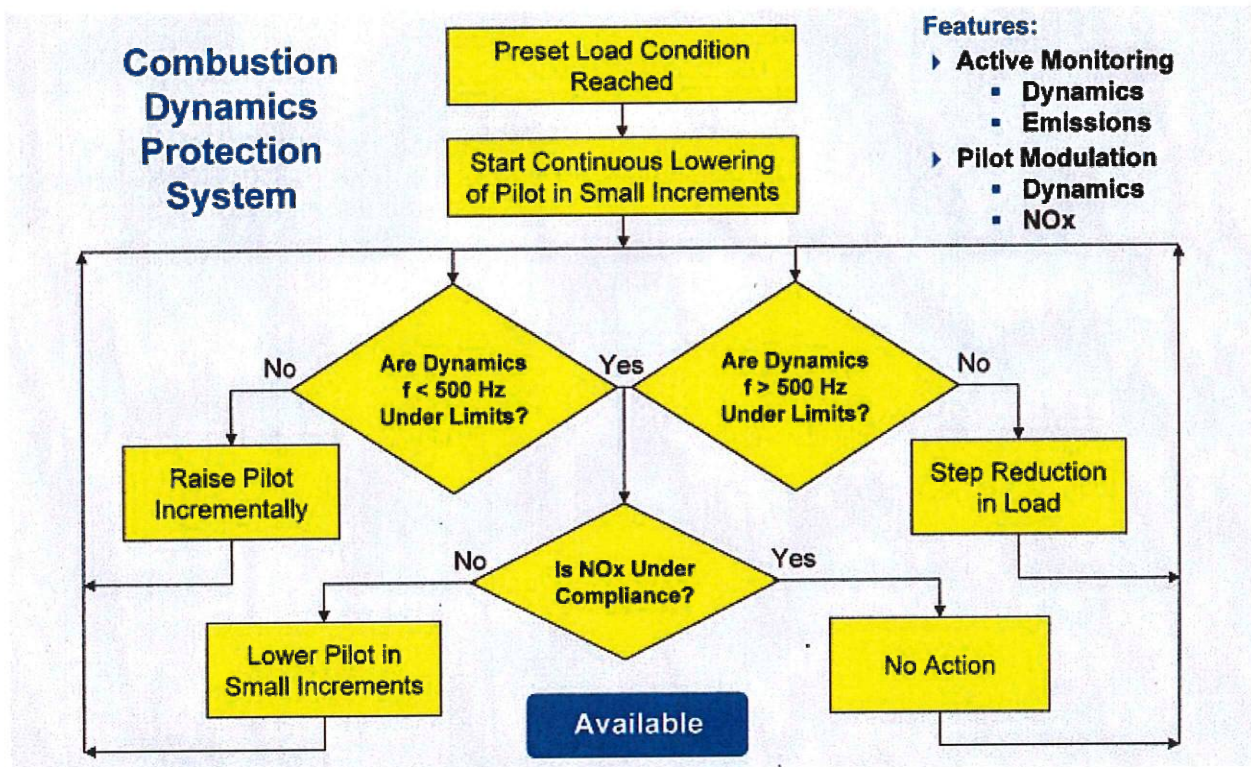
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combustion practice scheme. The actual key component is the human operator who is continuously monitoring the computer and cross checking to ensure that everything functions as it should

Mature W Frame Combustion Systems CDPS General Flow Diagram



3.2.1 Stable Operations

Within the context of this plan stable operation is defined as all turbine operating time that is not a portion of either a start-up or shutdown sequence. It has no correlation to the actual stability of turbine operation, but is intended to capture both normal and power augmentation modes of operation.

Good combustion practices on a combustion turbine consist of (1) maintaining a proper air fuel ratio, and (2) maintaining the combustion hardware in proper working condition. These functions are continuously measured and adjusted by the control computer, and their values are monitored by the operators.

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3.2.2 Fuel / Air Ratio

Maintaining the proper fuel air ratio is essential to controlling combustion. The operator's primary indication of good combustion and proper fuel / air ratio is indicated by the unit's NOx emissions which are continuously monitored. In addition the following parameters can also indicate proper air and fuel flow

Inlet Guide Vane Position

In a combustion turbine, the air to fuel ratio is controlled by the inlet guide vanes. The further open the inlet guide vanes are, the more air is passed through the turbine and made available to the burners. Consequently, proper positioning of the inlet guide vanes is essential for proper combustion. The actual positioning of the guide vanes is controlled by the master computer running the unit, and is proportional to the amount of power being produced (and to fuel consumed). While the operator has no direct control over this value, he is expected to monitor it and ensure it is positioned properly for good combustion.

Combustor Bypass Valve Position

While the inlet guide vanes provide coarse control to the total amount of air available, the actual fuel air ratio is adjusted by the combustor bypass valve. This valve actually takes some of the air away from the burner, making the fuel air ratio richer (less air for a given amount of fuel). The operation of this valve is again controlled by the master computer, with no input available from the operator other than to ensure that it is operating as intended. This operation is adjusted during emissions tuning to ensure good combustion.

Combustor Shell Pressure

Just as important as the amount of air available for combustion, is that the air must be of high enough pressure to flow as designed. Monitoring of the combustor shell pressure is essential to ensure adequate air pressure. While this is not an operator-controllable parameter, malfunctions such as improperly functioning compressor bleed valves that can reduce this pressure below acceptable limits for proper combustion.

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Therefore ensuring adequate pressure in the combustor case is essential to good combustion.

3.2.3 Combustor Hardware Maintenance

Maintaining the proper air fuel ratio is the best overall control of combustion; however, proper rates of flow don't mean anything if the burners themselves are in poor condition.

Periodic Maintenance

The combustion hardware needs to be periodically removed, inspected and cleaned or restored to maintain it in proper operating condition. Since the unit will not be available for generating electricity for extended periods lasting from several days to several weeks during these periods of maintenance, they must be planned and scheduled well in advance. Siemens, the original equipment manufacturer, has a recommended maintenance interval that should be followed. This recommendation is used in conjunction with projected unit operation to plan for and schedule outages to perform this maintenance.

Condition Based Maintenance

In addition to regular planned maintenance intervals, equipment condition may dictate that off schedule maintenance be performed. An excellent indicator of combustion health is blade path temperature spread_(BPTS). It is used to indicate proper burner functioning. In an ideally functioning combustion turbine, each burner operates identically, receiving equal amounts of air and fuel. In the real world, manufacturing and repair tolerances are such that each burner is not identical. Consequently there are minor deviations in how each burner actually performs. BPTS is the prime indicator of how well each burner is performing. For example, if a fuel nozzle were to become either partially clogged with debris, or to be damaged in some fashion, the performance of that burner would be changed. It could potentially be emitting greater CO than normal because its fuel air ratio is not what it should be, even though all of the other burners are operating correctly. This will be manifested in the BPT, by one burner operating at a higher (or lower) temperature than the others. Monitoring the blade path spread temperature is essential to ensuring proper combustion. Once again

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this value is not controllable, but if it exceeds a predetermined value, it is indicative that an in depth evaluation of the problem must be performed and a course of corrective action be determined. That determination may dictate that maintenance needs to be performed on the combustion hardware to restore proper function.

3.2.4 Startup and Shutdown

Startup Sequence

The startup of the combustion turbine is under control of an automatic sequencing system, and cannot be affected by the plant operators, except for a few specific hold conditions that can be initiated. Specific setpoints and adjustments are made when initially setting up the turbine, and whenever tuning or other adjustments are required, such as after replacement of a piece of equipment. Major systems that are subject to tuning and variables are the turbine inlet guide vanes, combustor bypass valves, and fuel control proportioning and pressures (pilot, stage "A", stage "B", and stage "C").

The following description of major events in the sequence are provided for informational purposes only, and cannot be affected by the operator.

The starting motor is energized, and begins to accelerate the turbine from turning gear speed (about 3 rpm). The inlet guide vanes are opened to the specified start value (19 degrees). The turbine must reach 225 rpm within a minute or an alarm is generated and the start is aborted. The turbine reaches ignition speed, 600 rpm, about 90 seconds later. If it does not reach 600 rpm within 2 minutes, an alarm is set and the start is aborted.

At this point, once light-off speed is achieved, ignition is permitted. The two igniters are turned on and the gas fuel valves are opened. However, at this time, the main fuel pressure regulators are kept closed and the start pressure regulator limits fuel pressure to 200 psig. The pilot throttle valve and the stage "A" throttle valve both step open to a preset ignition position. If a flame is not detected in all 14 burners, using the blade path thermocouples, the unit will trip. A successful ignition attempt requires less than 15 seconds. Immediately after a flame is established, the fuel ramp begins, at a

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programmed rate versus time. The unit begins to accelerate with the help of the starting motor. The speed should increase to 1600 rpm within 2.5 minutes or an alarm is generated and the start is aborted.

Beginning at 1600 rpm, the speed control takes over, and continues to ramp fuel based on a speed versus time curve. When the speed reaches approximately 2300 rpm, the starting motor is de-energized and disengaged. The turbine is then self sustaining to synchronous speed.

At approximately 3275 rpm the inlet guide vanes are repositioned. Shortly thereafter, the high pressure compressor bleed valve closes, followed by closing the low pressure bleed valve and the field breaker is closed. The main fuel pressure control valve is slowly opened, which will increase the fuel gas pressure upstream of the throttle valves to line (maximum) pressure. Speed control continues to increase speed to 100 percent speed, at which time the unit is ready to be synchronized. (At this point, there is still no load on the generator.)

From startup to 3600 rpm, the gas stage "B" is off, and the gas pilot fuel is 55% of the total fuel signal, and stage "A" is 45%. When the generator breaker is closed, the flow fractions are a function of Nominal load (determined by dividing Actual Load by the theoretical Base Load at the measured inlet temperature). Gas stage "B" burners are placed in service when nominal load is greater than 50% and extinguished when it falls below 45%. Stage "C" fuel valve opens with the "B" valve, and provides the "lean premix" portion of the total fuel mix by mixing fuel into the incoming combustion air outside the combustor baskets. This promotes lower NO_x emissions by providing a more uniform fuel mixture and promoting lower peak flame temperatures. As the actual load increases above 70% of nominal load, the Pilot Fraction is reduced for better NO_x control. During unloading, the Pilot Fraction is increased to provide better flame stability.

The control system is programmed to take 20 minutes from the time a start is initiated until the turbine reaches full speed of 3600rpm. It is assumed to take 30 seconds to synchronize to the electrical grid, and then the unit is loaded to base load conditions over the next several minutes. Synchronization can take slightly more or less time, depending on actual grid conditions at the time synchronization is attempted. The initial 20 minute ramp rate is dictated by Siemens Technical Advisory # 2000-016 rev 1. This advisory was issued to increase start-up times to reduce the risk of compressor

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disc migration on start-up. The operator may over ride the automatic load curve and set a faster or slower rate, but this practice is limited to abnormal conditions. Start-up ramp rates are calculated to minimize turbine stresses and to minimize the time before DLN control is active at 70% nominal load.

The automatic synchronizer raises and lowers the generator speed to match the system speed (frequency) and voltage. When the match is within tolerance, the system breaker is closed, and an increment (minimum load) is picked up. The system will then begin to ramp load up from this minimum. The load will continue to increase until the operator selected load is reached, or until temperature control becomes active and limits unit load. Base load is deemed to have been achieved when temperature control becomes active. Temperature control is used to limit load generated by the unit to ensure that maximum allowable temperatures are not exceeded that would lead to premature component failure. Temperature control actually consists of measuring both the blade path temperature (which is the actual temperature the last set of turbine blades is exposed to) and the actual exhaust gas temperature. Both temperatures have their own limit, and either one reaching that limit will cause the unit to go from load (megawatt) control to temperature control (base load). The dry low NOx burners are capable of meeting low NOx conditions at and above 70% of base load, and the combustion turbine is therefore never operated at lower loads except in startup or shutdown mode, or when a malfunction known as a runback occurs, in which the unit control system detects a problem and reduces load to a value where the problem is no longer evident.

Weather permitting (temperature above 60 degrees Fahrenheit) the evaporative cooler will start automatically at 60% nominal load. The evaporative cooler can be shutdown at any time. Power augmentation can be activated whenever the turbine is running at or above 90% of base load as calculated for the current operating conditions, with compressor inlet temperatures at or above 60 degrees F. Startup of the evaporative cooler can be manually initiated any time above 50% load if weather conditions have changed. The change in inlet air temperature and humidity from the evaporative cooler operation can cause the delicate balance of fuel/air in the low NOx burners to be upset, and generally results in a short term excursion in emissions. Initiating evaporative cooler operation is generally considered as part of the unit start-up process, due to the control system upsets that occur, and the physical changes underway to the ambient air conditions entering the turbine. Initiation of power

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augmentation introduces similar variables, but is generally considered to be a part of stable operations.

The turbine control system provides for fully automatic start and load to maximum or a preset load condition. It also provides for holding the unit at key events in the sequence and for operation at partial loads as desired.

Shutdown Sequence

When the CT opens its generator breaker during a normal stop, it continues to run at synchronous speed for 3 minutes (cooldown period) prior to shutdown. The CT will remain running until any trip occurs or a normal stop is requested by the operator. Normally, the load on the generator is reduced slowly prior to shutdown in order to minimize mechanical stresses due to rapid temperature changes, to minimize upsets of the interconnected electrical grid, and allow for other interconnected generating stations to match the load. Once at minimum load, the stop signal can be given, disconnecting the unit from the electrical grid, and starting a three minute cooldown period, after which the gas supply is shut off, and the turbine coasts to a stop. The ramp rate can be varied by the operator and can range from zero to over 6 megawatts per minute, depending on instructions from the area control center and other available system generator resources. The standard rate is to ramp down at a rate of 3 to 4 megawatts per minute.

Runback Condition

A number of factors not associated with good combustion are indicative of other operating problems with the turbine. The turbine control system upon sensing one of these conditions, will initiate a turbine runback. What that means is that power output will be reduced until the condition is alleviated. That may cause the unit to run below 70% nominal load where the DLN burners are functioning correctly. While the condition is not directly related to poor combustion, it can cause poor combustion to occur, or at least inhibit the low NOx features of the DLN burner equipment from functioning as designed

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Appendices

The information in the following appendices is intended to serve as an example only. Current information on these topics are readily available at the plant site, and are deliberately kept separate from this document.

Appendix A

Siemens Combustion Turbine Maintenance Guide

The Siemens service bulletins that detail the recommended maintenance schedule and other activities is a confidential document. As such it may not be included in this plan, but is incorporated by reference. Hard copies are readily available for review by anyone needing to reference those documents. Copies of these documents will be distributed with this revised plan.

Unit 3

Unit 3 has been upgraded to extended interval (16,000 hour) hardware. This makes the hardware identical to that installed in unit 4 a few years ago. As such Siemens' Service Bulletin # 54009 is the controlling document for the maintenance of this hardware and the methodology of determining the number of equivalent starts.

Unit 4

Unit 4 underwent a major inspection beginning in 2013 and ending in 2014. This was a routine inspection required under the applicable service bulletin. As part of the outage, the standard hardware was replaced by extended outage interval hardware. This is new design hardware from Siemens that was specifically designed and manufactured for the purpose of extending the time between outages. Consequently, the old service bulletin (#36803) is no longer valid for this unit. Instead the appropriate service bulletin is now Siemens' Service Bulletin #54009. A copy of the notification of change in service bulletins is included in this appendix for reference purposes.



April 26, 2017

Mr. Bruce Gomm
Xcel Energy

Re: Cunningham 3 Service Bulletin SB54009

Ref: Purchase Order M814947 Dated June 20, 2016

Dear Mr. Gomm,

Siemens Energy, Inc. ("Siemens") submits this letter to Xcel Energy ("Xcel") to document that as part of the recent outage at Cunningham 3, the unit was upgraded Siemens Service Bulletin 54009 Intervals. This upgrade included installation of extended interval combustion hardware and upgraded counter control logic.

Siemens appreciates your business. Please contact your local District Service Office if you have a warranty claim or have any other questions regarding this submittal.

Sincerely,

Austin Cunningham
Sales Account Representative
972-550-2111 (office)
713-294-3762 (cell)

CC:
Steven Niehaus – Xcel Energy
Don Templeman – Siemens
Chris Jonas – Siemens
Gustavo Gamboa – Siemens
Kyle Longville – Siemens
Rebecca Eyer – Siemens

Siemens Energy, Inc.

4400 Alafaya Trail
Orlando, FL 32826-2399

SIEMENS

Siemens Energy, Inc.
A Siemens Company
4400 Alafaya Trail
Orlando, FL 32826

December 09, 2014

Steven Niehaus
Highway 180, 13 miles West of Hobbs
Hobbs, NM 88240
FAX:

SUBJECT: Authorization to use SB-54009 for Cunningham Unit 4

Dear Mr. Niehaus,

This letter acknowledges with the completion of the Fall 2013 outage on Unit 4, Xcel Energy is authorized to use Service Bulletin 54009 for its maintenance and inspection intervals.

If you should have any questions or require further assistance, please do not hesitate to call.

Sincerely,

Chris Jonas for Don Templeman
281-460-6582

SERVICE BULLETIN 54009

Gas Turbine Maintenance and Inspection Interval Extension for W501D5, W501D5A and SGT6-3000E Units with Upgraded Product

Rev. No: 1	Rev. Date: June 02, 2008	Created: February 22, 2006
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Notice to Service Bulletin Users

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SERVICE BULLETIN 54009

Gas Turbine Maintenance and Inspection Interval Extension for W501D5, W501D5A and SGT6-3000E Units with Upgraded Product

Rev. No: 1	Rev. Date: June 02, 2008	Created: February 22, 2006
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REASON FOR BULLETIN

This service bulletin defines the extended inspection intervals that are to be used with Siemens' Inspection Interval Extension upgrade package (unless otherwise specified by Siemens). The extended inspection intervals in this document are specified in terms of both equivalent base load hours (EBH) and equivalent starts (ES).

An Inspection Interval Extension Package (IIEP) was developed by Siemens for the W501D5, W501D5A and SGT6-3000E frames to extend the intervals at which planned inspections are performed, and thereby increase availability and reduce planned maintenance outage costs. Implementation of the Inspection Interval Extension Package involves upgrading of specific hot gas path components to the IIEP configuration for enhanced durability, and a Siemens Engineering unit-specific review of remaining flowpath components to confirm their suitability for interval extension.

This bulletin is to be used only on specific engines meeting all applicability requirements as defined below. For these specific engines, this Service Bulletin supersedes SB36803, "Combustion Turbine Maintenance and Inspection Intervals."

BULLETIN APPLIES TO

This bulletin applies only to specific W501D5, W501D5A and SGT6-3000E gas turbine engines that have met all of the following criteria:

- The engine has completed the Inspection Interval Extension Product scope in full compliance with engine-specific upgrade requirements specified by Siemens Power Generation, Inc.
- The Inspection Interval Extension Product only applies to units operating on natural gas and distillate oil No. 2.
- Siemens Power Generation, Inc. has provided engine-specific written authorization to use this service bulletin on the engine.

This service bulletin supersedes SB54006, "Gas Turbine Maintenance and Inspection Intervals, Trip Factor Reduction for W501D5, W501D5A and SGT6-3000E Units with Upgraded Package."

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SCOPE

In addition to the new maintenance intervals and reduced trip factors, this bulletin provides:

- How to compile the required operating history (Procedure 1.0 and Table 1).
- Definitions of required parameters (Table 2 and Figure 1).
- How to calculate Equivalent Base Hours (EBH_{total}) and Equivalent Starts (ES) (Procedures 2.0 and 3.0, respectively).
- Recommended inspection intervals (Table 3).
- Description of various inspections (Table 4).
- Normal Start, Acceleration and Loading information (Table 5).

GENERAL GUIDELINES

These inspection recommendations were developed using Original Equipment Manufacturer (OEM) design knowledge and fleet experience. They are provided in the interest of maximizing unit availability and reliability. Inspection recommendations are based on a combination of factors that include fuel type, number of operating hours, number of starts, types of starts, whether operation or starts were performed using a single fuel or multiple fuels, and the number of trips from load.

NOTE

Technical Advisories or other customer communications from Siemens PG requiring more frequent intervals and/or different inspections may already apply or may be communicated to you in the future for your specific units. This Service Bulletin does not supersede those requirements. If you have any questions regarding your specific unit, contact your Siemens PG representative.

Guidelines are based on the assumption that the units have been operated and maintained according to Siemens PG operation and maintenance recommendations, and that a complete operating history for the unit has been compiled.

Operators should perform inspections at least as frequently as these recommended intervals, but some site-specific operating conditions may suggest more frequent and stringent inspection or maintenance practices. Additionally, site-specific practices may produce conditions that do not fit the definitions set forth in this bulletin. Siemens PG should be contacted with any questions.

NOTE

The calculations of Equivalent Base Hours and Equivalent Starts set forth below are solely for purposes of computing inspection intervals specific to this Service Bulletin and not for any other purpose.

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INSTRUCTIONS

Owners/operators of specific Siemens PG W501D5, W501D5A and SGT6-3000E gas turbines that meet the above criteria (see "BULLETIN APPLIES TO" section) should implement, as a minimum, the inspection guidelines in this document, as set forth in the owner's purchase or maintenance contract.

If you have questions about how these instructions affect your particular unit, contact your Siemens PG representative.

SPECIAL INSTRUCTIONS

The inspections and intervals stated in this bulletin may be modified or supplemented by Siemens PG special instructions. These include any additional requirements specified by Technical Advisories (TAs) and Service Bulletins (SBs) as recommended in outage planning instructions and in outage plans established for a specific unit.

PROCEDURES

1.0 How to Compile an Operating History

- 1.1 Use the Operating History Spreadsheet (Table 1) to collect operating data.
- 1.2 Keep an accurate running total of these parameters for each fuel.

Operating Hours

Fired Hours

Peak Firing Hours

Successful Starts

Normal Starts

Fast Starts

Fired Aborts

Trips From Load

Load at which each trip occurred.

- 1.3 Refer to Definitions of Required Parameters (Table 2 and Figure 1).

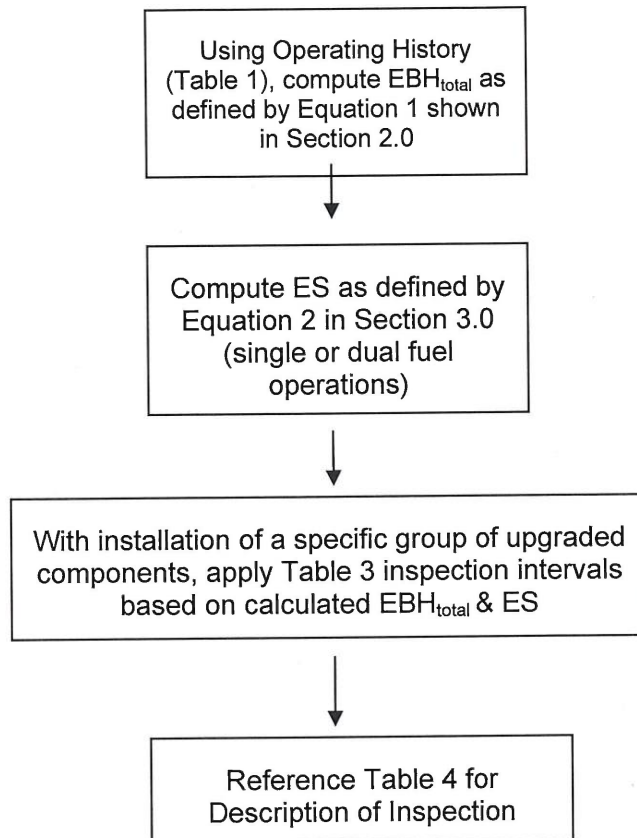
NOTE

Figure 1 is simply a graphical representation of the parameter definitions and should not be used specifically for a unit.

- 1.4 Maintain a running total of Equivalent Base Hours (EBH_{total}) and Equivalent Starts (ES), by performing the calculations explained in Procedures 2.0 (Equation 1) and 3.0 (Equation 2).
- 1.5 Refer to Description of Inspections (Table 4).

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- 1.6 Monitor the running totals of EBH_{total} and ES using the parameters' totals on the Operating History Spreadsheet (Table 1). Continuously compare the running totals against the Recommended Inspection Intervals (Table 3).
- 1.7 Process for using this Service Bulletin:



NOTE

Unit operating history should be tracked based on operator's log records. If electronic counters are currently installed, they must be re-configured for this bulletin.

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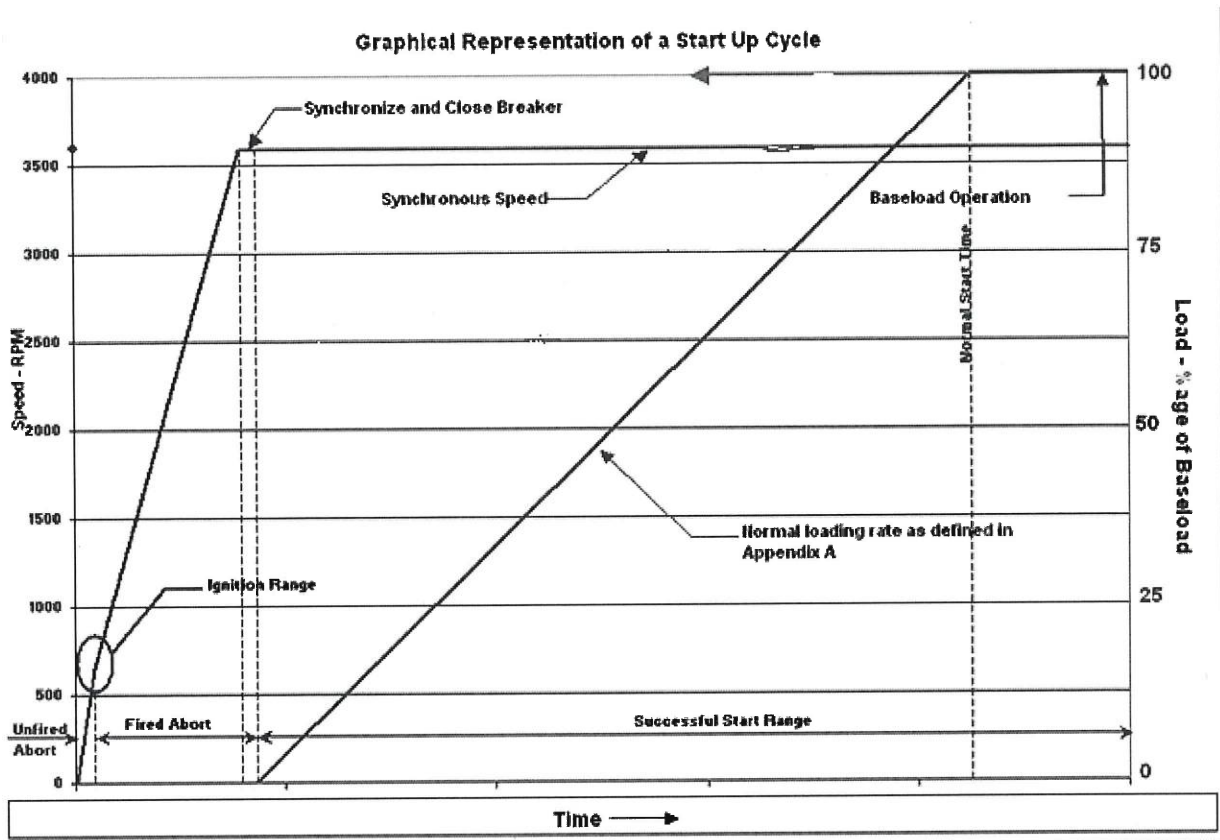


Figure 1. Graphical Representation of Parameter Definitions

NOTE

Any start sequence that results in reaching base load in a total time that is less than specified in Table 5 is considered a fast start.

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2.0 How to Calculate Equivalent Base Hours (EBH)

- 2.1 The effects of time at temperature are monitored using Equivalent Base Hours (EBH). Convert mixed-load operation hours to EBH for each type of fuel using parameters from the Operating History Spreadsheet (Table 1).

Equation 1

$$EBH_{total} = H_{Gas}^{\leq BL} + 3H_{Gas}^{> BL} + 1.3H_{Oil}^{\leq BL} + 3.9H_{Oil}^{> BL}$$

Where:

H = Hours of Operation or Fired Hours
EB = equivalent base
BL = base load

Where H denotes “hours of operation” or “fired hours”, the subscript denotes the fuel used during those hours of operation, and the superscript denotes either “less than or equal to base load” or “greater than base load”.

Apply this value to the EBH_{total} column on the recommended inspection interval (reference Table 3).

NOTE

Fuel, in all cases, must meet the requirements of the applicable fuel specification for your unit.

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3.0 How to Calculate Equivalent Starts (ES)

- 3.1 The effects of cyclic thermal and mechanical stress caused by starts and trips are cumulative and are monitored using ES. Use the factors from Table 6 when doing the calculations in equation 2. For definitions of starts and trips, see Table 2 and Figure 1.
- 3.2 Calculate ES using parameters from the Operating History Spreadsheet (Table 1) and Equation 2.

Equation 2

$$ES = \Sigma(A \times F_F) + \Sigma(S \times F_F \times S_F) + \Sigma(T \times F_F \times T_F)$$

Where:

ES = Equivalent Starts

A = fired abort

S = successful start

T = trip from load

F_F = fuel factor

S_F = start factor

T_F = trip factor

Apply this value to the ES column on the recommended inspection interval (reference Table 3).

NOTE

In addition to the elimination of the starts-based combustor inspection, the Inspection Interval Extension Product provides a reduction in the trip factors as shown in the following example. Equivalent Starts were calculated for 33 W501D5 and 36 of the ES based W501D5A units in the fleet from 1996 to 2004 using both the SB36803 and SB54009 equations. The results are shown in Figure 2. On average, the number of ES calculated using SB54009 was approximately 36% lower than calculated using SB36803. Based on this, it can be expected that starts based, hot path and major inspections will need to be performed less frequently using SB54009.

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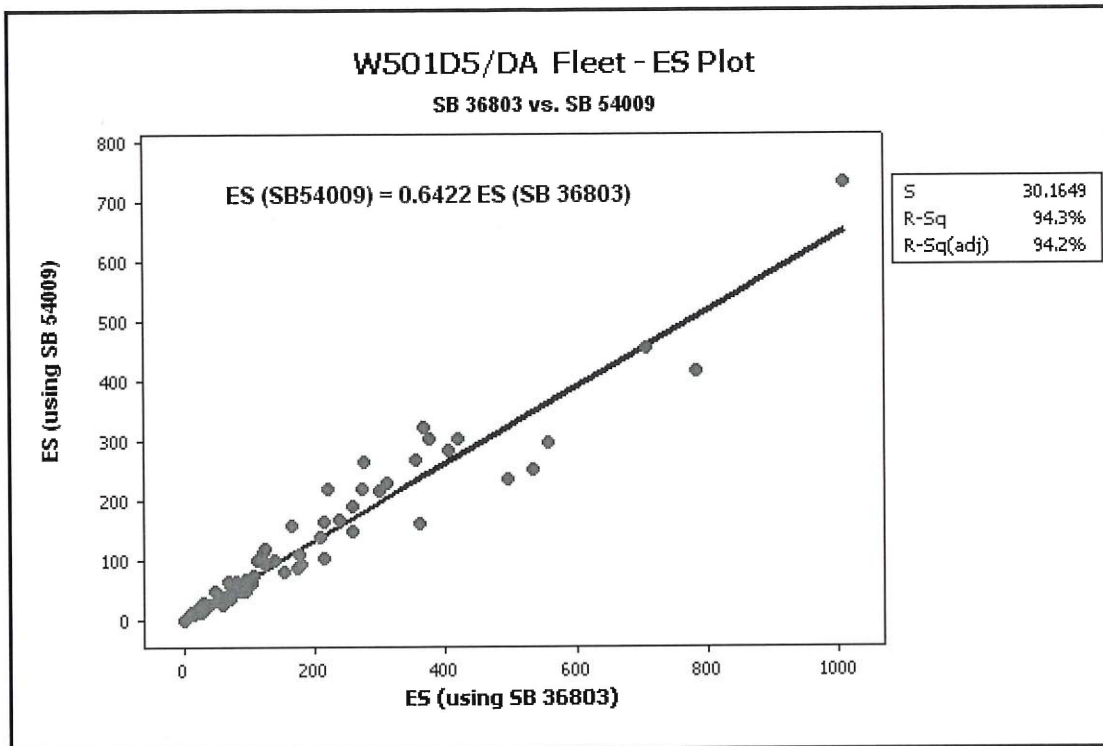


Figure 2. SB 36803 vs. SB 54009

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Table 1. Operating History Spreadsheet

OPERATING HOURS (TRACK SEPERATELY FOR EACH FUEL)		
FIRING MODE	NATURAL GAS	DISTILLATE OIL
Fired Hours		
Peak Firing Hours		

STARTS (TRACK SEPARATELY FOR EACH FUEL)		
TYPE OF START	NATURAL GAS	DISTILLATE OIL
NORMAL START		
FAST START		
FIRED ABORT		

TRIP FROM LOAD (TRACK SEPARATELY FOR EACH FUEL)		
Percent of base load at time of trip	NATURAL GAS	DISTILLATE OIL
$75\% \leq \text{Load} < 100\%$		
$50\% \leq \text{Load} < 75\%$		
$25\% \leq \text{Load} < 50\%$		
$10\% \leq \text{Load} < 25\%$		
Load < 10%		

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Table 2. Definitions of Required Parameters

HOURS

Fired Hours – operation at or below base load firing temperature. This includes all gas turbine operation after the generator breaker is closed. The time between ignition and synchronization is not counted towards fired hours when using the normal acceleration and loading rates defined in Table 6. Any abnormal operations at full speed no load (FSNL) extending beyond the normal rates defined in Table 6 are counted toward fired hours.

Peak Firing Hours – operation above base load firing temperature.

STARTS

A **Successful Start** occurs when a unit reaches synchronization. Successful starts are further classified, depending on the total time* to accelerate and reach base load.

Normal Start occurs if a unit reaches base load in the normal or greater than normal starting, acceleration and loading schedule guideline in Table 6.

Fast Start occurs whenever a unit reaches any portion of the starting, acceleration and loading schedule in less time than the guidelines specified in Table 6 (also Figure 1).

Successful starts that do not reach base load shall be classified based on the actual ramp rate and percent load at the time of trip.

* Start total times do NOT include times for purging exhaust and boiler ductwork.

ABORTS

Fired Abort - A fired abort is a start attempt that is aborted after combustor ignition has occurred but shuts down before reaching synchronization.

Unfired Abort occurs if the unit shuts down before combustor ignition. Unfired aborts are to be DISREGARDED in calculating equivalent starts.

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TRIPS

Trip From Load occurs if the unit is shutdown after synchronization AND the normal shutdown FSNL cool down sequence is not performed. This is an abrupt shutdown that does not follow the normal shutdown sequence including the specified FSNL cool down sequence (reference Trip Factors in Section 3.1).

When calculating the percentage of base load, use base load at time of trip. Base load at time of trip is dependent on current ambient conditions. This parameter is typically available at the control system output (JN6001).

Any post-load shutdown that does not include the specified FSNL cool down counts as a trip from no load.

Any load rejection that results in a trip at a lower load (including FSNL) would count as a trip from the original load prior to the load rejection.

For any trips that have occurred during operation above base load, consult Siemens PG for additional guidelines and recommendations.

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Table 3. Recommended Inspection Intervals

TOTAL EQUIVALENT BASE HOURS (EBH _{total})	TOTAL EQUIVALENT STARTS (ES)	INSPECTION TYPE RECOMMENDED
2,000 EBH (3)	200 ES (3)	COMBUSTOR (MINOR)
16,000 EBH	N/A	COMBUSTOR (MAJOR)
32,000 EBH	800 ES	TURBINE (HOT GAS PATH – INCLUDES MAJOR COMBUSTOR)
64,000 EBH	1,600 ES	MAJOR

NOTES

Before using this table, calculate EBH_{total} and ES as explained in Procedures 2.0 and 3.0.

Perform the inspection indicated at either the EBH or the ES interval specified on this table.

Minor combustor inspection is recommended for operation on oil fuel but is not required for operation on natural gas.

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Table 4. Description of Inspections

NOTE

These are general descriptions of the various inspections. For detailed information or work scope, consult your Siemens PG representative.

RUNNING INSPECTIONS

The running inspection is performed while the unit is operating. This inspection involves monitoring various gas turbine operating parameters to identify changes from a new or clean/overhaul condition. Gas turbine monitoring includes, but is not limited to:

- Blade path temperatures, spreads, and trends.
- Exhaust temperatures.
- Disc cavity temperatures.
- Vibration levels and trends.
- Bearing temperatures and oil pressure.
- Compressor fouling.
- Combustor shell pressure and combustion dynamics.

During normal operation, the operating data should be monitored and trended. An abnormal reading or trend in the direction of a problem area in any parameter should prompt an investigation and the correction of the cause (even if data levels are still within acceptable ranges).

NOTE

The following are off-line inspections to be performed while the gas turbine is in a stopped/off-line condition.

COMBUSTION SECTION (MINOR COMBUSTOR INSPECTION)

Minor Combustor inspection is recommended for operation on oil fuel at intervals of 2000 EBH or 200 ES (reaching either limit triggers an inspection), but is not required for operation on natural gas. The minor combustor inspection involves the removal, cleaning, and inspection of the fuel nozzle assemblies, and the inspection of the interior surfaces of the combustors and transitions through the nozzle openings. On units that have man-way access, a crawl-through inspection of the combustor shell should also be performed. The inspection is to verify that the nozzles are clean, and free of debris and leaks, and that the combustor baskets are clean and free of distortions or distress.

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COMBUSTION SECTION (MAJOR COMBUSTOR INSPECTION)

The major combustor inspection involves removal of all combustor components. These parts and the row 1 turbine vanes are inspected in accordance with appropriate service bulletins. Components that are not removable without a cover lift are inspected in-place. The Turbine Row 1 vanes for ES-based outages should not be removed prior to inspection.

Individual Row 1 vanes can be removed without a cover lift for a more thorough inspection. This allows for a visual inspection of Row 1 blades if warranted. Also, visual inspections can be made in-place for last row turbine blades, compressor inlet guide vanes (IGVs), Row 1 compressor blades, and compressor last-row outlet guide vanes (OGVs). For units with DLN combustion systems fitted with an external bypass valve system, the bypass valve system external piping/ connections shall be inspected per TA-2000-010, "Safety Hazard/Potential Equipment Failure at Critical Combustor Bypass Flange Interface" guidelines.

TURBINE SECTION (HOT GAS PATH) INSPECTION

The turbine section (hot gas path) inspection includes a major combustor inspection, plus inspection of the remainder of the turbine hot gas path. Access requires removal of the appropriate cylinder cover and blade rings. In most cases, blades and associated parts are removed from the rotor, cleaned and inspected. Turbine disc blade root serrations are also cleaned and inspected. Vanes and ring segments are removed from the blade ring as required for cleaning and inspection, and interstage seal housings and baffles are inspected before disassembly.

MAJOR INSPECTION

The major inspection is the most comprehensive inspection carried out on the gas turbine. It includes a turbine section (hot gas path) inspection plus the lifting of the inlet, compressor, compressor-combustor and turbine cylinders, and the torque tube housing covers. Compressor diaphragms are removed, cleaned, and inspected. Compressor blades and discs are cleaned and inspected in-place. Compressors with the shrunk-on disc design should be inspected for disc gaps. Compressor and turbine bearings and bearing seals are also inspected. The rotor may be removed or inspected in place.

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TABLE 5. NORMAL START, ACCELERATION, AND LOADING INFORMATION

	W501D5 (S.O. below 37A3900)	W501D5 (S.O. 37A3900 and above), W501D5A (all) and SGT6-3000E (all)
Acceleration from turning gear to 3600 (minutes) ⁽¹⁾	20.0	20.0
Synch and Min Load Pickup (minutes)	0.5	0.5
Min Load to Base Load (minutes)	9.0	7.5
Total Time (minutes) ⁽¹⁾	29.5	28.0
Normal Shutdown Rate (MW/minute)	20.0	20.0

NOTE

- (1) **Time spent during spin-hold (to purge exhaust, boiler ductwork or any other reason) should not be counted as part of the total acceleration time.**

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Table 6. Factors

Start Factors

Total Time to Accelerate and Reach Base Load	Start Factor (S_F)
Normal Start (reference Table 5)	1.0
Fast Start ⁽¹⁾	10.0

Fuel Factors (For use with Equivalent Starts Equation 2 Only)

Fuel Used	Fuel Factor (F_F)
Natural Gas	1.0
Distillate Oil #2	1.3

Trip Factors

Percentage of Base Load at Time of Trip	Trip Factor (T_F)
$75\% \leq \text{load} < 100\%$	8.0
$50\% \leq \text{load} < 75\%$	6.0
$25\% \leq \text{load} < 50\%$	4.0
$10\% \leq \text{load} < 25\%$	2.0
load < 10%	1.0

NOTE

Any start sequence that results in reaching base load in a total time that is less than specified in Table 5 is considered a fast start.

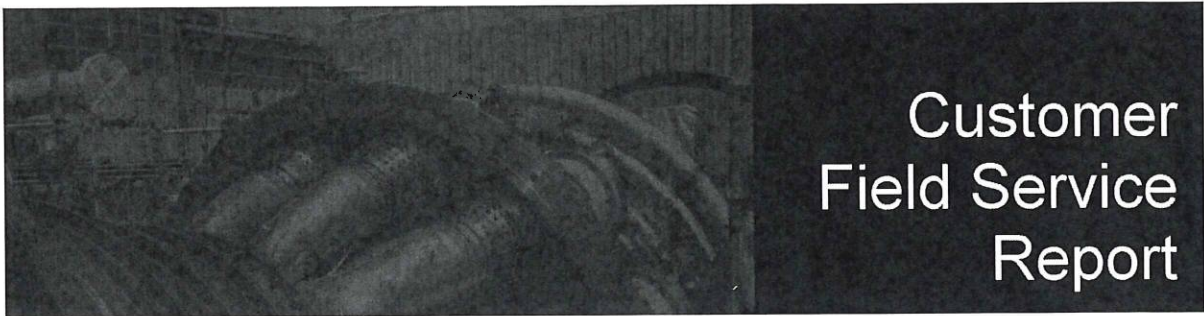
As a world leader in gas turbine manufacture and repair, Siemens PG can provide quotations on specific information or services you may request as result of this bulletin.

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Appendix B

Combustion Turbine Emissions Tuning Report

(EXAMPLE)




Report No.	CFSR 001227
Task	Combustion Tuning
Task Description	Combustion Tuning
Customer	Xcel Energy
Plant / Unit	Cunningham / GT3
Event Date	6/18/2018 - 6/22/2018

Author: Wayne Roznowski
Approved By: Justin Bosnoian



The Proven Alternative

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	Cunningham / GT3		001227	
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	Wayne Roznowski	Service Eng	6/26/2018	2 / 29

REPORT INFORMATION			
Report No	CFSR 001227		
Report Date: June 26, 2018		Total Pages: 26	
Author: Wayne Roznowski	Department: Service Eng	Title: St. Engineer Systems/ DLN tuning	

SITE INFORMATION			
Customer: Xcel Energy		Site Name: Cunningham	
Point of Contact: Steven Niehaus		Site Address: 13 Miles W of Hobbs on Hwy 62	
Unit: GT3	City, State: Hobbs, NM		Country: USA
System: Gas Turbine	System Frame / Comb Sys: W501FD2	Machine Serial No.: 37A7441-1	

TASK INFORMATION	
Business Case: Customer support	Charge Code: 19S-00296-34015250
Task: Combustion Tuning	
Task Description: Combustion Tuning	
Task Date: June 19, 2018 - June 21, 2018	
Approved By: Justin Bosnoian	Date: August 23, 2018

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	Plant / Unit		Report No.	
	Cunningham / GT3		001227	
	Author	Department	Date	Page
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1.0 Summary

GT3 was seasonally tuned. A full tuning program was completed with fuel system split checks performed at:


- Baseload with Evaporative Coolers and Wet Compression
- Baseload with Evaporative Coolers
- Baseload Dry
- 85% load with Evaporative Coolers
- 85% load Dry
- 70% load with Evaporative Coolers
- 70% load Dry

In brief:

- Combustion dynamics were tuned within limits across entire load range on all inlet conditions
 - **Wet Compression** Max IFD2 on loudest can was observed to be 0.2 psi. Max IFD3 observed to be 0.14 psi.
 - **Evap Cooling** Max IFD2 on loudest can was observed to be 0.2 psi. Max IFD3 observed to be 0.14 psi.
 - **Dry** Max IFD2 on loudest can was observed to be 0.2 psi. Max IFD3 observed to be 0.14 psi.
- Baseload NO_x was tuned below limits under all inlet operating conditions
 - **Wet Compression** 23.5 ppm corrected to 15% O₂ at an inlet temperature of 69.8°F
 - **Evap Cooling** 15.7 ppm corrected to 15% O₂ at an inlet temperature of 70.3°F
 - **Dry** 16.4 ppm corrected to 15% O₂ at an inlet temperature of 77.5°F.
- Exhaust spreads were good at < 33.7°F
- Dry and Evap fuel split constants were optimized to low emissions and stable dynamics.
- As found Evap Cooling split schedules did not add up to 1 on breakpoints 10-12 and were corrected
- Optimized and corrected schedules were implemented at the end of the tuning day

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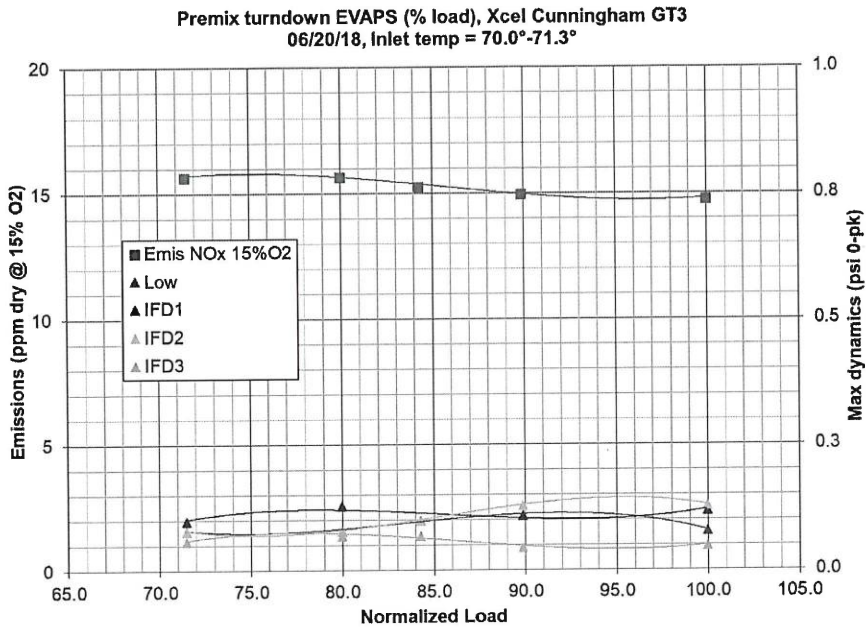


Figure 1: Premix Turndown with Evaps (% load)

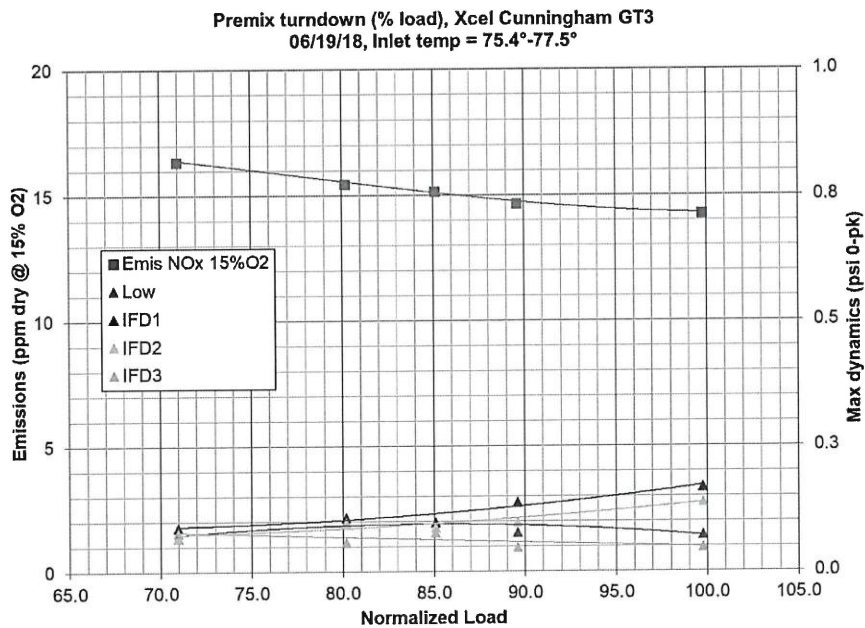



Figure 2: Premix Turndown Dry (% load)

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Summaries at Base Load:

Date	-	6/19/2018
Inlet temp	°F	69.80
Baseload split	Pilot/AStage/BStage/CStage	17.1/38.5/38.5/6.0
Emis NOx 15%O2	ppm	23.48
Emis O2	%	14.00
Low dynamics	max, psi 0-pk	0.07
IFD1 dynamics	max, psi 0-pk	0.08
IFD2 dynamics	max, psi 0-pk	0.15
IFD3 dynamics	max, psi 0-pk	0.04
Blade path spread	°F	23.70
Blade path variance	°F	37.90

Table 1: Baseload Wet Compression summary

Date	-	6/20/2018
Inlet temp	°F	70.00
Baseload split	Pilot/AStage/BStage/CStage	7.6/40.4/40.4/11.6
Emis NOx 15%O2	ppm	14.80
Emis O2	%	14.80
Low dynamics	max, psi 0-pk	0.08
IFD1 dynamics	max, psi 0-pk	0.12
IFD2 dynamics	max, psi 0-pk	0.13
IFD3 dynamics	max, psi 0-pk	0.05
Blade path spread	°F	31.80
Blade path variance	°F	32.50

Table 2: Baseload Evap Cooling summary

Date	-	6/20/2018
Inlet temp	°F	77.45
Baseload split	Pilot/AStage/BStage/CStage	7.0/40.5/40.5/12.0
Emis NOx 15%O2	ppm	14.30
Emis O2	%	14.80
Low dynamics	max, psi 0-pk	0.08
IFD1 dynamics	max, psi 0-pk	0.17
IFD2 dynamics	max, psi 0-pk	0.14
IFD3 dynamics	max, psi 0-pk	0.05
Blade path spread	°F	29.80
Blade path variance	°F	30.10

Table 3: Baseload Dry summary

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Table 4 shows the priority and margins for emissions and dynamics used for choosing the as-left control settings.

Priority	Name	Freq range	Target Margin	Min Margin	Limit
1	LFD	15-50 Hz	2.0%	1.0%	0.5 psi 0-pk
2	IFD1	50-100 Hz	2.0%	1.0%	1.0 psi 0-pk
3	NOx	-	-	-	18 ppm
4	IFD2	100-500 Hz	2.0%	1.0%	2.0 psi 0-pk
5	CO	-	-	-	900 lb/hr

Table 4: Tuning Targets

2.0 Purpose & Workscope

PSM was contracted to perform:

- 1) Seasonal combustion tuning across the premix operating range

3.0 Duration & Milestones

Plant / Unit		Cunningham / GT3	
No.	Milestone	Planned Date	Actual Date
1	Combustion tuning complete	2018-06-20	2018-06-20

4.0 Personnel

Plant / Unit		Cunningham / GT3			
No.	Name	Dept.	Function	Arrival Date	Dep. Date
1	Wayne Roznowski	430	Tuning engineer	2018-06-18	2018-06-22

5.0 Work Performed


5.1 Control Settings: As Found, As Left

Changes are indicated in *bold red italic*.

No change to any other control constants.

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Pilot Split Schedule >50% Load MBY10DF001 PLTHILOAD_DRY_X071 (292938)					A-Stg Split Schedule >50% Load MBY10DF001 ASTGHILOAD_DRY_X151 (292945)				
As found		As left			As found		As left		
x	Load	Fraction	Load	Fraction	x	Load	Fraction	Load	Fraction
	%	-	%	-		%	-	%	-
1	20	0.250	20	0.2500	1	20	0.3400	20	0.3400
2	29	0.210	29	0.2100	2	29	0.3570	29	0.3570
3	35	0.190	35	0.1900	3	35	0.3650	35	0.3650
4	40	0.170	40	0.1700	4	40	0.3735	40	0.3735
5	45	0.150	45	0.1500	5	45	0.3825	45	0.3825
6	50	0.140	50	0.1400	6	50	0.3860	50	0.3860
7	64	0.126	64	0.1210	7	64	0.3895	64	0.3920
8	69	0.123	69	0.1125	8	69	0.3903	69	0.3953
9	75	0.115	75	0.1070	9	75	0.3925	75	0.3965
10	85	0.095	85	0.0890	10	85	0.4000	85	0.4030
11	90	0.080	90	0.0800	11	90	0.4050	90	0.4050
12	96	0.070	96	0.0700	12	96	0.4050	96	0.4050

B-Stg Split Schedule >50% Load MBY10DF001 BSTGHILOAD_DRY_X431 (292961)					C-Stg Split Schedule >50% Load MBY10DF001 CSTGHILOAD_DRY_X451 (292976)				
As found		As left			As found		As left		
x	Load	Fraction	Load	Fraction	x	Load	Fraction	Load	Fraction
	%	-	%	-		%	-	%	-
1	20	0.3400	20	0.3400	1	20	0.070	20	0.070
2	29	0.3570	29	0.3570	2	29	0.076	29	0.076
3	35	0.3650	35	0.3650	3	35	0.080	35	0.080
4	40	0.3735	40	0.3735	4	40	0.083	40	0.083
5	45	0.3825	45	0.3825	5	45	0.085	45	0.085
6	50	0.3860	50	0.3860	6	50	0.088	50	0.088
7	64	0.3895	64	0.3920	7	64	0.095	64	0.095
8	69	0.3903	69	0.3953	8	69	0.097	69	0.097
9	75	0.3925	75	0.3965	9	75	0.100	75	0.100
10	85	0.4000	85	0.4030	10	85	0.105	85	0.105
11	90	0.4050	90	0.4050	11	90	0.110	90	0.110
12	96	0.4050	96	0.4050	12	96	0.120	96	0.120

Table 5: Fuel Split Schedules Above 50% Load (EVAP OFF)

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Pilot Split Schedule >50% Load MBY10DF001 PLTWETOAD_WET_X072(292937)					A-Stg Split Schedule >50% Load MBY10DF001 ASTGWETOAD_WET_X152 (292944)				
As found		As left			As found		As left		
	Load	Fraction	Load	Fraction		Load	Fraction	Load	Fraction
x	%	-	%	-	x	%	-	%	-
1	20	0.2500	20	0.250	1	20	0.3400	20	0.3400
2	29	0.2100	29	0.210	2	29	0.3570	29	0.3570
3	35	0.1900	35	0.190	3	35	0.3650	35	0.3650
4	40	0.1700	40	0.170	4	40	0.3735	40	0.3735
5	45	0.1500	45	0.150	5	45	0.3825	45	0.3825
6	50	0.1400	50	0.140	6	50	0.3860	50	0.3860
7	64	0.1260	64	0.1210	7	64	0.3895	64	0.3920
8	69	0.1225	69	0.1125	8	69	0.3903	69	0.3953
9	75	0.1150	75	0.1060	9	75	0.3925	75	0.3970
10	85	0.0980	85	0.0920	10	85	0.3965	85	0.4040
11	90	0.0850	90	0.0850	11	90	0.4010	90	0.4075
12	98	0.0780	98	0.0760	12	98	0.4030	98	0.4120

B-Stg Split Schedule >50% Load MBY10DF001 BSTGWETOAD_WET_X432 (292960)					C-Stg Split Schedule >50% Load MBY10DF001 CSTGWETOAD_WET_X452 (292975)				
As found		As left			As found		As left		
	Load	Fraction	Load	Fraction		Load	Fraction	Load	Fraction
x	%	-	%	-	x	%	-	%	-
1	20	0.3400	20	0.3400	1	20	0.070	20	0.070
2	29	0.3570	29	0.3570	2	29	0.076	29	0.076
3	35	0.3650	35	0.3650	3	35	0.080	35	0.080
4	40	0.3735	40	0.3735	4	40	0.083	40	0.083
5	45	0.3825	45	0.3825	5	45	0.085	45	0.085
6	50	0.3860	50	0.3860	6	50	0.088	50	0.088
7	64	0.3895	64	0.3920	7	64	0.095	64	0.095
8	69	0.3903	69	0.3953	8	69	0.097	69	0.097
9	75	0.3925	75	0.3970	9	75	0.100	75	0.100
10	85	0.3965	85	0.4040	10	85	0.100	85	0.100
11	90	0.4010	90	0.4075	11	90	0.100	90	0.100
12	98	0.4030	98	0.4120	12	98	0.100	98	0.100

Table 6: Fuel Split Schedules Above 50% Load (EVAP ON)

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Bypass Valve Schedule FM45337 EVAPCOOLER OFF X291 (X291)					Bypass Valve T1C Bias FM45337 EVAPCOOLER OFF X751 (X751)				
As found		As left			As found		As left		
Load	Vlv Pos	Load	Vlv Pos	%	Amb Temp	Bias	Amb Temp	Bias	%
x	%	%	%	%	x	F	-	F	-
1	0	60.0	0	60.0	1	15	2.000	15	2.000
2	4	60.0	4	60.0	2	30	2.000	30	1.000
3	10	60.0	10	60.0	3	50	0.000	50	0.000
4	20	60.0	20	60.0	4	69	0.000	69	0.000
5	25	57.0	25	57.0	5	78	0.000	78	0.000
6	35	57.0	35	57.0	6	88	0.000	88	0.000
7	45	50.0	45	50.0	7	90	0.000	90	0.000
8	60	30.0	60	30.0	8	93	0.000	93	0.000
9	70	5.0	70	5.0	9	96	0.000	96	0.000
10	75	0.0	75	0.0					
11	98	0.0	98	0.0					


Table 7: Bypass Valve Schedule (EVAPS OFF)

Bypass Valve Schedule FM45337 EVAPCOOLING ON (X292)					Bypass Valve T1C Bias FM45337 EVAPCOOLING ON (X753)				
As found		As left			As found		As left		
Load	Vlv Pos	Load	Vlv Pos	%	T1C	Bias	T1C	Bias	%
x	%	%	%	%	x	F	-	F	-
1	0	60.0	0	60.0	1	0	0.000	0	0.000
2	4	60.0	4	60.0	2	10	0.000	10	0.000
3	10	60.0	10	60.0	3	20	0.000	20	0.000
4	20	60.0	20	60.0	4	45	0.000	45	0.000
5	25	57.0	25	57.0	5	61	0.000	61	0.000
6	35	57.0	35	57.0	6	66	0.000	66	0.000
7	45	50.0	45	50.0	7	68	0.000	68	0.000
8	60	30.0	60	30.0	8	70	0.000	70	0.000
9	70	5.0	70	5.0	9	80	1.000	80	1.000
10	80	2.0	80	2.0					
11	96	0.0	96	0.0					

Table 8: Bypass Valve Schedule (EVAPS ON)

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IGV Schedule					IGV T1C Bias				
MBA10DG005					MBA10DG005				
IGVSCHG_X692 (351077)					IGVSCHG (82573)				
As found		As left			As found		As left		
Load	IGV	Load	IGV	x	T1C	Bias	T1C	Bias	
%	Deg	%	Deg		F	Deg	F	Deg	
1	0	26.8	0	26.8	1	-40	1.0	-40	1.0
2	4	32.0	4	32.0	2	-5	1.0	-5	1.0
3	20	36.0	20	36.0	3	5	0.5	5	0.5
4	25	36.0	25	36.0	4	15	0.3	20	0.3
5	40	35.5	40	35.5	5	20	0.0	30	0.0
6	50	34.0	50	34.0	6	40	0.0	40	0.0
7	60	32.0	60	32.0	7	45	0.0	45	0.0
8	70	29.0	70	29.0	8	70	0.0	70	0.0
9	75	26.0	75	26.0	9	80	0.0	80	0.0
10	80	23.0	80	23.0	10	90	-1.0	90	-1.0
11	85	18.0	85	18.0	11	100	-2.0	100	-2.0
12	90	12.0	90	12.0	12	110	-2.0	110	-2.0
13	95	3.0	95	3.0					
14	98	-4.0	98	-4.0					
14	105	-4.0	105	-4.0					


Table 9: IGV Schedule

Pilot T1C Bias				
MBY10EU001				
X791 (292953)				
As found		As left		
Amb Temp	Bias	Amb Temp	Bias	
x	F	F	-	
1	8	0.0020	8	0.0020
2	20	0.0005	20	0.0005
3	30	0.0000	30	0.0000
4	40	0.0000	40	0.0000
5	50	0.0000	50	0.0000
6	55	0.0000	55	0.0000
7	70	0.0000	70	0.0000
8	80	0.0000	80	0.0000
9	100	-0.0005	100	-0.0005

Table 10: Pilot Ambient Temp Bias

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% Normalized Load MKA01EU902A Z599 72376				
<i>As found</i>			<i>As left</i>	
	T1C	Load	T1C	Load
x	F	MW	F	MW
1	0	116.00	0	116.00
2	20	109.00	20	109.00
3	40	102.00	40	102.00
4	60	95.00	60	95.00
5	80	88.00	80	88.00
6	100	81.00	100	81.00
7	120	74.00	120	74.00
8	120	74.00	120	74.00
9	120	74.00	120	74.00

Table 11: Normalized Load Ref

Baseload Exh Control Curve MBY10DT001 COMMBASECURVE COMM/BASELOAD CURVE_X501				
<i>As found</i>			<i>As left</i>	
	P2C	TTRX	P2C	TTRX
x	psi	F	psi	F
1	0	1050.0	0	1050.0
2	165	1050.0	165	1050.0
3	170	1037.1	170	1037.1
4	180	1013.2	180	1013.2
5	190	992.4	190	992.4
6	200	974.9	200	974.9
7	210	960.6	210	960.6
8	220	949.4	220	949.4
9	230	941.5	230	941.5


Table 22: Exhaust Control Curve

Wet Compression Pilot Clamp PILOT_WC_BIAS_STG.375169				
<i>As found</i>			<i>As left</i>	
x				
2	Pilot	0.170000	Pilot	0.170000

Table 33: Wet Compression clamp Settings

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Wet Compression Bias PILOT_WC_BIAS_STG.375330					
		As found		As left	
x					
1	Pilot	0.012375			0.012375
1	C-Stage	0.060000			0.0600

Table 14: Wet Compression Bias multiplier

IGV Startup Control MBA10DG005 59539					
		As found		As left	
		Speed	IGV	Speed	IGV
x		RPM	DEG	RPM	DEG
1		0	18.0	0	18.0
2		1500	19.2	1500	19.2
3		3000	23.6	3000	23.6
4		3500	26.8	3500	26.8
5		4000	26.8	4000	26.8


Table 15: IGV startup control

Bypass Valve Startup Schedule FM35337 X302					
		As found		As left	
		Speed	BYPASS	Speed	BYPASS
x		RPM	%	RPM	%
1		0	45.0	0	45.0
2		850	45.0	850	45.0
3		1200	50.0	1200	50.0
4		3000	60.0	3000	60.0
5		3590	65.0	3590	65.0
6		4000	65.0	4000	65.0

Table 16: Bypass Valve startup control

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5.2 Controller Software Changes

None to report.


5.3 Performance Summary

Operating mode	-	Baseload WET
Date	-	6/19/2018
From	-	10:16:00
To	-	10:21:00
Load actual	MW	105.2
Normalized Load	%	115%
Pilot	%	17.1
A Stage	%	38.5
B Stage	%	38.5
C Stage	%	6.0
Fuel gas flow total	KPPH	53.7
Fuel gas temp ABC	°F	68.5
Inlet temp	°F	69.8
Inlet guide vane	deg	-4.0
Compressor discharge pres	psia	192.6
Compressor discharge temp	°F	693.2
Exhaust temp mean	°F	1004.0
Blade path spread	°F	23.7
Blade path variance	°F	37.9
Emis NOx 15%O2	ppm	23.5
Emis O2	ppm	14.0

Table 17: Performance summary WET

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Operating mode	-	Baseload EVAP
Date	-	6/20/2018
From	-	13:41:00
To	-	13:43:00
Load actual	MW	91.3
Normalized Load	%	100%
Pilot	%	7.6
A Stage	%	40.4
B Stage	%	40.4
C Stage	%	11.6
Fuel gas flow total	KPPH	47.7
Fuel gas temp ABC	°F	69.6
Inlet temp	°F	70.0
Inlet guide vane	deg	-4.0
Compressor discharge pres	psia	186.2
Compressor discharge temp	°F	772.8
Exhaust temp mean	°F	1001.0
Blade path spread	°F	31.8
Blade path variance	°F	32.5
Emis NOx 15%O2	ppm	14.8
Emis O2	ppm	14.8


Table 18: Performance summary EVAP

Operating mode	-	Baseload DRY
Date	-	6/20/2018
From	-	08:07:00
To	-	08:09:00
Load actual	MW	88.3
Normalized Load	%	100%
Pilot	%	7.0
A Stage	%	40.5
B Stage	%	40.5
C Stage	%	12.0
Fuel gas flow total	KPPH	46.2
Fuel gas temp ABC	°F	67.2
Inlet temp	°F	77.5
Inlet guide vane	deg	-4.0
Compressor discharge pres	psia	182.6
Compressor discharge temp	°F	784.1
Exhaust temp mean	°F	1008.0
Blade path spread	°F	29.8
Blade path variance	°F	30.1
Emis NOx 15%O2	ppm	14.3
Emis O2	ppm	14.8

Table 19: Performance summary DRY

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6.0 Conclusions

Baseload and part load emissions and dynamics (as-left split schedule):

Baseload with Evaporative Coolers and Wet Compression:

- NO_x: 23.4 ppmvd @ 15% O₂
- Low: 0.07 psi 0-pk
- IFD1: 0.08 psi 0-pk
- IFD2: 0.15 psi 0-pk
- IFD3: 0.04 psi 0-pk

Baseload with Evaporative Coolers:

- NO_x: 14.8 ppmvd @ 15% O₂
- Low: 0.08 psi 0-pk
- IFD1: 0.12 psi 0-pk
- IFD2: 0.13 psi 0-pk
- IFD3: 0.05 psi 0-pk

Baseload Dry:

- NO_x: 14.3 ppmvd @ 15% O₂
- Low: 0.08 psi 0-pk
- IFD1: 0.17 psi 0-pk
- IFD2: 0.14 psi 0-pk
- IFD3: 0.05 psi 0-pk

85% load with Evaporative Coolers:

- NO_x: 15.3 ppmvd @ 15% O₂
- Low: 0.1 psi 0-pk
- IFD1: 0.1 psi 0-pk
- IFD2: 0.1 psi 0-pk
- IFD3: 0.07 psi 0-pk

85% load Dry:

- NO_x: 15.2 ppmvd @ 15% O₂
- Low: 0.1 psi 0-pk
- IFD1: 0.1 psi 0-pk
- IFD2: 0.09 psi 0-pk
- IFD3: 0.08 psi 0-pk

70% load with Evaporative Coolers:

- NO_x: 15.7 ppmvd @ 15% O₂
- Low: 0.08 psi 0-pk
- IFD1: 0.1 psi 0-pk
- IFD2: 0.08 psi 0-pk
- IFD3: 0.06 psi 0-pk

70% load Dry:



- NO_x: 16.4 ppmvd @ 15% O₂
- Low: 0.07 psi 0-pk
- IFD1: 0.09 psi 0-pk
- IFD2: 0.07 psi 0-pk
- IFD3: 0.08 psi 0-pk

As left fuel split schedule provides acceptable margin to elevated IDF2 and IDF3 dynamics from 70% load to baseload:

- IFD2: < 0.15 psi
- IFD3: < 0.08 psi

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7.0 Recommendations

Monitor performance during wet compression for excessive LFD dynamics and very low NOx emissions during change in seasons.

PSM recommends that the combustor tuning be checked for emissions and combustion dynamics seasonally to avoid excessive NO_x, blow outs, or excessive dynamics on hot or cold days.

Changes in Pilot Valve position did not yield expected changes in NOx in some instances. Recommend checking valve stroke for possible sticking and/or hanging up.

DC2 temperatures ~85 degrees cooler than setpoint. Recommend performing assessment to reduce Disc Cavity 2 Cooling Orifice area to increase DC2 temperatures to 775 degree setpoint.


DC3 temperatures ~140 degrees cooler than setpoint. Recommend performing assessment to reduce Disc Cavity 3 Cooling Orifice area to increase DC3 temperatures to 775 degree setpoint.

8.0 Open Items

None to report.

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9.0 Enclosure

9.1 CEMS and CDMS Attributes

CEMS installation type	Plant CEMS
CEMS probe location	Stack
NOx permit	18 ppm hourly average
CO permit	900 lb/hr

Table20: CEMS attributes

CDMS installation type	Permanent
Sensor mounting	UV port
Sensor type	Darling Tube
CDMS computer type	Alta
Frequency span	5000
Spectral bins	3200
Windowing function	Hanning
Scans to average	1

Table 21: CDMS attributes


9.2 Control System

Control System	T3000
----------------	-------

Table 22: Control system attributes

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10.0 Appendix

10.1 Combustion Split Check – Emissions and Dynamics

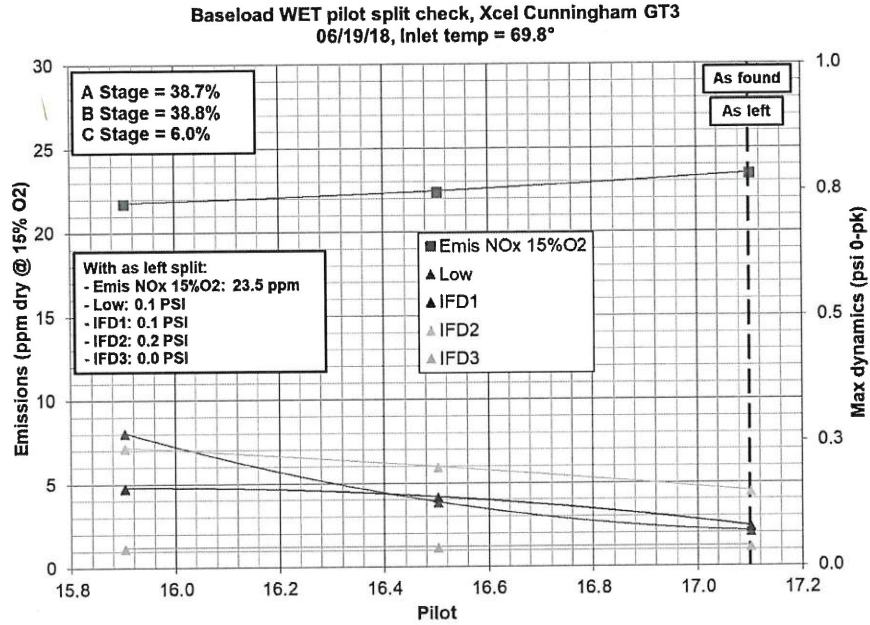


Figure 3: Baseload WET pilot split check

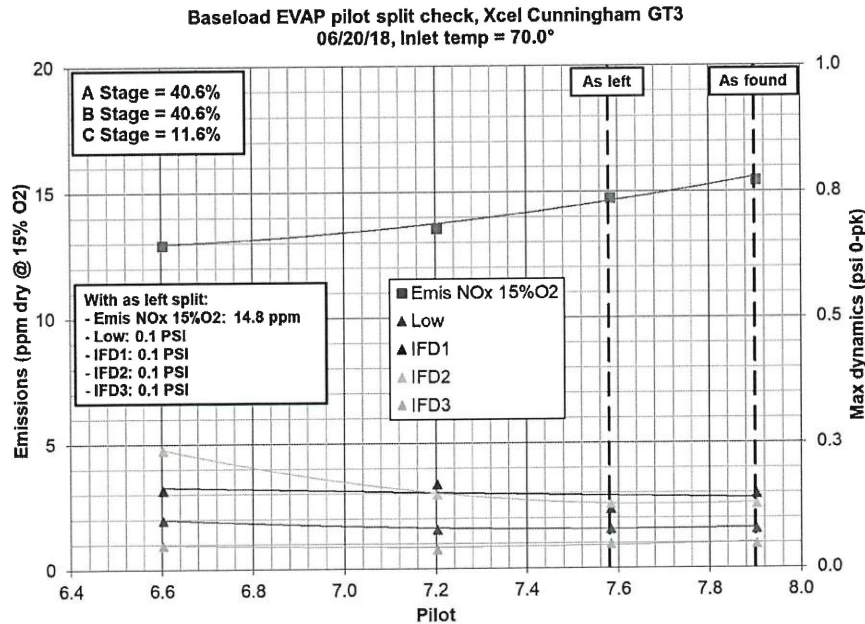



Figure 4: Baseload EVAP pilot split check

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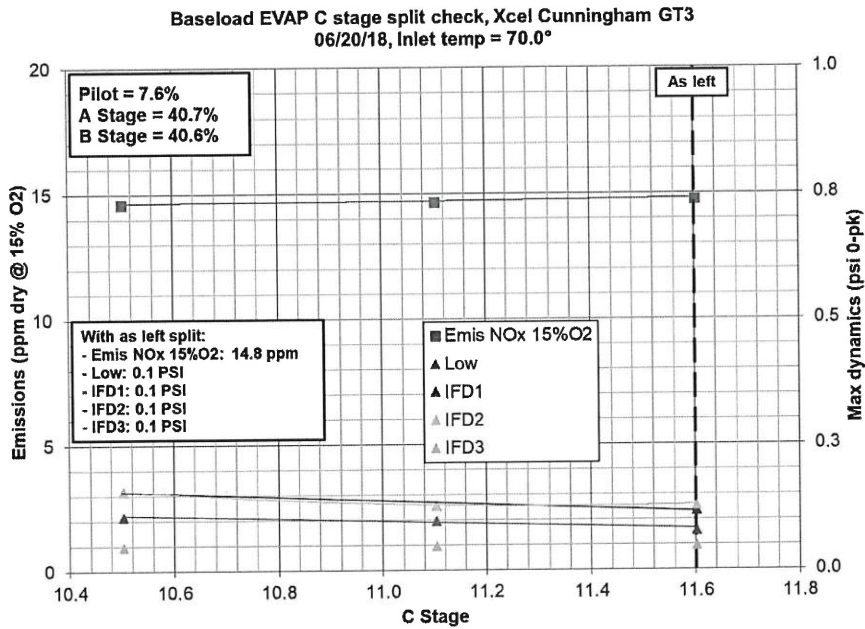


Figure 5: Baseload EVAP C stg split check

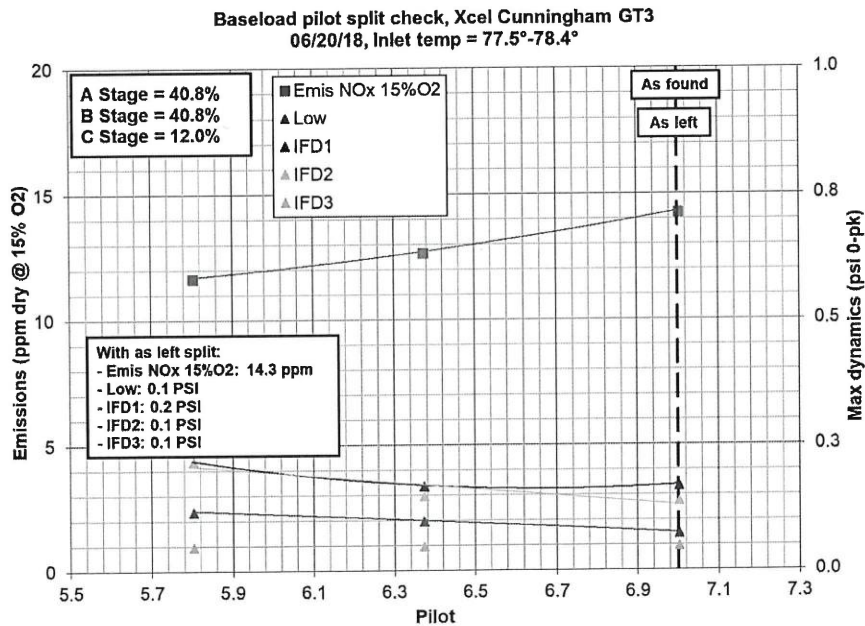



Figure 6: Baseload DRY pilot split check

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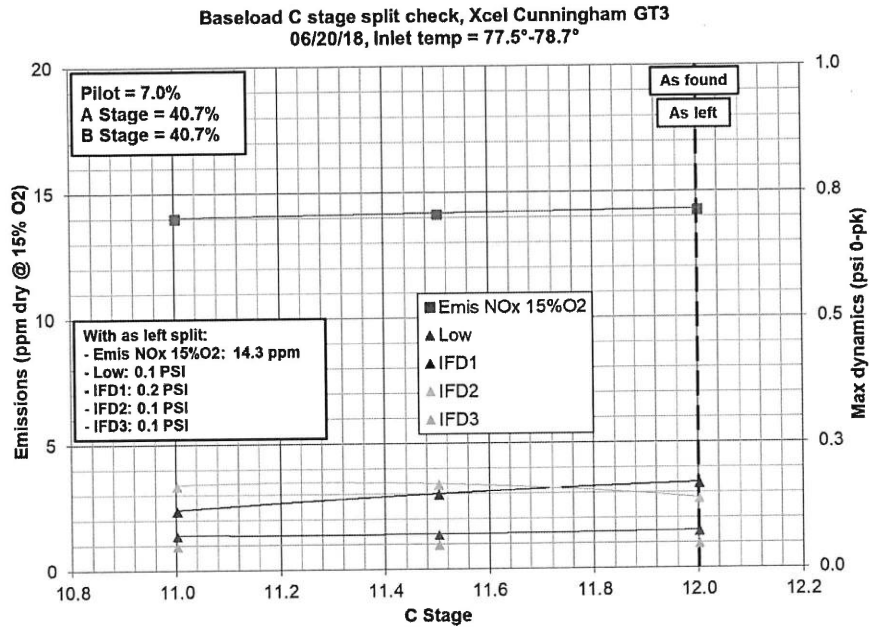


Figure 7: Baseload DRY C stg split check

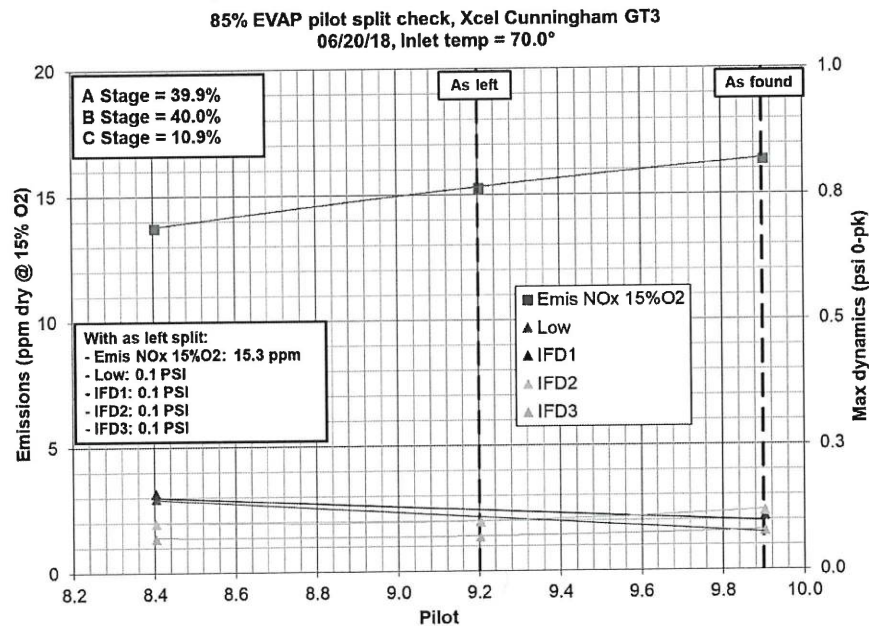



Figure 8: 85% EVAP pilot split check

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85% EVAP C stage split check, Xcel Cunningham GT3
06/20/18, Inlet temp = 70.0°

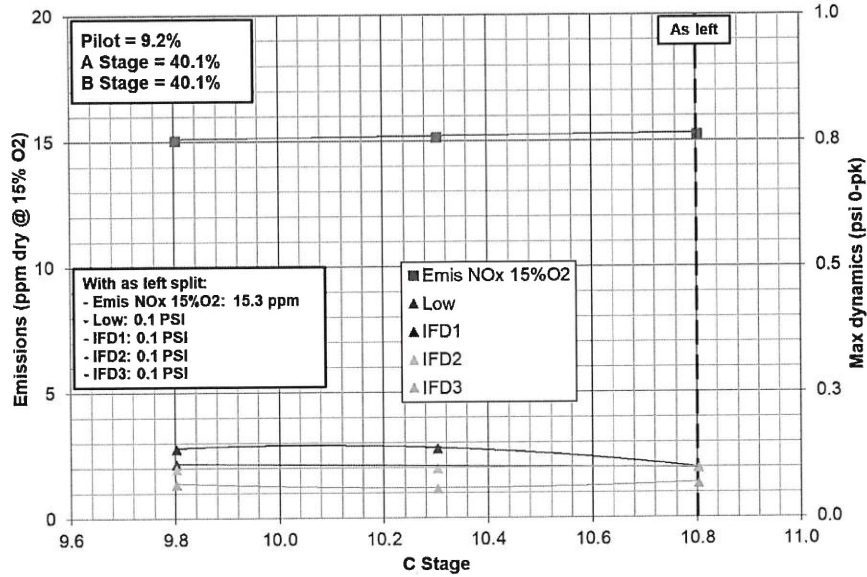


Figure 9: 85% EVAP C stg split check

85% pilot split check, Xcel Cunningham GT3
06/27/39, Inlet temp = 77.4°

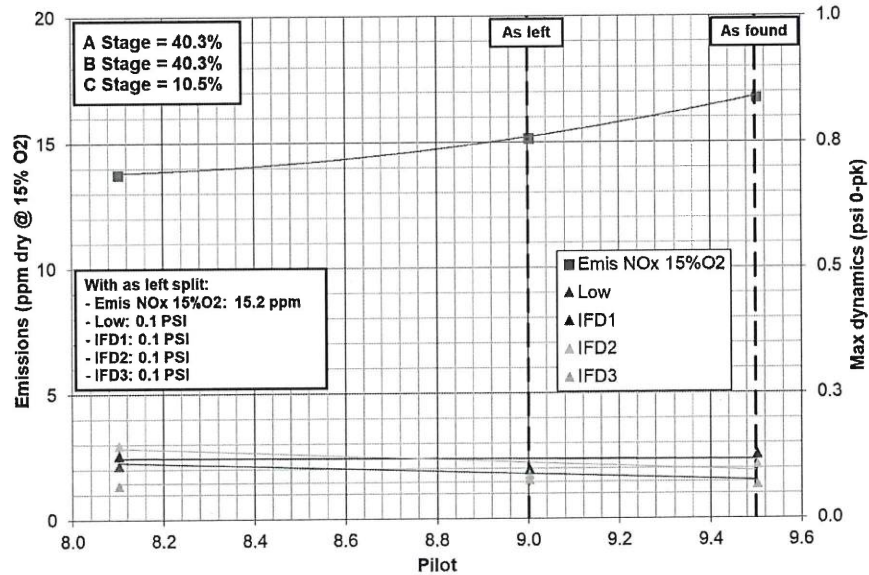



Figure 10: 85% DRY pilot split check

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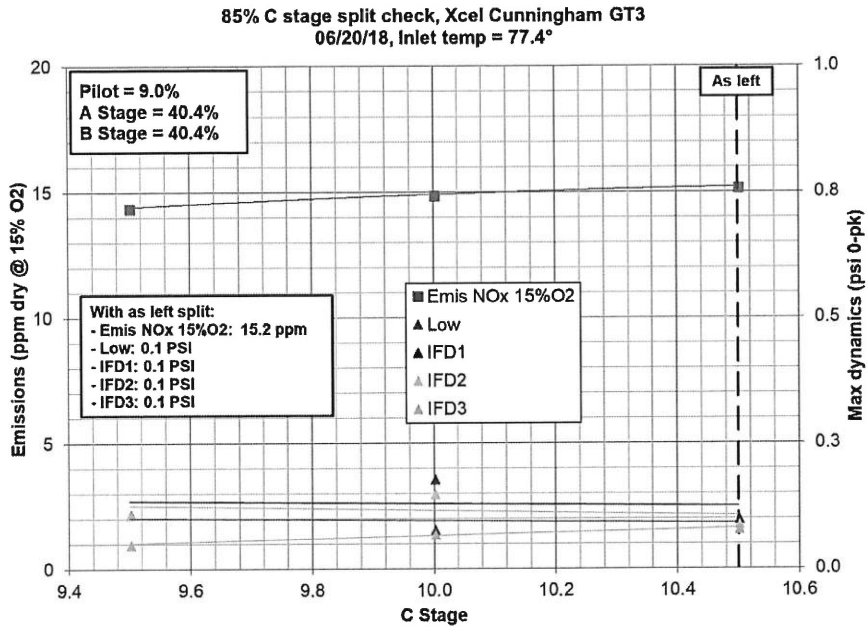


Figure 11: 85% DRY C stg split check

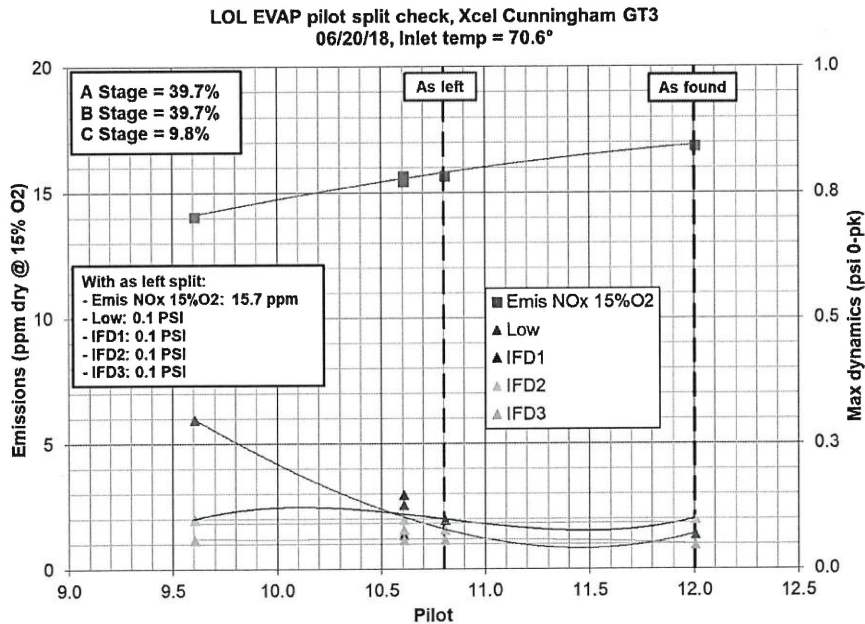



Figure 12: LOL EVAP pilot split check

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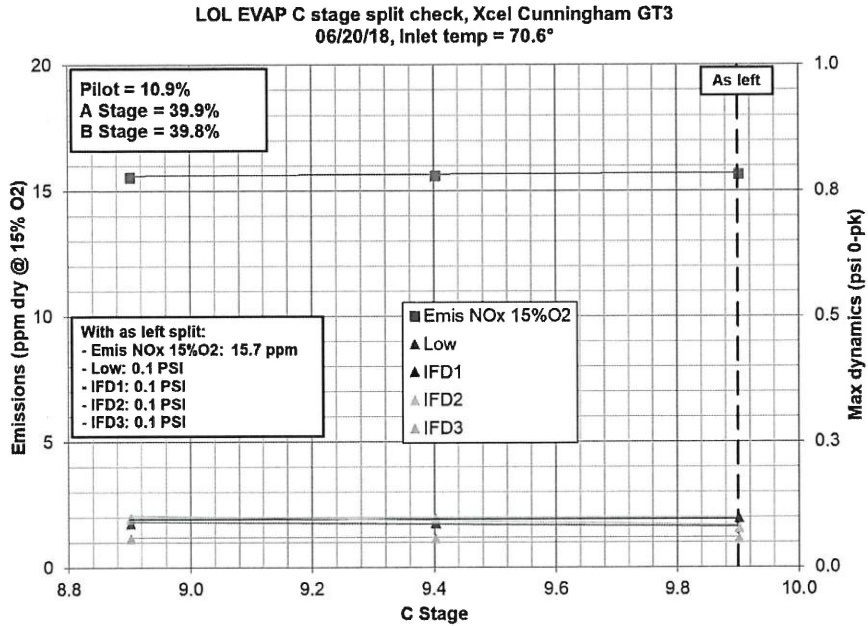


Figure 13: LOL EVAP C stg split check

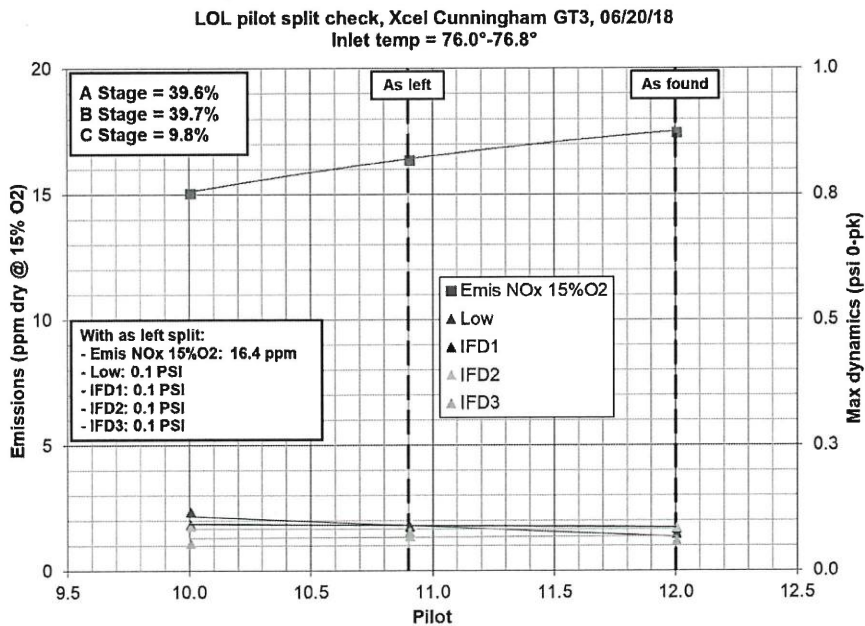



Figure 14: LOL DRY pilot split check

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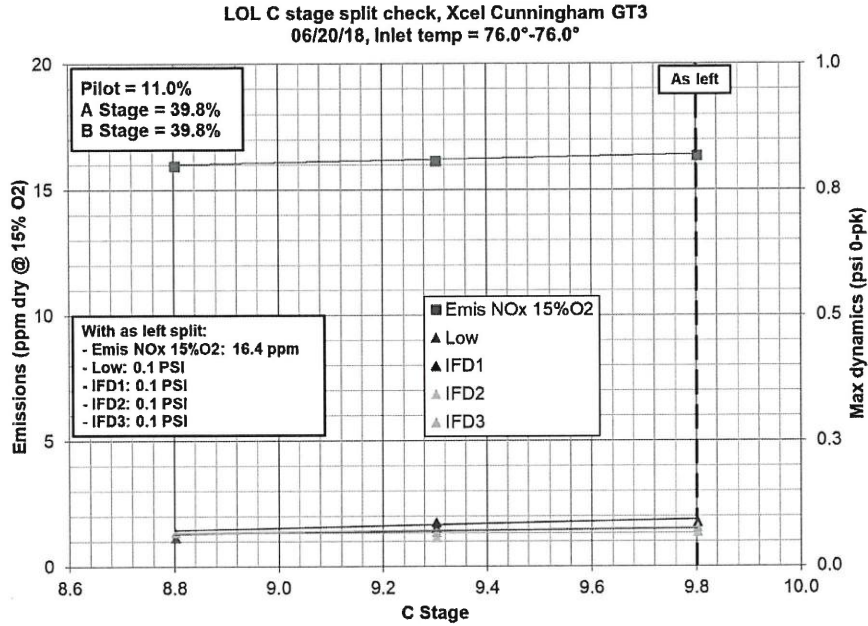


Figure 15: LOL DRY C stg split check

10.2 Run Log Sheets

Located at the following location on the PSM corporate server:

R:\06-Tuning\W501D&F_tuning\Xcel Energy - Cunningham_Hobbs\GT3\2018-06-19 Tuning

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Cunningham / GT3

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Wayne Roznowski

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Service Eng

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Tags-->FE451475XQ07460015XQC MK401EU902A XQ01 M8A10EG90145310 XQ03B30CF001R XQ11BP21CF001R XQ022CF001R X

Point attributes	Description	Date	Start time	End time	Inlet temp °F	Load actual MW	Normalized Load %	Inlet guide vane deg	IGV/LIN %	Pilot %	A Stage %	B Stage %
BLW, BLWP, AFW, ALW	Baseload WET, As Found, As Left	6/19/2018	10:16:00	10:21:00	69.80	105.20	115.00	-4.00	100.00	17.40	38.50	38.50
BLW, BLWP	Baseload WET, -1.1 Pilot	6/19/2018	10:36:00	10:41:00	69.80	105.20	115.00	-4.00	100.00	15.90	39.00	39.00
BLW, BLWP	Baseload WET, -0.5 Pilot	6/19/2018	10:45:00	10:50:00	69.80	105.20	115.00	-4.00	100.00	16.50	38.70	38.90
BL, BLP, BLC, AF, AL	Baseload, As Found, As Left	6/20/2018	08:07:00	08:09:00	77.45	88.33	99.70	-4.00	100.00	7.00	40.50	40.50
BL, BLP	Baseload, -1.2 Pilot	6/20/2018	08:31:00	08:33:00	78.35	87.80	99.70	-4.00	100.00	5.80	41.10	41.10
BL, BLP	Baseload, -0.6 Pilot	6/20/2018	08:41:00	08:43:00	78.35	87.80	99.70	-4.00	100.00	6.37	40.70	40.80
BL, BLC	Baseload, -0.5 Cstg	6/20/2018	09:04:00	09:06:00	78.70	88.00	99.70	-4.00	100.00	7.00	40.80	40.80
BL, BLC	Baseload, -1.0 Cstg	6/20/2018	09:08:00	09:10:00	78.70	88.00	99.70	-4.00	100.00	7.00	40.80	40.80
85L, 85P, AF	85%, As Found	6/20/2018	09:24:00	09:26:00	77.40	75.50	85.00	18.20	44.30	9.50	40.00	40.00
85L, 85P	85%, -1.6 Pilot	6/20/2018	09:51:00	09:53:00	77.40	75.50	85.00	18.20	44.30	8.10	40.70	40.70
85L, 85P, 85C, AL	85%, -0.6 Pilot, As Left	6/20/2018	09:59:00	10:01:00	77.40	75.50	85.00	18.20	44.30	9.00	40.20	40.20
85L, 85C	85%, -0.5 Cstg	6/20/2018	10:08:00	10:10:00	77.40	75.50	85.00	18.20	44.30	9.00	40.40	40.40
85L, 85C	85%, -1.0 Cstg	6/20/2018	10:16:00	10:18:00	77.40	75.50	85.00	18.20	44.30	9.10	40.60	40.60
LOL, LOLEP, AF	LOL, As Found	6/20/2018	10:50:00	10:52:00	76.80	63.30	70.90	28.40	19.00	12.00	39.20	39.10
LOL, LOLEP	LOL, -2.0 Pilot	6/20/2018	11:13:00	11:15:00	76.00	63.40	70.90	28.50	18.80	10.00	40.10	40.10
LOL, LOLEP, LOLE, AL	LOL, -1.0 Pilot, As Left	6/20/2018	11:20:00	11:22:00	76.00	63.40	70.90	28.50	18.80	10.90	39.50	39.80
LOL, LOLE	LOL, -0.5 Cstg	6/20/2018	11:25:00	11:27:00	76.00	63.40	70.90	28.50	18.80	11.00	39.60	39.60
LOL, LOLE	LOL, -1.0 Cstg	6/20/2018	11:28:00	11:30:00	76.00	63.40	70.90	28.50	18.80	11.00	40.20	39.90
90L, AL	90%, As Left	6/20/2018	12:07:00	12:09:00	75.70	71.60	80.10	23.10	32.50	9.80	40.00	40.00
90L, AL	90%, As Left	6/20/2018	12:30:00	12:32:00	75.40	79.80	89.50	13.10	32.50	8.20	40.30	40.30
BLE, BLEP, AFE	Baseload EVAP, As Found	6/20/2018	13:13:00	13:15:00	70.00	91.30	99.90	-4.00	100.00	7.90	40.40	40.40
BLE, BLEP	Baseload EVAP, -1.2 Pilot	6/20/2018	13:30:00	13:32:00	70.00	91.30	99.90	-4.00	100.00	6.60	41.00	40.90
BLE, BLEP	Baseload EVAP, -0.6 Pilot	6/20/2018	13:34:00	13:36:00	70.00	91.30	99.90	-4.00	100.00	7.20	40.60	40.70
BLE, BLEP, BLEC, ALE	Baseload EVAP, -0.2 Pilot, As Left	6/20/2018	13:41:00	13:43:00	70.00	91.30	99.90	-4.00	100.00	7.58	40.40	40.40
BLE, BLEC	Baseload EVAP, -0.5 Pilot	6/20/2018	13:44:00	13:46:00	70.00	91.30	99.90	-4.00	100.00	7.60	40.80	40.60
BLE, BLEC	Baseload EVAP, -1.0 Cstg	6/20/2018	13:47:00	13:49:00	70.00	91.30	99.90	-4.00	100.00	7.60	40.90	40.90
85LE, 85LEP, AFE	85% EVAP, As Found	6/20/2018	14:08:00	14:10:00	70.00	77.60	84.20	18.50	44.30	9.90	39.60	39.60
85LE, 85LEP	85% EVAP, -1.6 Pilot	6/20/2018	14:23:00	14:25:00	70.00	77.60	84.20	18.50	44.30	8.40	40.30	40.40
85LE, 85LEP, 85LEC, ALE	85% EVAP, -0.6 Pilot, As Left	6/20/2018	14:27:00	14:29:00	70.00	77.60	84.20	18.50	44.30	9.20	39.80	40.10
85LE, 85LEC	85% EVAP, -0.5 Cstg	6/20/2018	14:33:00	14:35:00	70.00	77.60	84.20	18.50	44.30	9.20	40.30	40.30
85LE, 85LEC	85% EVAP, -1.0 Cstg	6/20/2018	14:37:00	14:39:00	70.00	77.60	84.20	18.50	44.30	9.30	40.30	40.30
LOLE, LOLEP, AFE	LOLE EVAP, As Found	6/20/2018	14:55:00	14:57:00	70.60	65.20	71.40	28.20	19.60	12.00	39.10	39.10
LOLE, LOLEP	LOLE EVAP, -1.4 Pilot	6/20/2018	15:07:00	15:09:00	70.60	65.20	71.40	28.20	19.60	10.60	39.90	39.70
LOLE, LOLEP	LOLE EVAP, -2.4 Pilot	6/20/2018	15:13:00	15:15:00	70.60	65.20	71.40	28.20	19.60	9.60	40.30	40.30
LOLE, LOLEP	LOLE EVAP, -1.2 Pilot	6/20/2018	15:18:00	15:20:00	70.60	65.20	71.40	28.20	19.60	10.60	39.70	39.90
LOLE, LOLEP, LOLEEC, ALE	LOLE EVAP, -1.0 Pilot	6/20/2018	15:28:00	15:30:00	70.60	65.20	71.40	28.20	19.60	10.80	39.70	39.60
LOLE, LOLEEC	LOLE EVAP, -0.5 Pilot	6/20/2018	15:32:00	15:34:00	70.60	65.20	71.40	28.20	19.60	10.90	39.90	39.80
LOLE, LOLEEC	LOLE EVAP, -1.0 Pilot	6/20/2018	15:35:00	15:37:00	70.60	65.20	71.40	28.20	19.60	10.90	40.10	40.00
80LE, ALE	80% EVAP, As Left	6/20/2018	14:37:00	14:39:00	70.60	72.70	79.90	23.00	32.30	9.90	39.80	39.80
90LE, ALE	90% EVAP, As Left	6/20/2018	15:03:00	15:05:00	71.30	81.80	89.80	12.40	59.20	8.40	40.20	40.20

Tags-->3P23CF001R RQ FM45337Z002 IM20E091ZCAI02XQ03NE10CQ151XQ078A10E002A ZQMBY100T001ZQ06

Point attributes	Description	Date	Start time	End time	CStage %	CBPV %	Flashback max temp °F	Emis O2 ppm	Emis NOx 15%O2 ppm	Exhaust temp mean °F	Exhaust temp setpoint °F	Exhaust Temp variance °F
BLW, BLWP, AFW, ALW	Baseload WET, As Found, As Left	6/19/2018	10:16:00	10:21:00	6.00	0.00	13.10	14.00	23.48	1004.00	1004.00	0.00
BLW, BLWP	Baseload WET, -1.1 Pilot	6/19/2018	10:36:00	10:41:00	6.00	0.00	13.10	14.00	21.80	1004.00	1004.00	0.00
BLW, BLWP	Baseload WET, -0.5 Pilot	6/19/2018	10:45:00	10:50:00	6.00	0.00	13.10	14.00	22.45	1004.00	1004.00	0.00
BL, BLP, BLC, AF, AL	Baseload, As Found, As Left	6/20/2018	08:07:00	08:09:00	12.00	0.00	9.80	14.80	14.30	1008.00	1008.00	0.00
BL, BLP	Baseload, -1.2 Pilot	6/20/2018	08:31:00	08:33:00	12.00	0.00	9.50	14.80	11.70	1009.00	1009.00	0.00
BL, BLP	Baseload, -0.6 Pilot	6/20/2018	08:41:00	08:43:00	12.00	0.00	9.50	14.80	12.70	1009.00	1009.00	0.00
BL, BLC	Baseload, -0.5 Cstg	6/20/2018	09:04:00	09:06:00	11.50	0.00	11.40	14.85	14.17	1007.00	1007.00	0.00
BL, BLC	Baseload, -1.0 Cstg	6/20/2018	09:08:00	09:10:00	11.00	0.00	11.40	14.86	14.04	1007.00	1007.00	0.00
85L, 85P, AF	85%, As Found	6/20/2018	09:24:00	09:26:00	10.50	5.80	9.50	15.00	16.80	1006.00	1040.00	34.00
85L, 85P	85%, -1.6 Pilot	6/20/2018	09:51:00	09:53:00	10.50	5.90	8.10	14.98	13.80	1006.00	1040.00	34.00
85L, 85P, 85C, AL	85%, -0.6 Pilot, As Left	6/20/2018	09:59:00	10:01:00	10.50	5.90	8.10	15.00	15.20	1006.00	1040.00	34.00
85L, 85C	85%, -0.5 Cstg	6/20/2018	10:08:00	10:10:00	10.00	5.90	8.10	15.00	14.90	1006.00	1040.00	34.00
85L, 85C	85%, -1.0 Cstg	6/20/2018	10:16:00	10:18:00	9.50	5.90	8.10	15.00	14.40	1006.00	1040.00	34.00
LOL, LOLEP, AF	LOL, As Found	6/20/2018	10:50:00	10:52:00	9.80	15.50	11.80	15.20	17.50	989.33	1040.00	50.67
LOL, LOLEP	LOL, -2.0 Pilot	6/20/2018	11:13:00	11:15:00	9.80	16.00	10.30	15.20	15.10	985.00	1040.00	55.00
LOL, LOLEP, LOLE, AL	LOL, -1.0 Pilot, As Left	6/20/2018	11:20:00	11:22:00	9.80	16.00	10.30	15.20	16.40	985.00	1040.00	55.00
LOL, LOLE	LOL, -0.5 Cstg	6/20/2018	11:25:00	11:27:00	9.30	16.00	10.30	15.20	16.20	985.00	1040.00	55.00
LOL, LOLE	LOL, -1.0 Cstg	6/20/2018	11:28:00	11:30:00	8.90	16.00	10.30	15.20	16.00	985.00	1040.00	55.00
90L, AL	90%, As Left	6/20/2018	12:07:00	12:09:00	10.20	3.70	10.20	14.98	15.50	1005.00	1040.00	35.00
90L, AL	90%, As Left	6/20/2018	12:30:00	12:32:00	10.10	3.70	10.50	15.00	14.70	1001.00	1027.00	26.00
BLE, BLEP, AFE	Baseload EVAP, As Found	6/20/2018	13:13:00	13:15:00	11.57	0.00	11.25	14.80	15.50	1001.00	1000.00	-1.00
BLE, BLEP	Baseload EVAP, -1.2 Pilot	6/20/2018	13:30:00	13:32:00	11.60	0.00	11.25	14.80	12.98	1001.00	1000.00	-1.00
BLE, BLEP	Baseload EVAP, -0.6 Pilot	6/20/2018	13:34:00	13:36:00	11.60	0.00	11.25	14.80	13.60	1001.00	1000.00	-1.00
BLE, BLEP, BLEC, ALE	Baseload EVAP, -0.2 Pilot, As Left	6/20/2018	13:41:00	13:43:00	11.60	0.00	11.25	14.80	14.80	1001.00	1000.00	-1.00
BLE, BLEC	Baseload EVAP, -0.5 Pilot	6/20/2018	13:44:00	13:46:00	11.10	0.00	11.25	14.80	14.70	1001.00	1000.00	-1.00
BLE, BLEC	Baseload EVAP, -1.0 Cstg	6/20/2018	13:47:00	13:49:00	10.50	0.00	11.25	14.80	14.65	1001.00	1000.00	-1.00
85LE, 85LEP, AFE	85% EVAP, As Found	6/20/2018	14:08:00	14:10:00	10.90	5.80	11.16	14.95	16.40	997.50	1039.00	41.50
85LE, 85LEP	85% EVAP, -1.6 Pilot	6/20/2018	14:23:00	14:25:00	10.90			14.95	13.76			0.00
85LE, 85LEP, 85LEC, ALE	85% EVAP, -0.6 Pilot, As Left	6/20/2018	14:27:00	14:29:00	10.80			14.95	15.30			0.00
85LE, 85LEC	85% EVAP, -0.5 Cstg	6/20/2018	14:33:00	14:35:00	10.30			14.95	15.20			0.00
85LE, 85LEC	85% EVAP, -1.0 Cstg	6/20/2018	14:37:00	14:39:00	9.80			14.95	15.10			0.00
LOLE, LOLEP, AFE	LOLE EVAP, As Found	6/20/2018	14:55:00	14:57:00	9.80	15.00	11.20	15.10	16.90	987.80	1040.00	52.20
LOLE, LOLEP	LOLE EVAP, -1.4 Pilot	6/20/2018	15:07:00	15:09:00	9.80			15.10	15.68			0.00
LOLE, LOLEP	LOLE EVAP, -2.4 Pilot	6/20/2018	15:13:00	15:15:00	9.80			15.10	14.10			0.00
LOLE, LOLEP	LOLE EVAP, -1.2 Pilot	6/20/2018	15:18:00	15:20:00	9.80			15.15	15.50			0.00
LOLE, LOLEP, LOLEEC, ALE	LOLE EVAP, -1.0 Pilot	6/20/2018	15:28:00	15:30:00	9.90			15.11	15.70			0.00
LOLE, LOLEEC	LOLE EVAP, -0.5 Pilot	6/20/2018	15:32:00	15:34:00	9.40			15.11	15.65			0.00
LOLE, LOLEEC	LOLE EVAP, -1.0 Pilot	6/20/2018	15:35:00	15:37:00	8.90			15.11	15.60			0.00



Plant / Unit
Cunningham / GT3

Author
Wayne Roznowski


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001227

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Point attributes	Description	Date	Start time	End time	Blade path average	Blade path spread	Blade path variance	Compressor discharge pres	Compressor discharge temp	Fuel flow P	Fuel flow A	Fuel flow B
					°/°	°/°	°/°	psi	°	KPPH	KPPH	KPPH
BLW, BLWP, AFW, ALW	Baseload WET, As Found, As Left	6/19/2018	10:16:00	10:21:00	1038.00	23.70	37.90	192.60	693.20	9.18	20.70	20.70
BLW, BLWP	Baseload WET, -1.1 Pilot	6/19/2018	10:36:00	10:41:00	1038.00	23.70	37.90	192.60	693.20	9.18	20.70	20.70
BLW, BLWP	Baseload WET, -0.5 Pilot	6/19/2018	10:45:00	10:50:00	1038.00	23.70	37.90	192.60	693.20	9.18	20.70	20.70
BL, BLP, BLC, AF, AL	Baseload, As Found, As Left	6/20/2018	08:07:00	08:09:00	1039.00	29.80	30.10	182.60	784.10	3.20	18.70	18.70
BL, BLP	Baseload, -1.2 Pilot	6/20/2018	08:31:00	08:33:00	1039.00	29.10	30.20	182.10	785.60	2.70	18.90	18.90
BL, BLP	Baseload, -0.6 Pilot	6/20/2018	08:41:00	08:43:00	1039.00	29.10	30.20	182.10	785.60	2.70	18.90	18.90
BL, BLC	Baseload, -2.0 Cstg	6/20/2018	09:04:00	09:06:00	1038.00	30.30	30.30	182.90	786.10	3.20	18.80	18.80
BL, BLC	Baseload, -1.0 Cstg	6/20/2018	09:08:00	09:10:00								
85L, 85P, AF	85%, As Found	6/20/2018	09:24:00	09:26:00	1039.00	21.90	20.50	163.20	752.10	3.90	16.40	16.40
85L, 85P	85%, -1.6 Pilot	6/20/2018	09:51:00	09:53:00								
85L, 85P, 85C, AL	85%, -0.6 Pilot, As Left	6/20/2018	09:59:00	10:01:00								
85L, 85C	85%, -0.5 Cstg	6/20/2018	10:08:00	10:10:00								
85L, 85C	85%, -1.0 Cstg	6/20/2018	10:16:00	10:18:00								
LOL, LO1P, AF	LOL, As Found	6/20/2018	10:50:00	10:52:00	1007.00	33.70	20.00	147.60	722.90	4.33	14.10	14.10
LOL, LO1P	LOL, -2.0 Pilot	6/20/2018	11:13:00	11:15:00	1002.00	31.50	19.20	147.90	719.90	3.62	14.50	14.50
LOL, LO1P, LO1C, AL	LOL, -1.0 Pilot, As Left	6/20/2018	11:20:00	11:22:00								
LOL, LO1C	LOL, -0.5 Cstg	6/20/2018	11:25:00	11:27:00								
LOL, LO1C	LOL, -1.0 Cstg	6/20/2018	11:28:00	11:30:00								
80L, AL	80%, As Left	6/20/2018	12:07:00	12:09:00	1036.00	32.60	18.40	157.30	735.00	3.90	15.80	15.80
90L, AL	90%, As Left	6/20/2018	12:30:00	12:32:00	1036.00	17.20	26.60	170.10	752.00	3.40	17.40	17.40
BLE, BLEP, AFE	Baseload EVAP, As Found	6/20/2018	13:13:00	13:15:00	1033.00	31.80	32.50	186.20	772.80	3.70	19.20	19.20
BLE, BLEP	Baseload EVAP, -1.2 Pilot	6/20/2018	13:30:00	13:32:00	1033.00	31.80	32.50	186.20	772.80	3.70	19.20	19.20
BLE, BLEP	Baseload EVAP, -0.6 Pilot	6/20/2018	13:34:00	13:36:00	1033.00	31.80	32.50	186.20	772.80	3.70	19.20	19.20
BLE, BLEP, BLEC, ALE	Baseload EVAP, -0.2 Pilot, As Left	6/20/2018	13:41:00	13:43:00	1033.00	31.80	32.50	186.20	772.80	3.70	19.20	19.20
BLE, BLEC	Baseload EVAP, -0.5 Pilot	6/20/2018	13:44:00	13:46:00	1033.00	31.80	32.50	186.20	772.80	3.70	19.20	19.20
BLE, BLEC	Baseload EVAP, -1.0 Cstg	6/20/2018	13:47:00	13:49:00	1033.00	31.80	32.50	186.20	772.80	3.70	19.20	19.20
85LE, 85LEP, AFE	85% EVAP, As Found	6/20/2018	14:08:00	14:10:00	1030.00	23.40	20.70	165.50	739.10	4.12	16.60	16.60
85LE, 85LEP	85% EVAP, -1.6 Pilot	6/20/2018	14:23:00	14:25:00								
85LE, 85LEP, 85LEC, ALE	85% EVAP, -0.6 Pilot, As Left	6/20/2018	14:27:00	14:29:00								
85LE, 85LEC	85% EVAP, -0.5 Cstg	6/20/2018	14:33:00	14:35:00								
85LE, 85LEC	85% EVAP, -1.0 Cstg	6/20/2018	14:37:00	14:39:00								
LOLE, LOLEP, AFE	LOLE EVAP, As Found	6/20/2018	14:55:00	14:57:00	1007.00	32.70	19.80	149.30	715.70	4.40	14.40	14.40
LOLE, LOLEP	LOLE EVAP, -1.4 Pilot	6/20/2018	15:07:00	15:09:00								
LOLE, LOLEP	LOLE EVAP, -2.4 Pilot	6/20/2018	15:13:00	15:15:00								
LOLE, LOLEP	LOLE EVAP, -1.2 Pilot	6/20/2018	15:18:00	15:20:00								
LOLE, LOLEP, LOLEEC, ALE	LOLE EVAP, -1.0 Pilot	6/20/2018	15:28:00	15:30:00								
LOLE, LOLEEC	LOLE EVAP, -0.5 Pilot	6/20/2018	15:32:00	15:34:00								
LOLE, LOLEEC	LOLE EVAP, -1.0 Pilot	6/20/2018	15:35:00	15:37:00								
80LE, ALE	80% EVAP, As Left	6/20/2018	14:37:00	14:39:00	1039.00	32.10	19.90	157.60	727.60	4.00	15.90	16.00
90LE, ALE	90% EVAP, As Left	6/20/2018	15:03:00	15:05:00	1035.00	18.00	27.00	171.00	748.00	3.70	17.60	17.60

Point attributes	Description	Date	Start time	End time	Fuel gas flow			Fuel gas pres			Viv Pos 1	Viv Pos 2	Viv Pos 3	Viv Pos 4	Low
					total	ABC	ABC	ABC	ABC	ABC					
					KPPH	°/°	psi	psi	psi	psi	psi	psi	psi	psi	psi
BLW, BLWP, AFW, ALW	Baseload WET, As Found, As Left	6/19/2018	10:16:00	10:21:00	3.20	53.65	68.50	332.10	51.00	47.10	45.90	30.60	30.60	0.07	
BLW, BLWP	Baseload WET, -1.1 Pilot	6/19/2018	10:36:00	10:41:00	3.20	53.65	68.50	332.10	48.60	47.60	46.40	30.70	30.70	0.27	
BLW, BLWP	Baseload WET, -0.5 Pilot	6/19/2018	10:45:00	10:50:00	3.20	53.65	68.50	332.10	50.10	47.60	46.20	30.80	30.80	0.13	
BL, BLP, BLC, AF, AL	Baseload, As Found, As Left	6/20/2018	08:07:00	08:09:00	5.50	46.20	67.20	344.30	28.50	42.40	41.10	38.00	38.00	0.08	
BL, BLP	Baseload, -1.2 Pilot	6/20/2018	08:31:00	08:33:00	5.50	45.90	67.20	344.70	26.00	42.60	41.30	37.80	37.80	0.12	
BL, BLP	Baseload, -0.6 Pilot	6/20/2018	08:41:00	08:43:00	5.50	45.90	67.20	344.70	27.20	42.40	41.10	37.80	37.80	0.10	
BL, BLC	Baseload, -0.5 Cstg	6/20/2018	09:04:00	09:06:00					28.60	42.90	41.70	37.40	37.40	0.07	
BL, BLC	Baseload, -1.0 Cstg	6/20/2018	09:08:00	09:10:00					28.60	43.10	41.80	36.60	36.60	0.07	
85L, 85P, AF	85%, As Found	6/20/2018	09:24:00	09:26:00	4.30	41.00	67.80	350.00	30.40	38.60	37.30	33.20	33.20	0.07	
85L, 85P	85%, -1.6 Pilot	6/20/2018	09:51:00	09:53:00					28.10	39.00	37.80	33.20	33.20	0.11	
85L, 85P, 85C, AL	85%, -0.6 Pilot, As Left	6/20/2018	09:59:00	10:01:00					29.80	38.60	37.40	33.20	33.20	0.10	
85L, 85C	85%, -0.5 Cstg	6/20/2018	10:08:00	10:10:00					29.80	38.80	37.70	32.50	32.50	0.08	
85L, 85C	85%, -1.0 Cstg	6/20/2018	10:16:00	10:18:00					29.80	38.90	37.80	31.80	31.80	0.11	
LOL, LO1P, AF	LOL, As Found	6/20/2018	10:50:00	10:52:00	3.50	36.20	68.50	353.50	31.50	35.40	34.10	30.20	30.20	0.08	
LOL, LO1P	LOL, -2.0 Pilot	6/20/2018	11:13:00	11:15:00	3.50	36.20	68.50	352.70	29.20	35.90	34.80	30.23	30.23	0.12	
LOL, LO1P, LO1C, AL	LOL, -1.0 Pilot, As Left	6/20/2018	11:20:00	11:22:00					30.40	35.60	34.50	30.20	30.20	0.07	
LOL, LO1C	LOL, -0.5 Cstg	6/20/2018	11:25:00	11:27:00					30.40	35.70	34.50	29.60	29.60	0.08	
LOL, LO1C	LOL, -1.0 Cstg	6/20/2018	11:28:00	11:30:00					30.40	35.90	34.70	29.00	29.00	0.06	
80L, AL	80%, As Left	6/20/2018	12:07:00	12:09:00	4.00	39.50	69.60	348.50	30.30	37.80	36.70	32.37	32.37	0.10	
90L, AL	90%, As Left	6/20/2018	12:30:00	12:32:00	4.70	43.00	69.60	345.70	29.30	40.30	39.20	35.00	35.00	0.08	
BLE, BLEP, AFE	Baseload EVAP, As Found	6/20/2018	13:13:00	13:15:00	5.50	47.70	69.60	340.20	30.60	43.80	42.40	38.30	38.30	0.08	
BLE, BLEP	Baseload EVAP, -1.2 Pilot	6/20/2018	13:30:00	13:32:00	5.50	47.70	69.60	340.20	28.30	44.40	43.00	38.40	38.40	0.10	
BLE, BLEP	Baseload EVAP, -0.6 Pilot	6/20/2018	13:34:00	13:36:00	5.50	47.70	69.60	340.20	29.50	44.00	42.60	38.30	38.30	0.08	
BLE, BLEP, BLEC, ALE	Baseload EVAP, -0.2 Pilot, As Left	6/20/2018	13:41:00	13:43:00	5.50	47.70	69.60	340.20	30.20	43.90	42.50	38.30	38.30	0.08	
BLE, BLEC	Baseload EVAP, -0.5 Pilot	6/20/2018	13:44:00	13:46:00	5.50	47.70	69.60	340.20	30.30	44.20	42.80	37.60	37.60	0.10	
BLE, BLEC	Baseload EVAP, -1.0 Cstg	6/20/2018	13:47:00	13:49:00	5.50	47.70	69.60	340.20	30.20	44.30	43.00	36.70	36.70	0.11	
85LE, 85LEP, AFE	85% EVAP, As Found	6/20/2018	14:08:00	14:10:00	4.50	41.90	70.60	347.70	31.40	39.00	37.70	34.20	34.20	0.08	
85LE, 85LEP	85% EVAP, -1.6 Pilot	6/20/2018	14:23:00	14:25:00					28.90	39.40	38.20	34.20	34.20	0.15	
85LE, 85LEP, 85LEC, ALE	85% EVAP, -0.6 Pilot, As Left	6/20/2018	14:27:00	14:29:00					30.40	39.20	37.69	34.20	34.20	0.10	
85LE, 85LEC	85% EVAP, -0.5 Cstg	6/20/2018	14:33:00	14:35:00					30.50	39.40	38.00	33.50	33.50	0.10	
85LE, 85LEC	85% EVAP, -1.0 Cstg	6/20/2018	14:37:00	14:39:00					30.60	39.60	38.40	32.80	32.80	0.11	
LOLE, LOLEP, AFE	LOLE EVAP, As Found	6/20/2018	14:55:00	14:57:00	3.60	36.80	70.80	347.80	32.10	36.10	34.80	30.70	30.70	0.07</	

	Plant / Unit	Report No.		
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Point attributes	Description	Date	Start time	End time	Tags ->			FT45932 XQ01	PT45944 XQ01	PM45944 ZQ03	TE45117 XQ01
					IFD1	IFD2	IFD3	Wet Compression	Wet Compression	Wet Compression	DC2-1
					PSI	PSI	PSI	Water Flow	Water Pressure	Valve Pos	°F
BLW, BLWP, AFW, ALW	Baseload WET, As Found, As Left	6/19/2018	10:16:00	10:21:00	0.08	0.15	0.04	91.53	200.00	12.80	691.00
BLW, BLWP	Baseload WET, -1.1 Pilot	6/19/2018	10:36:00	10:41:00	0.16	0.24	0.04	91.40	199.40	12.85	691.00
BLW, BLWP	Baseload WET, -0.5 Pilot	6/19/2018	10:45:00	10:50:00	0.14	0.20	0.04	91.20	200.00	12.86	691.00
BL, BLP, BLC, AF, AL	Baseload, As Found, As Left	6/20/2018	08:07:00	08:09:00	0.17	0.14	0.05	13.54	17.70	100.00	693.00
BL, BLP	Baseload, -1.2 Pilot	6/20/2018	08:31:00	08:33:00	0.22	0.22	0.05				
BL, BLP	Baseload, -0.6 Pilot	6/20/2018	08:41:00	08:43:00	0.17	0.15	0.05				
BL, BLC	Baseload, -0.5 Cstg	6/20/2018	09:04:00	09:06:00	0.15	0.17	0.05				
BL, BLC	Baseload, -1.0 Cstg	6/20/2018	09:08:00	09:10:00	0.12	0.17	0.05				
85L, 85P, AF	85%, As Found	6/20/2018	09:24:00	09:26:00	0.13	0.11	0.07				671.00
85L, 85P	85%, -1.6 Pilot	6/20/2018	09:51:00	09:53:00	0.13	0.15	0.07				
85L, 85P, 85C, AL	85%, -0.6 Pilot, As Left	6/20/2018	09:59:00	10:01:00	0.10	0.09	0.08				
85L, 85C	85%, -0.5 Cstg	6/20/2018	10:08:00	10:10:00	0.18	0.15	0.07				
85L, 85C	85%, -1.0 Cstg	6/20/2018	10:16:00	10:18:00	0.11	0.11	0.05				
LOL, LOLP, AF	LOL, As Found	6/20/2018	10:50:00	10:52:00	0.09	0.09	0.06				
LOL, LOLP	LOL, -2.0 Pilot	6/20/2018	11:13:00	11:15:00	0.09	0.09	0.06				
LOL, LOLP, LOLC, AL	LOL, -1.0 Pilot, As Left	6/20/2018	11:20:00	11:22:00	0.09	0.07	0.08				
LOL, LOLC	LOL, -0.5 Cstg	6/20/2018	11:25:00	11:27:00	0.09	0.06	0.07				
LOL, LOLC	LOL, -1.0 Cstg	6/20/2018	11:28:00	11:30:00	0.07	0.07	0.07				
80L, AL	80%, As Left	6/20/2018	12:07:00	12:09:00	0.11	0.10	0.06				
90L, AL	90%, As Left	6/20/2018	12:30:00	12:32:00	0.14	0.10	0.05				685.00
BLE, BLEP, AFE	Baseload EVAP, As Found	6/20/2018	13:13:00	13:15:00	0.15	0.13	0.05				
BLE, BLEP	Baseload EVAP, -1.2 Pilot	6/20/2018	13:30:00	13:32:00	0.16	0.24	0.05				
BLE, BLEP	Baseload EVAP, -0.6 Pilot	6/20/2018	13:34:00	13:36:00	0.17	0.15	0.04				
BLE, BLEP, BLEC, ALE	Baseload EVAP, -0.2 Pilot, As Left	6/20/2018	13:41:00	13:43:00	0.12	0.13	0.05				
BLE, BLEC	Baseload EVAP, -0.5 Pilot	6/20/2018	13:44:00	13:46:00	0.13	0.13	0.05				
BLE, BLEC	Baseload EVAP, -1.0 Cstg	6/20/2018	13:47:00	13:49:00	0.16	0.16	0.05				
85LE, 85LEP, AFE	85% EVAP, As Found	6/20/2018	14:08:00	14:10:00	0.11	0.12	0.08				
85LE, 85LEP	85% EVAP, -1.6 Pilot	6/20/2018	14:23:00	14:25:00	0.16	0.10	0.07				
85LE, 85LEP, 85LEC, ALE	85% EVAP, -0.6 Pilot, As Left	6/20/2018	14:27:00	14:29:00	0.10	0.10	0.07				
85LE, 85LEC	85% EVAP, -0.5 Cstg	6/20/2018	14:33:00	14:35:00	0.14	0.10	0.06				
85LE, 85LEC	85% EVAP, -1.0 Cstg	6/20/2018	14:37:00	14:39:00	0.14	0.10	0.07				
LOLE, LOLEP, AFE	LOL EVAP, As Found	6/20/2018	14:55:00	14:57:00	0.10	0.10	0.05				
LOLE, LOLEP	LOL EVAP, -1.4 Pilot	6/20/2018	15:07:00	15:09:00	0.15	0.10	0.06				
LOLE, LOLEP	LOL EVAP, -2.4 Pilot	6/20/2018	15:13:00	15:15:00	0.10	0.10	0.06				
LOLE, LOLEP	LOL EVAP, -1.2 Pilot	6/20/2018	15:18:00	15:20:00	0.07	0.08	0.06				
LOLE, LOLEP, LOLEC, ALE	LOL EVAP, -1.0 Pilot	6/20/2018	15:28:00	15:30:00	0.10	0.08	0.06				
LOLE, LOLEC	LOL EVAP, -0.5 Pilot	6/20/2018	15:32:00	15:34:00	0.09	0.10	0.06				
LOLE, LOLEC	LOL EVAP, -1.0 Pilot	6/20/2018	15:35:00	15:37:00	0.10	0.10	0.06				
80LE, ALE	80% EVAP, As Left	6/20/2018	14:37:00	14:39:00	0.13	0.08	0.07				
90LE, ALE	90% EVAP, As Left	6/20/2018	15:03:00	15:05:00	0.11	0.13	0.05				

Point attributes	Description	Date	Start time	End time	Tags ->			
					DC2-2	DC3-1	DC3-2	DC4-01
					°F	°F	°F	°F
BLW, BLWP, AFW, ALW	Baseload WET, As Found, As Left	6/19/2018	10:16:00	10:21:00	691.00	636.00	540.00	551.00
BLW, BLWP	Baseload WET, -1.1 Pilot	6/19/2018	10:36:00	10:41:00	691.00	636.00	540.00	551.00
BLW, BLWP	Baseload WET, -0.5 Pilot	6/19/2018	10:45:00	10:50:00	691.00	636.00	540.00	551.00
BL, BLP, BLC, AF, AL	Baseload, As Found, As Left	6/20/2018	08:07:00	08:09:00	693.00	632.00	640.00	588.00
BL, BLP	Baseload, -1.2 Pilot	6/20/2018	08:31:00	08:33:00				
BL, BLP	Baseload, -0.6 Pilot	6/20/2018	08:41:00	08:43:00				
BL, BLC	Baseload, -0.5 Cstg	6/20/2018	09:04:00	09:06:00				
BL, BLC	Baseload, -1.0 Cstg	6/20/2018	09:08:00	09:10:00				
85L, 85P, AF	85%, As Found	6/20/2018	09:24:00	09:26:00	671.00	617.00	626.00	590.00
85L, 85P	85%, -1.6 Pilot	6/20/2018	09:51:00	09:53:00				
85L, 85P, 85C, AL	85%, -0.6 Pilot, As Left	6/20/2018	09:59:00	10:01:00				
85L, 85C	85%, -0.5 Cstg	6/20/2018	10:08:00	10:10:00				
85L, 85C	85%, -1.0 Cstg	6/20/2018	10:16:00	10:18:00				
LOL, LOLP, AF	LOL, As Found	6/20/2018	10:50:00	10:52:00				
LOL, LOLP	LOL, -2.0 Pilot	6/20/2018	11:13:00	11:15:00				
LOL, LOLP, LOLC, AL	LOL, -1.0 Pilot, As Left	6/20/2018	11:20:00	11:22:00				
LOL, LOLC	LOL, -0.5 Cstg	6/20/2018	11:25:00	11:27:00				
LOL, LOLC	LOL, -1.0 Cstg	6/20/2018	11:28:00	11:30:00				
80L, AL	80%, As Left	6/20/2018	12:07:00	12:09:00				
90L, AL	90%, As Left	6/20/2018	12:30:00	12:32:00				
BLE, BLEP, AFE	Baseload EVAP, As Found	6/20/2018	13:13:00	13:15:00	685.00	629.00	621.00	579.00
BLE, BLEP	Baseload EVAP, -1.2 Pilot	6/20/2018	13:30:00	13:32:00				
BLE, BLEP	Baseload EVAP, -0.6 Pilot	6/20/2018	13:34:00	13:36:00				
BLE, BLEP, BLEC, ALE	Baseload EVAP, -0.2 Pilot, As Left	6/20/2018	13:41:00	13:43:00				
BLE, BLEC	Baseload EVAP, -0.5 Pilot	6/20/2018	13:44:00	13:46:00				
BLE, BLEC	Baseload EVAP, -1.0 Cstg	6/20/2018	13:47:00	13:49:00				
85LE, 85LEP, AFE	85% EVAP, As Found	6/20/2018	14:08:00	14:10:00				
85LE, 85LEP	85% EVAP, -1.6 Pilot	6/20/2018	14:23:00	14:25:00				
85LE, 85LEP, 85LEC, ALE	85% EVAP, -0.6 Pilot, As Left	6/20/2018	14:27:00	14:29:00				
85LE, 85LEC	85% EVAP, -0.5 Cstg	6/20/2018	14:33:00	14:35:00				
85LE, 85LEC	85% EVAP, -1.0 Cstg	6/20/2018	14:37:00	14:39:00				
LOLE, LOLEP, AFE	LOL EVAP, As Found	6/20/2018	14:55:00	14:57:00				
LOLE, LOLEP	LOL EVAP, -1.4 Pilot	6/20/2018	15:07:00	15:09:00				
LOLE, LOLEP	LOL EVAP, -2.4 Pilot	6/20/2018	15:13:00	15:15:00				
LOLE, LOLEP	LOL EVAP, -1.2 Pilot	6/20/2018	15:18:00	15:20:00				
LOLE, LOLEP, LOLEC, ALE	LOL EVAP, -1.0 Pilot	6/20/2018	15:28:00	15:30:00				
LOLE, LOLEC	LOL EVAP, -0.5 Pilot	6/20/2018	15:32:00	15:34:00				
LOLE, LOLEC	LOL EVAP, -1.0 Pilot	6/20/2018	15:35:00	15:37:00				
80LE, ALE	80% EVAP, As Left	6/20/2018	14:37:00	14:39:00				
90LE, ALE	90% EVAP, As Left	6/20/2018	15:03:00	15:05:00				

Table 23: Log Sheet

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	Plant / Unit		Report No.	
	Cunningham / GT3		001227	
CFSR	Author	Department	Date	Page
	Wayne Roznowski	Service Eng	6/26/2018	29 / 29

10.3 Run Program

Times indicated are estimated durations prior to tuning.

Xcel Cunningham GT3 & GT4 - W501F				
Run Program June 19-21, 2018				
Run Point	Load Range	%Load	Duration	Comments
	MW	%	min	
6/19/2018 GT3 & 4 Wet Compression Split Check				
1	105	115%	60	GT3 100% Load WET Split Check
2	105	115%	60	GT4 100% Load WET Split Check
Run time at base load			120	
6/20/2018 GT3 EVAP and Dry Tuning				
1	90	100%	60	100% Load Split Check
Run time at base load			60	
2	150	85%	60	85% Load Split Check
3	124	70%	60	70% Load Split Check
4	141	80%	10	80% Load As Left
5	159	90%	10	90% Load As Left
1	105	100%	60	100% Load EVAP Split Check
2	150	85%	60	85% Load EVAP Split Check
3	124	70%	60	70% Load EVAP Split Check
4	141	80%	10	80% Load EVAP As Left
5	159	90%	10	90% Load EVAP As Left
Run time at part load			140	
6/21/2018 GT4 EVAP and Dry Tuning				
1	105	100%	60	100% Load Split Check
Run time at base load			60	
2	150	85%	60	85% Load Split Check
3	124	70%	60	70% Load Split Check
4	141	80%	10	80% Load As Left
5	159	90%	10	90% Load As Left
1	105	100%	60	100% Load EVAP Split Check
2	150	85%	60	85% Load EVAP Split Check
3	124	70%	60	70% Load EVAP Split Check
4	141	80%	10	80% Load EVAP As Left
5	159	90%	10	90% Load EVAP As Left
Run time at part load			140	
Total Test Time			9:00	Hours

Table 24: Run program

PROPRIETARY INFORMATION

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Appendix C

Combustion Turbine

Unit Operating Hours Summary

(example)

STARTS / STOPS	Outage	Dec 2010
NORMAL STARTS	63	154 %
EQUIVALENT STARTS	785	793 %
FIRED ABORTS	6	11 %
UNFIRED ABORTS	1	7 %
NORMAL STOPS	55	151 %

TRIPS FROM LOAD	Count	%
50% < LOAD	7	9 %
30% < LOAD < 50%	0	1 %
15% < LOAD < 30%	0	1 %
LOAD < 15%	144	388 %
TOTAL TRIPS FROM LOAD	151	399 %

MW TOTALIZER
0.00 MW
TOT RST

MW LAST CAPTURED
0.00 MW
CAP RSET

CAP RSET

OPR CAP

TOTAL MINUS CAPTURED
0.00 MW

OPERATING HOURS	timer accuracy, test	Outage	Dec 2010
EXHAUST TEMP < 850 °F	812 hours	151	197 %
850 °F < EXHAUST TEMP < 950 °F		88.9	144.3 %
950 °F < EXHAUST TEMP < 1000 °F		2244.7	2398.3 %
1000 °F < EXHAUST TEMP < 1100 °F		745.3	1586.7 %
1100 °F < EXHAUST TEMP < 1160 °F		0	143.4 %
1160 °F < EXHAUST TEMP		0	143.4 %
FIRED HOURS		131	342 %

MISCELLANEOUS COUNTERS	Count	%
PURGE CYCLES	56	110 %
THERMAL CYCLES	26	80 %

MISCELLANEOUS TIMERS	Count	Unit
TIME UNDER OVERFREQUENCY	0	SEC
TIME UNDER FREQUENCY	1261	SEC
TIME SINCE THIS LAST START	0	HR
MORE THAN 1 BLADE PATH TC FAILED	5.5	HR
ON TURNING GEAR HOURS	8089.1	HR
	30645.8	HR

CT TRIP

SPEED 0 RPM CT MW 0 MW CEMS NOX 3404.2 % CEMS O2 20.9 % EXH TEMP 44 °F BP AVG 43 °F BP SPREAD 0 °F IGV POSN 11.8 Deg T2C 44.9 °F T2C 12.2 PSIA INLET TEMP 59 °F NORM LOAD 0 %

SHUTDOWN COMPLETE

CHC 3

GAS TURBINE OVERVIEW

STARTS / STOPS Outage Dec 2010

NORMAL STARTS	312	401	%
EQUIVALENT STARTS	1784	3109	%
FRED ABORTS	26	36	%
UNFRED ABORTS	31	46	%
NORMAL STOPS	263	341	%

MW TOTALIZER

0.00 MW


MW LAST CAPTURED

0.00 MW

CAP RSET

OPR GAP

TOTAL MINUS CAPTURED

0.00 MW

TRIPS FROM LOAD

50% < LOAD	7	8	%
30% < LOAD < 50%	1	2	%
15% < LOAD < 30%	0	0	%
LOAD < 15%	692	884	%
TOTAL TRIPS FROM LOAD	700	894	%

OPERATING HOURS timer accuracy test Outage Dec 2010

EXHAUST TEMP < 850 °F	657.8	hours	617	%	828.3	%
850 °F < EXHAUST TEMP < 950 °F			499.2	%	776.3	%
950 °F < EXHAUST TEMP < 1000 °F			11571.6		12645.1	%
1000 °F < EXHAUST TEMP < 1100 °F			420.2		521	%
1100 °F < EXHAUST TEMP < 1160 °F			0		0	%
1160 °F < EXHAUST TEMP			0		0	%
FRED HOURS			579		746	%

MISCELLANEOUS COUNTERS

PURGE CYCLES	175	233	%
THERMAL CYCLES	134	175	%

MISCELLANEOUS TIMERS

TIME UNDEROVERFREQUENCY	0	SEC	
TIME UNDER FREQUENCY	3379	SEC	
TIME SINCE THIS LAST START	4.5	HR	
MORE THAN 1 BLADE PATH TC FAILED	0.2	HR	
ON TURNING GEAR HOURS	14160.5	HR	
		51626.2	HR



SPEED	3601	RPM	CT MW	99	MW	CEMS NOX	18	PPM	CEMS O2	15	%	EXH TEMP	973	°F	BP AVG	1003	°F	BP SPREAD	18	°F	IGV POSN	-4.1	DEG	T2C	756.4	°F	P2C	201.1	PSIA	T1C INLET TEMP	46	°F	NORM LOAD	101	%
-------	------	-----	-------	----	----	----------	----	-----	---------	----	---	----------	-----	----	--------	------	----	-----------	----	----	----------	------	-----	-----	-------	----	-----	-------	------	----------------	----	----	-----------	-----	---

GT IS ONLINE

EXHAUST TEMP CONTROLLATIVE

Appendix D

Combustion Turbine Maintenance Deviation Records

(example)

Outages are typically required to be scheduled and budgeted three years in advance. Due to this, and the way that equivalent starts are calculated it is extremely difficult to make the outage schedule coincide precisely with the Siemens recommendations. As such, in the event that it is not possible to maintain the specific recommended outage interval, thorough combustion and other inspections shall be conducted. These inspections shall be sufficiently detailed to ensure that the unit can be operated within normal guidelines.

In the event that a deviation is necessary, these inspections shall be documented and saved for review as necessary. Typical inspection reports of the type used to document that the unit can continue to operate normally are included in this appendix.

Cunningham Station

Unit 3

Borescope Exam

September 30, 2010

Overview

A borescopic and visual examination was conducted on Cunningham unit 3 on September 30, 2010. The purpose of this exam is to document the current condition of the unit with 483 starts (298 actual plus 185 equivalent) and 4,789 operating hours since the last outage (Hot gas path inspection ending May 6 2007). Three burners were partially disassembled to facilitate this examination. The selected burners were numbers 3, 8 and 11. These burners were selected to be representative of the overall condition of the unit. Burners 8 and 11 were selected based on being the highest operating temperature burners as indicated by blade path thermocouples 10 and 13. Burner 3 was chosen because it was the lowest operating temperature as indicated by blade path temperature #5.

Only the pilot nozzle assembly was removed from burners 3 and 11. An old pilot nozzle tube was used to guide the borescope camera into the combustion basket and to observe the pilot and main nozzle swirlers. In addition, a short piece of stainless steel tubing was used to borescope the entry to the transitions. Both the pilot nozzle and the support housing (main fuel nozzle) were removed from burner 8. This was done to facilitate a full combustion components inspection, including the entire length of the transition and the row 1 vanes.

Summary

The borescope exam showed no signs of any abnormal wear or damage. There were signs of some relatively minor thermal barrier coating spawling in the transitions, but there were no signs of any cracking or other significant damage to the transitions. There were no signs of any cracking or significant TBC coating loss on the row 1 vanes. The cooling holes all appear to be open and in good condition. There are some signs of minor fretting on the main fuel nozzles (rocket tips) but nothing that appears to be significant. The pilot nozzle burner tips are in good condition, with some discoloration, but no significant damage. The main fuel nozzles are also in good condition, with little signs of damage or other problems. All of the main nozzle swirlers appear to be in good condition, with no obvious hot spots or other signs of degradation. The pilot nozzle swirlers also all appear to be in good condition.

During this examination it was discovered that the combustion baskets contained within this unit are of a different style than those in unit 4. Specifically this unit has a tighter swirl on the pilot nozzle swirler assembly. The swirler vanes themselves are installed on a sharper angle, providing a much tighter air flow pattern. These combustion baskets are of a newer design than the original, as they were purchased and installed used during the last outage. This combustion basket difference is likely the reason that this unit is more readily tunable for emissions than is unit 4. This matter bears further investigation

Conclusions

Based on the visual examination conducted on approximately 20% of the combustion hardware in the unit, the current unit condition does not justify the performance of an outage at this time. Therefore, the planned outage should be deferred from spring 2011 to fall 2011. Additional delays in the outage may be possible, but should only be done following another detailed examination of a different group of burners, so as to broaden the base percentage of hardware actually examined.

Documentation

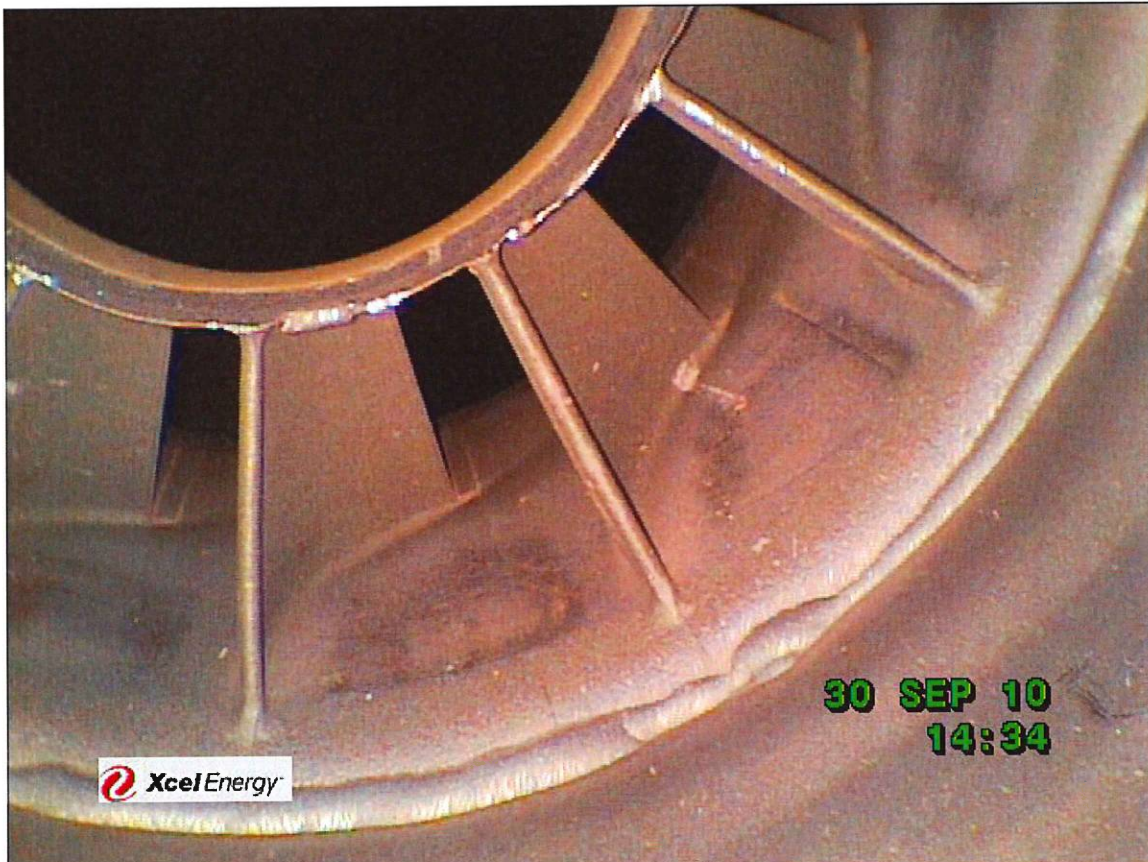
The actual borescope examination is documented visually in the following pages. The photos depicted on those pages are a mix of borescope photos and digital camera photos of exposed equipment. The accompanying comments are observations made during the conductance of the exam.

Attachment A

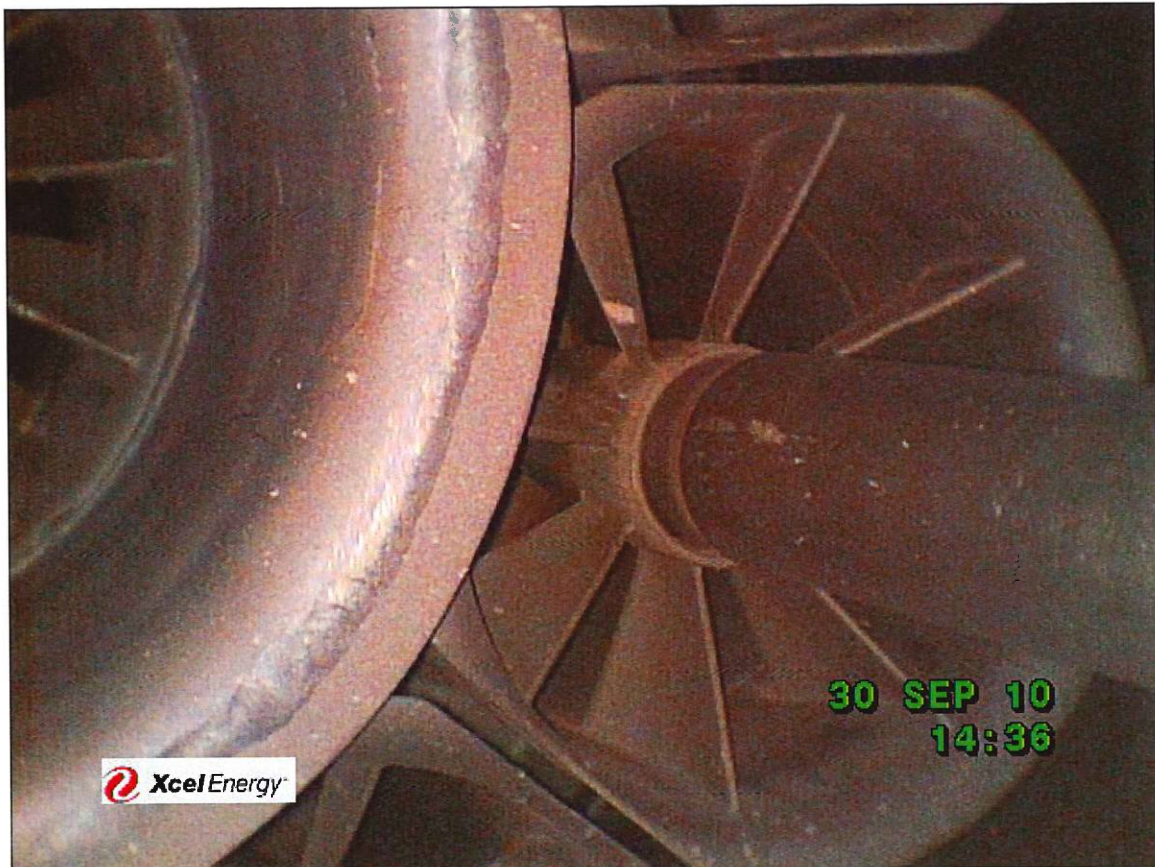
Photographic Condition of Parts



Unit 3, burner 3, view with borescope into transition area. No signs of cracking, or TBC coating loss at this point



Burner 3 pilot nozzle swirler – typical condition all around, this view is ~4:00 – 7:00. No weld cracking or other signs of significant deterioration.



Borescope photo of #3 burner showing the main nozzle rocket tip and swirler at the 4:00 position, with no obvious signs of damage. Rocket tip appears to be in contact with the swirler guide tube, but fretting in this area is not uncommon.



Main nozzle and rocket tip from the opposite side of #3 burner. Note how this rocket tip appears to be more centered in the guide tube. No obvious signs of any distress.



A slightly wider view of the pilot swirler on burner 3. No signs of any significant deterioration.



Borescope photo of the transition piece from burner #14. No signs of cracking, distortion, plugged cooling holes or other issues



Borescope photo of transition outlet to row 1 vanes. General condition of the transition appears to be pretty good with no obvious signs of significant TBC coating loss.



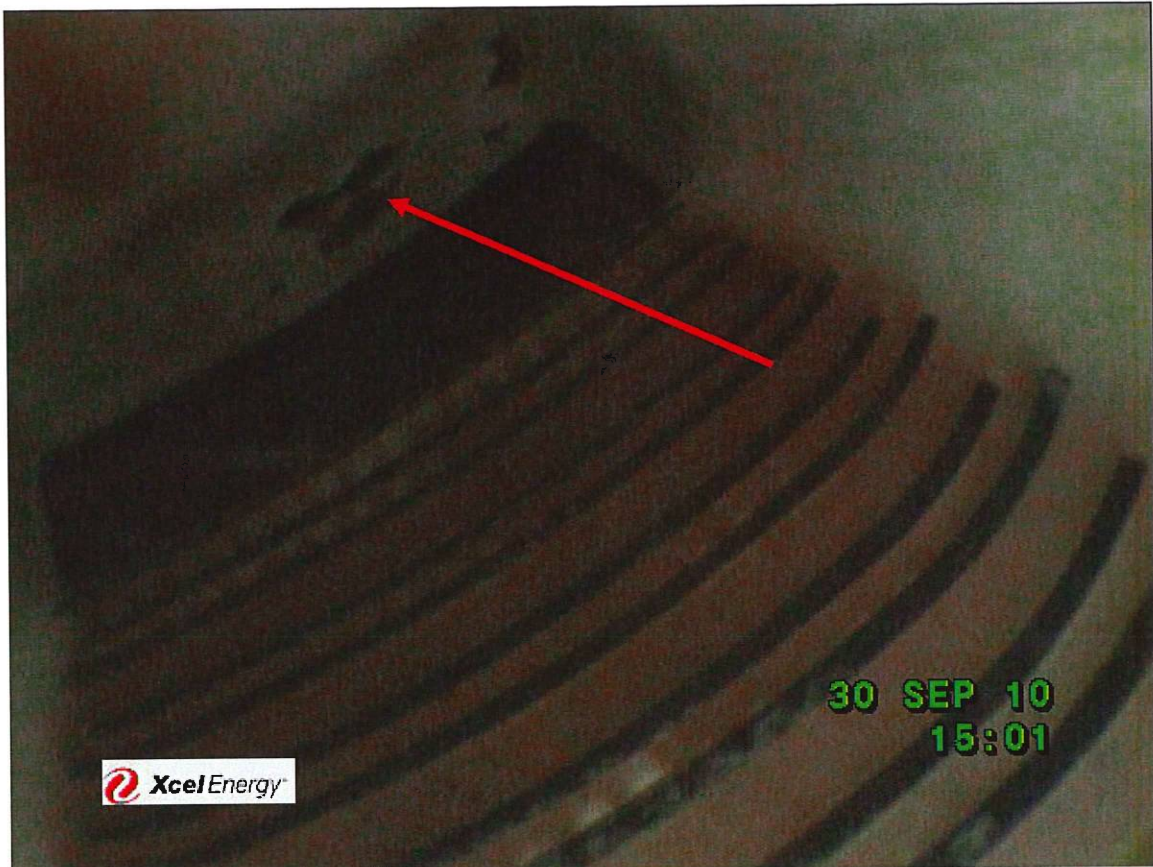
Pilot swirler and main fuel nozzles on burner #14 showing no significant problems.



Pilot swirler on burner 14 indicates some minor fretting in the guide tube, but again nothing serious.



Burner #14 pilot nozzle tip. Note the discoloration on the tip, but this is fairly typical. No obvious signs of distress associated with the fretting shown above.



Burner #8 Transition piece showing signs of TBC coating loss. Material loss is relatively minor and should not cause any impediment to ongoing operations



Burner #8 transition showing what appears to be a crack in the TBC coating. It does not appear to be a crack in the transition itself due to its orientation. This is not believed to be significant.



More minor TBC coating loss on #8 burner. This is believed to be typical of all, we just did not get sufficient detail on the transitions going through the pilot nozzle only.



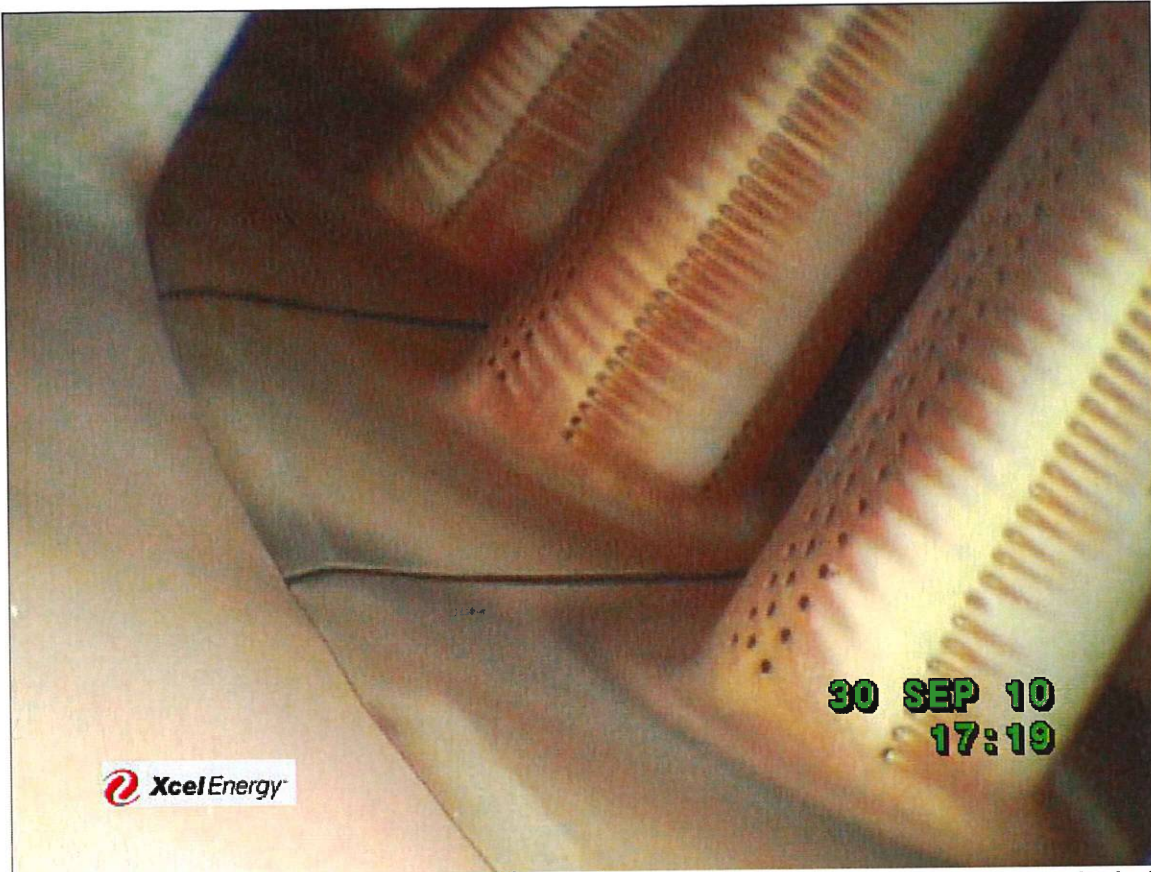
#8 burner transition cooling holes, no obvious signs of cracking or other distress.



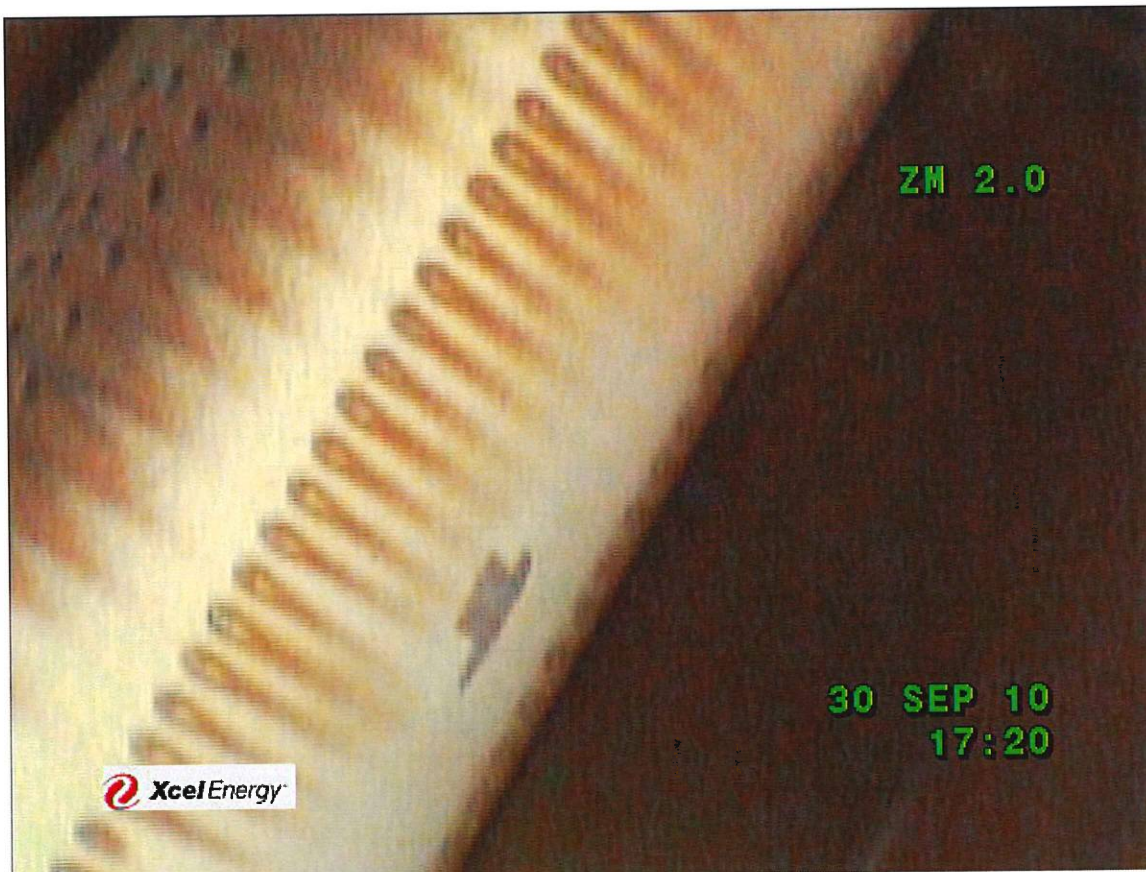
Row 1 vane at burner #8 No signs of cooling hole cracking or other signs of distress



Close-up view of the row 1 vanes at #8 burner. Once again no obvious signs of damage or distress.



A wider angle view of the row 1 vanes at #8 burner. The observed indications are typical of a vane that has been in service. Once again no indications of any problems



Another row 1 vane, note the loss of TBC coating. However, once again nothing that would indicate a need to open the machine



Main fuel nozzle from burner #8. Note some minor signs of fretting at the base of the tip where it goes through the swirler guide.



Closer view of the rocket nozzle tips on the main fuel nozzle from burner #8. Note the relatively blunt tip on one of the rockets (close-up in next photo).



Blunt tip on one of the rocket tips. While not of major concern it does bear monitoring if the outage is indefinitely delayed (beyond fall 2011)



This is what a normal rocket tip should look like

Appendix E

Combustion Turbine

Operator Log Sheet

CUNNINGHAM STATION GAS TURBINE DAILY LOG

g:\thead.xls

DATE	Unit	TIME-ONLINE	TIME-OFFLINE

TIME	MW	LOAD %	AMB. TEMP F	AMB. HUMID %RH	T1 TEMP F	P2C PRESS PSIA	T2C TEMP F	SHELT ER TEMP	AVG BP TEMP F	B P SPREAD TEMP F	AVG EXHAUS T TEMP F	#2 DISC CAVITY TEMP F	#3 DISC CAVITY TEMP F	#4 DISC CAVITY TEMP F	FUEL GAS BTU	Fuel GAS PRESS PSIA	STACK O2 %	NOX PPM	NOX LBS/HR	HIGH-VIB MILLS	HIGH BRG TEMP-F	LUBE OIL TEMP F		
23																								
22																								
21																								
20																								
19																								
18																								
17																								
16																								
15																								
14																								
13																								
12N																								
11																								
10																								
9																								
8																								
7																								
6																								
5																								
4																								
3																								
2																								
1																								
MIN																								

TIMES - EVAP COOLER ON _____ EVAP COOLER OFF _____ WET COMP ON _____ WET COMP OFF _____