

## Kathleen Truesdell

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**From:** Jim McLucas <jim.mclucas@radback.com>  
**Sent:** Thursday, October 21, 2010 11:23 AM  
**To:** Kathleen Truesdell  
**Cc:** Greg Darvin  
**Subject:** OGS - Additional Information on Startups  
**Attachments:** RE: good combustion practice; FW: OGS - Description of Startup and Shutdown Sequences for BAAQMD

Kathleen –

These two E-mails provided most of the pieces to understand the startup sequence and why there are higher emissions during startups than during normal operations. GE's Rapid Response write-up describes the startup sequence in general terms. GER3568g describes the combustion modes for the dry low NO<sub>x</sub> (DLN) 2.6 combustors. Figure 23 in GER3568g shows the loading sequence of the DLN 2.6 combustors. Figures 25 and 26 show how NO<sub>x</sub> and CO emissions vary with combustion mode and % turbine load.

Using the information in these two documents and adding a few durations from GE's startup curves here's a quick summary of the hot/warm startup sequence (assuming Purge Credit has been established):

- The load commutated inverter (LCI) begins rolling the gas turbine up to speed
- The combustors are ignited 1 to 2 minutes after roll (PM1+PM2 mode in Figure 23)
- The gas turbine is ramped up to 95% speed over the next 5 to 6 minutes (PM2 mode in Figure 23)
- At about 95% load, the LCI is disengaged and the gas turbine ramps to full speed (PM1 mode in Figure 23 or Mode 1 in Figures 25 and 26)
- Once the gas turbine is at full speed, the generator is synchronized with the grid
- Over the next 5 to 6 minutes, the gas turbine ramps up to the minimum emissions compliance load (MECL), which varies from 49 to 53%, depending upon the compressor inlet temperature
  - At about 10% load, the combustion mode transfers from PM1 to PM1+PM2 per Figure 23 or Mode 3 in Figures 25 and 26
  - At about 25% load, the combustion mode transfers from PM1+PM2 to PM1+PM3 per Figure 23 or Mode 4 in Figures 25 and 26
  - At about 40% load, the combustion mode briefly transfers from PM1+PM3 to PM2+PM3 followed by a transfer from PM2+PM3 to PM2+PM3+Q in Figure 23 or Mode 5Q in Figures 25 and 26
  - At about 45% load, the combustion mode transfers from PM2+PM3+Q to PM1+PM2+PM3+Q in Figure 23 or Mode 6Q in Figures 25 and 26

Cold starts would be similar with the exception being that there would be a low load hold for about 30 minutes at around 10 percent load. The purpose of this hold is to allow the heat recovery steam generator (HRSG) to heat up more slowly to mitigate thermal stresses.

Without purge credit, the time preceding the ignition of the combustors would increase to about 15 minutes for hot, warm, and cold starts.

Thanks!

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