Lean Blow Out Troubleshooting Guide

7FA,7FA+, 7FA+e DLN 2.6 machines

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Introduction

This is a general guide intended to stream line the analysis and investigation associated with Lean Blow Out events.

Applicability

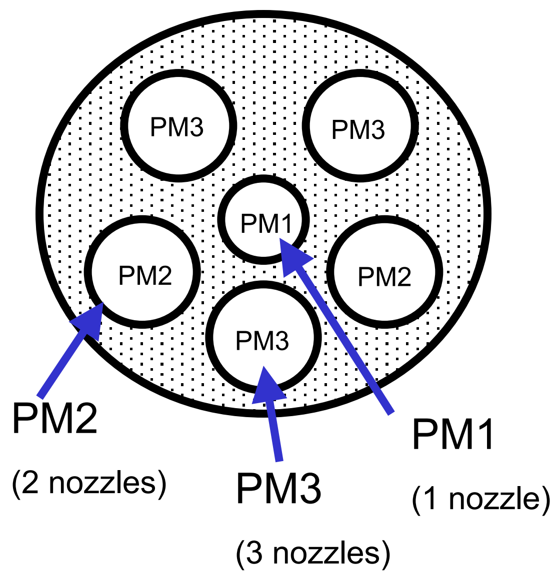
- The guide has been written for 7F, 7FA+ and 7FA+e DLN 2.6 gas turbines.
- Similar principles can be applied to any GE gas turbine equipped with a Dry Low NOx combustion system.
- This guide is NOT inclusive of all possible scenarios and drivers for Lean Blow Out events.

Definitions

A Lean Blow Out (LBO) is a combustion event that results from flame instability in one or more combustion chambers, leading to a gas turbine trip.

Expected process alarms

High Exhaust Temperature Spread Trip (most common.)
Loss of Flame Trip



1. Gathering Trip Data

Recommended frequency: Once per second minimum.

The instructions below are general. Some units may have different configurations.

Data retrieval for MKVI:

On the C: Drive there should be a HISTORIAN_DATA folder. Within this folder there should be TWO Main Folders:
LIVE_DATA
TRIP_DATA

On LIVE_DATA there should be trend recording all times at 1 sec
On TRIP_DATA there should be trend files named DCA files (extension .DCA) These files contain the SOE and Alarms, same as Fast Speed data at the time of the trip (40 ms)

• Can also use the Windows “search” function to look for .DCA files.

• See GEH 6403, chapter 12 for more details.

Data retrieval for MKV:

For <I>

- There is a TRIP log that is recorded for every trip event. The file needs to be manually saved by the operator.
- See GEH-5979D, pp. 2-26, for more information.

For <HMI>

- On windows desktop select: START, TURBINE CONTROL MAINTENANCE, UNIT_T# then TRIP LOG VIEWER.
- See GEH 6126, pp. 2-5 and chapter 3 for more information.

Data retrieval from the On Site Monitor (OSM):

• For either MK V or MKVI units, more data can be obtained from the OSM.

• MK VI DCA files are fairly comprehensive. MK V trip logs, however, are often not sufficient.

• To obtain data from the OSM, one can do so directly onsite, or with the help of the MD center or CTS (Customer Technology Services.)

• OSM data is also invaluable for investigating the exhaust thermocouple profile for the unit. See section 2.4. for more details.

Recommended OSM tags:

The list below is a good starting point. More tags maybe required depending on the specific case at hand.

L4, TNR, TNH, DWATT, CPD, CPR, FSR, FSR1, FSR2, CSRGV, CSGV, CTIM, L52GX, L94X, L28FDX, FD_INTENS_1, FD_INTENS_2, FD_INTENS_3, FD_INTENS_4, TTRF1, TTXM, TTXSP1, TTXSP2, TTXSP3, TTXSPL, FQG, FPG2, FPG3, FPRGOUT, FAGR, FSGR, DLN_MODE, FSR_CONTROL, FSRG1OUT, FSRG2OUT, FSRG3OUT, FSRGQOUT, FAGPM1, FAGPM2, FAGPM3, FAGQ, FSGPM1, FSGPM2, FSGPM3, FSGQ, CSBHX, CSRBH, CSRGVOUT, L20TH1X, L33TH4C, CSRGVTXB, CSRIH, CSRIHOUT, TTRF1, TTXM, TTRX, TTRXGV, TTRXB, TTRXP, TTRXS, AFPAP, AFPEP, AFPCS, TTXD1_1, TTXD1_2…..TTXD1_27

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2. Trip Data Analysis
2.1. Process Alarms

Investigate alarms proceeding the "high exhaust temperature spread trip" or "loss of flame" alarms. Some alarms may directly lead to the root cause of the trip and require investigation. Alarms that are of particular interest:

Gas fuel pressure low
Inlet Guide Vane control trouble alarm
Inlet Guide Vane position servo trouble
GCV out of position alarm
IBH control valve not tracking alarm
Any other alarms associated with the Gas Control Valves, Inlet Bleed Heat valve, IGVs or gas fuel pressure.
Any transducer trouble alarms.

See subsequent sections for more help on these items.

2.2. Unit Operational History

Fleet experience has shown that a significant number of trips may be avoided by studying a unit's history of trips.

Investigate unit operational history through Clarify search (GE only), analysis of previous trip logs and feedback from site. Typically, a 30-90 day window proceeding the trip event is sufficient.

Have Lean Blow Out events been a recurring issue?
Have the same combustion chambers been affected in most of the previous trips?
Have there been any combustion profile change escalations from the MD center?
Does the MD escalation point to the same suspected chambers?
Are the LBO events recurring even after a DLN re-tune?

If the data indicate that a select number of combustion chambers had been frequently affected in several trips, there is strong evidence that a hardware problem may exist.

2.2. Unit Operational History

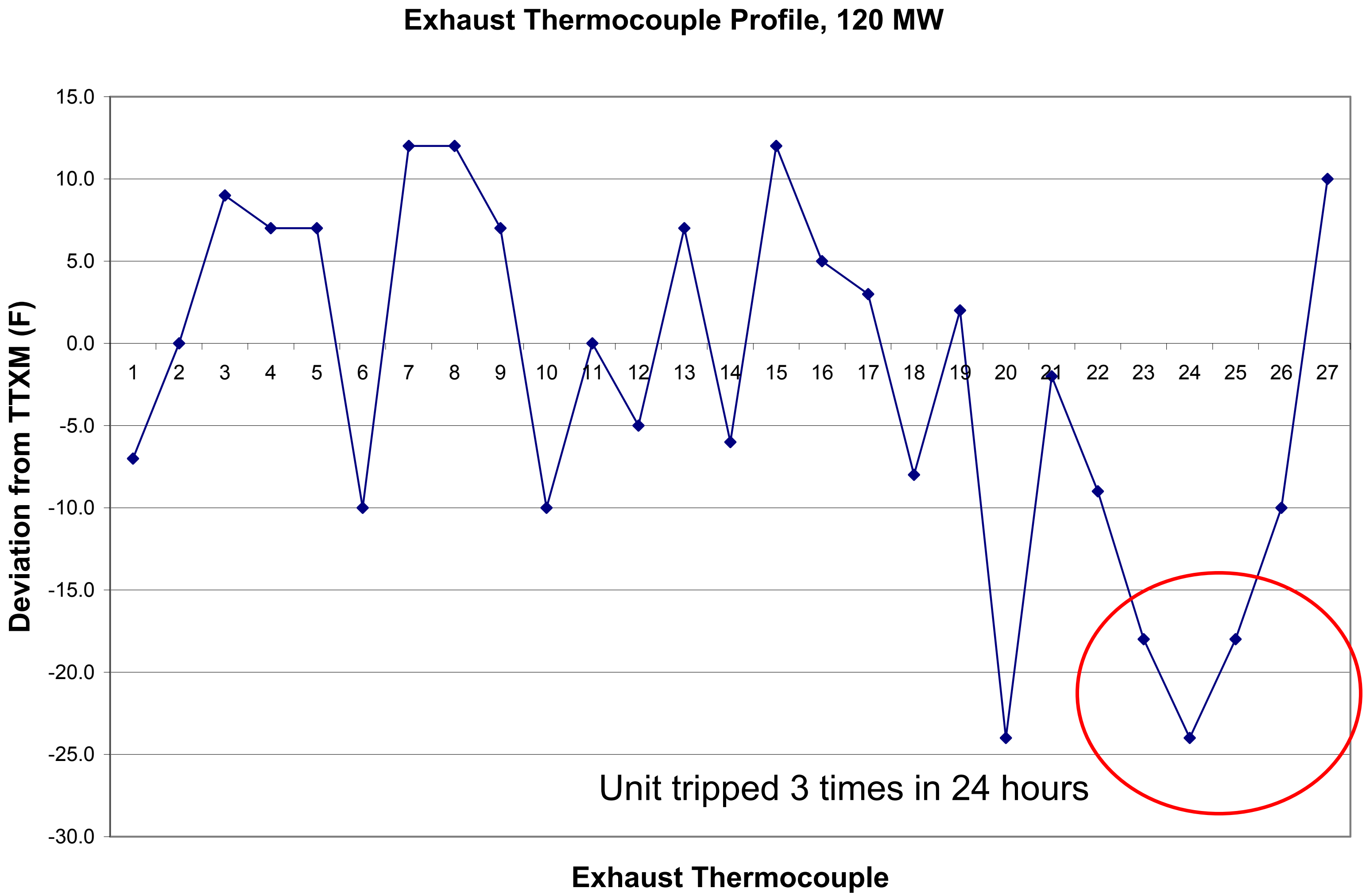
In the case of a suspected hardware issue, a **bore-scope inspection** of the suspected chambers is needed.

• DLN probe holes, flame detector ports are commonly used for the inspection of internal combustion components.
• Removal of man-way covers or extraction piping is necessary to inspect the Impingement Sleeves.

Most common hardware problems causing LBO events:
• Disengagement of inner cross fire tube(s) from the liner.
• Loss of cross outer cross fire tube packing causing excessive leaks.
• Disengagement of TP from the 1st stage nozzle due to problems with the TP side seals or floating seals.
• Impingement sleeve body cracks allowing for increased air flow into affected chamber.
• End-cover leaks, contamination (debris, liquid hydrocarbons, etc) or other problems.
•**Note that end-cover problems cannot be detected visually in most instances and may require testing at a GE service shop.**

2.2.1 Exhaust Thermocouple Profile

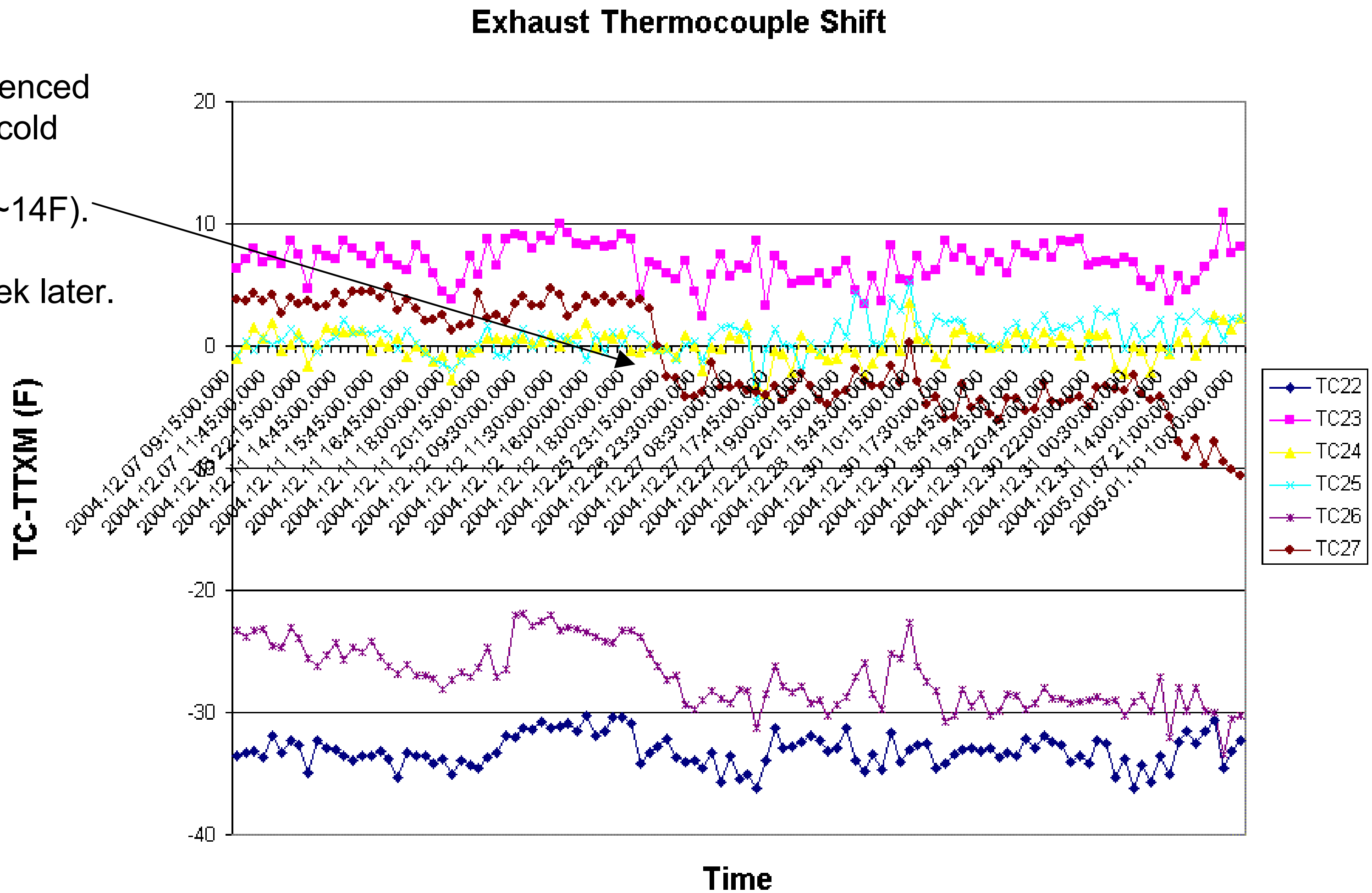
Abnormal cold or hot spots may point to a hardware problem.
Check if cold (or hot) spot is consistent with chamber affected by trip.



2.2.2. Exhaust Thermocouple Shifts

Exhaust thermocouple trend changes or “shifts” (under comparable conditions) in the cold direction may suggest that a hardware problem exists.

TC 27 experienced a shift in the cold direction (net decrease of ~14F). Unit tripped 5 times a week later.



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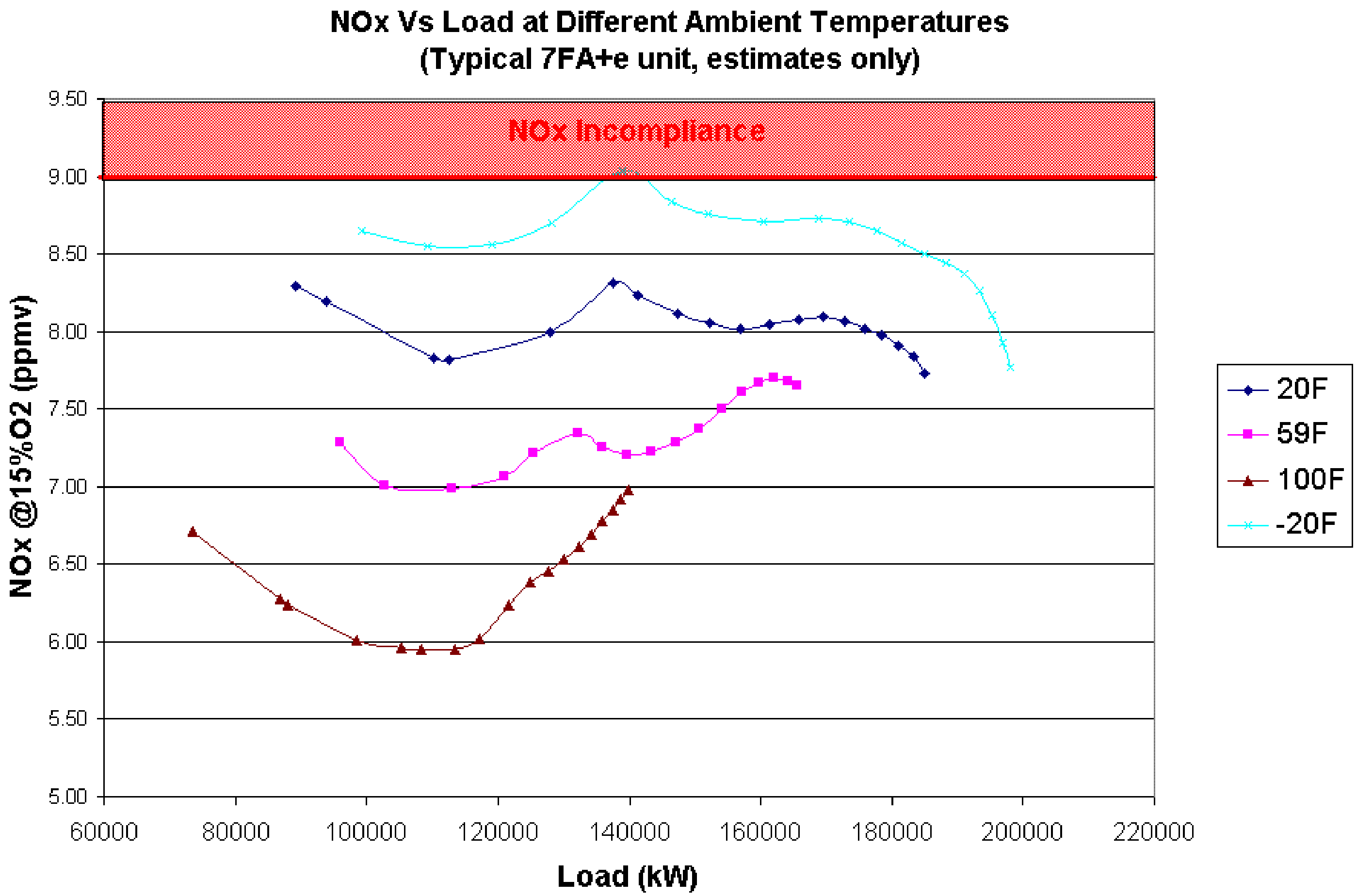
2.2.2 DLN Tuning Settings

NOx emissions are a function of ambient conditions.

A trend of decreasing NOx levels, coupled with Lean Blow Out events, may suggest that DLN Tuning is needed to enhance the Lean Blow Out margin.



2.3. Accessory systems:

Fuel and air flow management for fully premixed flames requires strict specifications for the various accessory systems that are involved. Problems may affect these systems even if no alarms had been annunciated.

This section will provide further insight to these systems.

- 2.3.1. Gas Control Valves
- 2.3.2. Inlet Guide Vanes
- 2.3.3. Inlet Bleed Heat
- 2.3.4. Gas Fuel Supply Pressure Regulators
- 2.3.5. Inter-valve (P2) Pressure Control

2.3.1. Gas Control Valves

GCV problems that cause a trip are typically coupled with a GCV position trouble alarm. Nevertheless, it is a good practice to insure all GCVs are properly calibrated.

Compare position reference and feedback for all gas control valves:

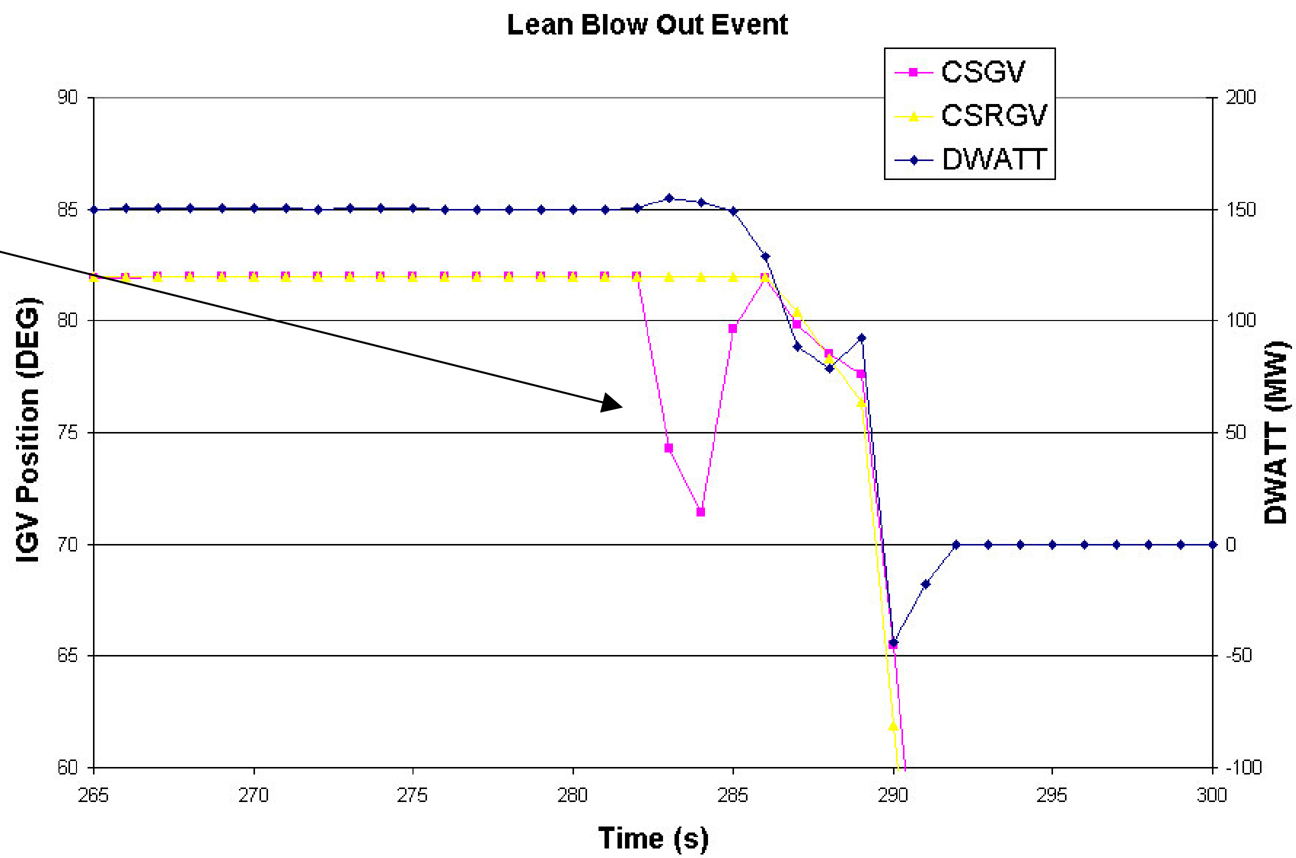
PM1: FSRG1OUT (REF) VS FSGPM1 (FEEDBACK)
PM2: FSRG2OUT (REF) VS FSGPM2 (FEEDBACK)
PM3: FSRG3OUT (REF) VS FSGPM3 (FEEDBACK)
QUAT: FSRGQOUT (REF) VS FSGQ (FEEDBACK)

A difference of ±0-1%, with no oscillations, is generally considered normal. Valve oscillations or excessive deviation may require calibration and further valve/servo check up.

2.3.2. Inlet Guide Vanes

- IGVs play a major role for controlling total compressor air flow.
- IGV servo or actuator problems can lead to air flow disturbances and LBO events.
- IGV-related Alarms are not always annunciated in such events.
- Compare CSRGV (position reference) Vs CSGV (position feedback.)

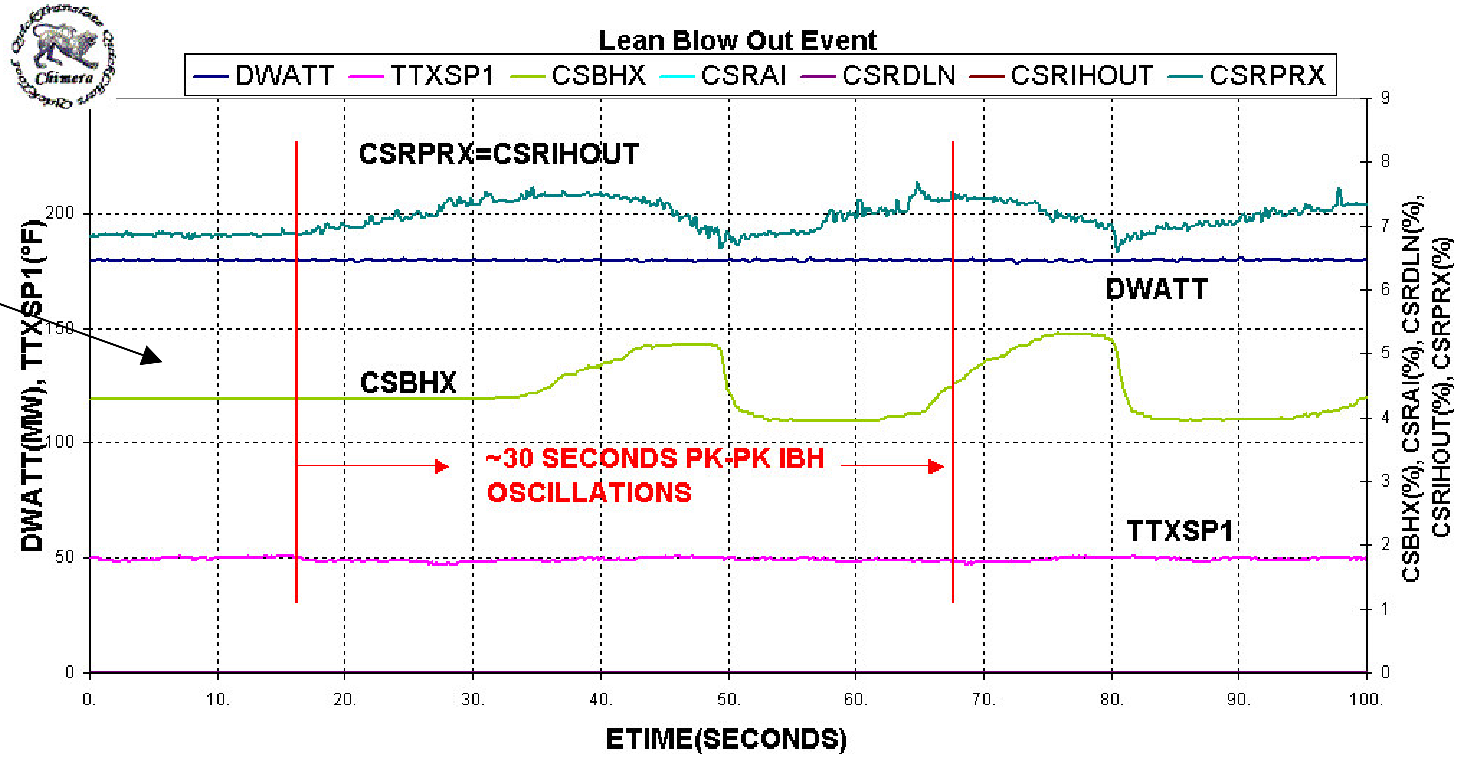
Contaminated IGV servo lead to a sudden drop and subsequent raise in the IGV angle while unit was running at base load.
A Lean Blow Out event followed.



2.3.3. Inlet Bleed Heat

• Significant oscillations or “jerky” valve movements can lead to lean blow out events, especially during mode transfers.
• Due to the nature of the valve and associated control mechanisms, it is not possible to completely eliminate all valve oscillations. However, checking valve calibration is a good practice when troubleshooting trips that are difficult to resolve.
• TIL 1317 also has instructions on setting up Fisher IBH valves.
• Compare CSRIHOUT (position reference) VS CSBHX (position FEEDBACK)

CSBHX oscillations resulted in sporadic LBO events on this unit.



2.3.4. Gas fuel supply pressure regulators:

A properly controlled gas fuel pressure supply is essential, and is the responsibility of our customers. Below are the GE requirements for supply pressure.
The DLN 2.6 combustion system maybe able to handle more significant variation, but potentially at the expense of more frequent LBO events.

Steady-state operation:

The Steady State gas supply pressure regulation at any operating point within the gas turbine capability, shall remain within ± 1% pressure at a rate not to exceed ± 0.25%/sec over the range of minimum required pressure to maximum operating pressure.

Transient operation:

Maximum Transient supply pressure excursions are limited to either 1% per second ramp or 5% step. The 1% per second ramp is applicable over the range of minimum required pressure to maximum operating pressure. The 5% step is applicable over the range of minimum required pressure to 95% of maximum operating pressure and with a maximum of one 5% step change in 5 seconds.

Controller tags are generally FPG3 or FPG1.

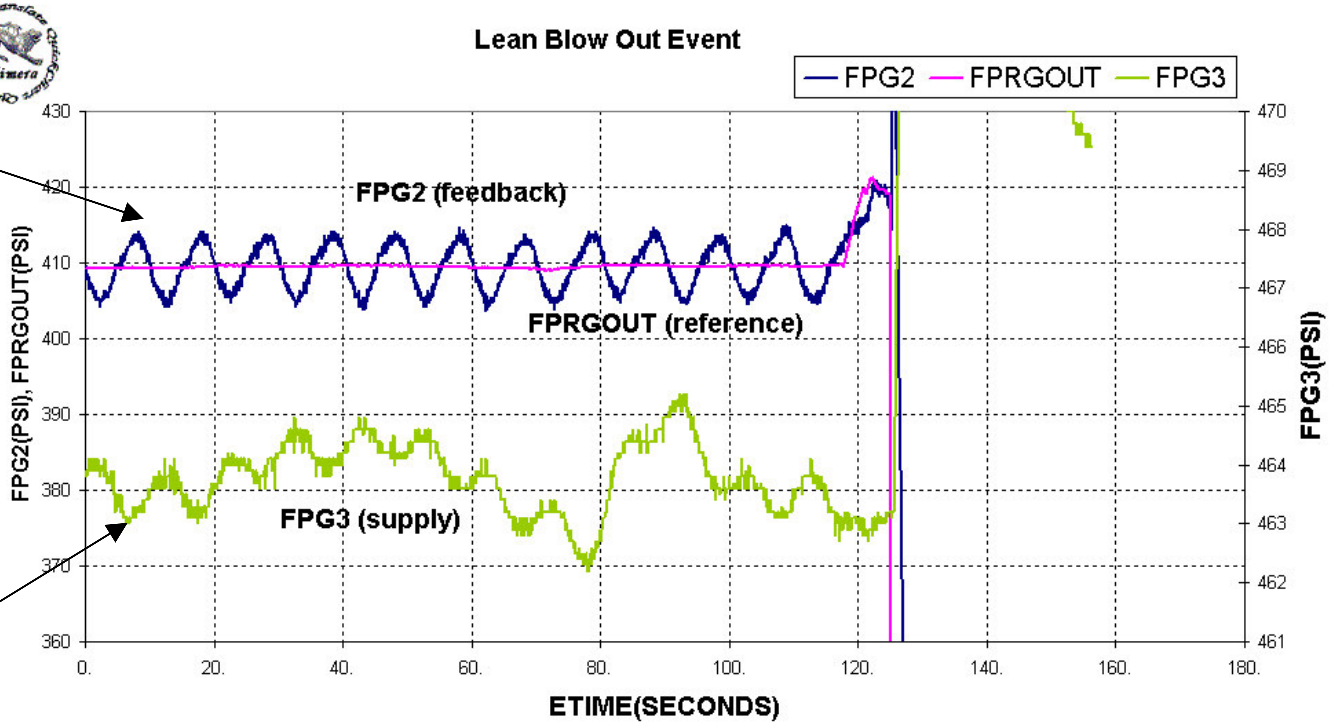
2.3.5. Inter-valve (P2) pressure control

Stable FPG2 (or P2) pressure is the responsibility of the Stop Ratio Valve (SRV.) P2 pressure stability problems can lead to unstable fuel flow through the gas control valves, which can lead to trips. Instability can be due to the following:

- Unstable supply pressure (see 2.2.4.)
- P2 pressure transducer problems
- Problems with the SRV.

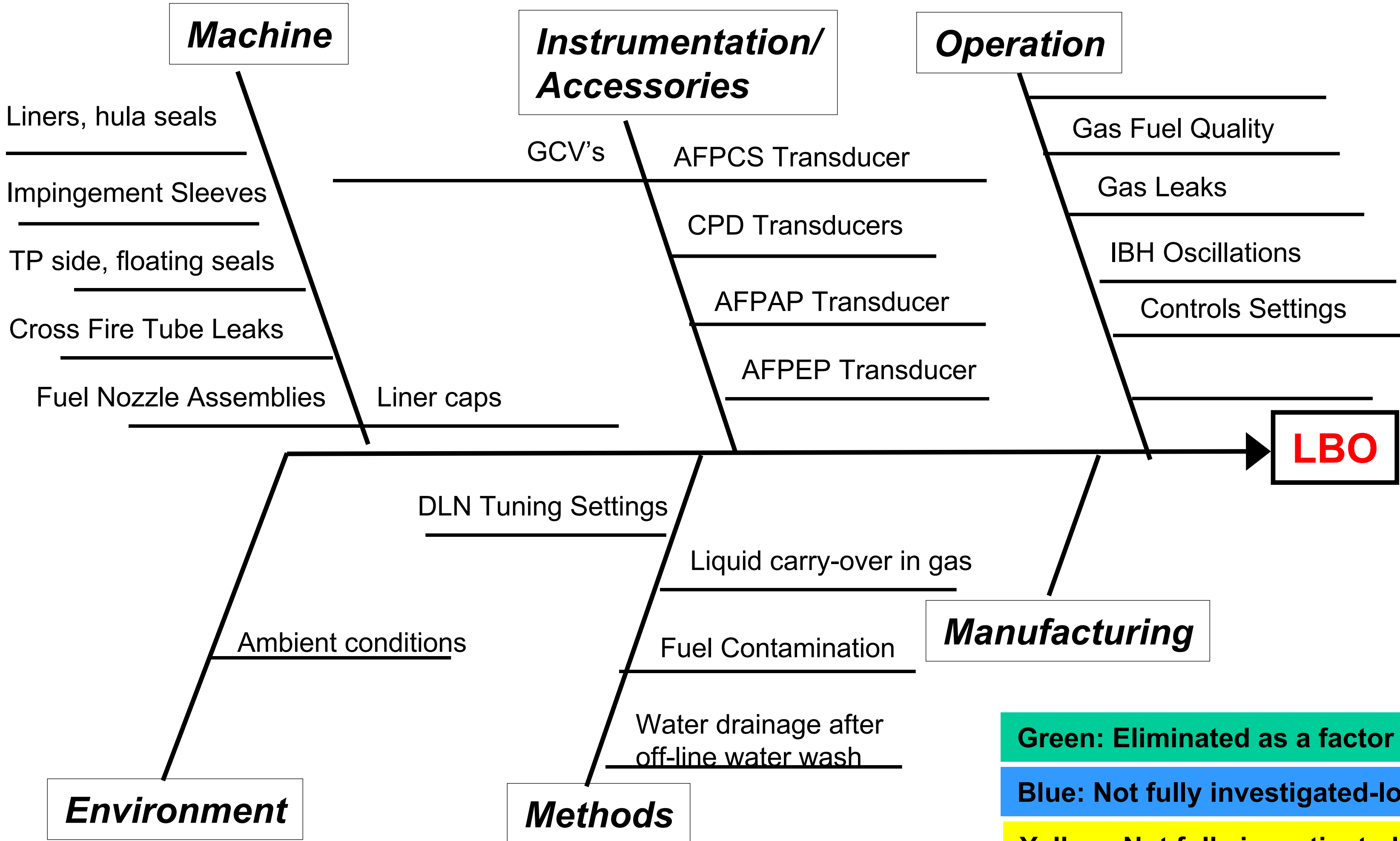
Steady-state and transient operational limits listed in 2.2.4. can be applied here. These limits are intended to minimize operational problems. Violating these limits may not always result in a trip.

FPG2 oscillations of +/- 1.25% resulted in an LBO event on this unit.



Acceptable gas fuel supply pressure

3. Example Fish-bone



Green: Eliminated as a factor

Blue: Not fully investigated-low impact

Yellow: Not fully investigated-high impact

Orange: Minor Contributing Factor

Red: Major Contributing Factor

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