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July 28, 2014

Steven Moore
Senior Air Pollution Control Engineer
San Diego County Air Pollution Control District
10124 Old Grove Road
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Subject: ATC Application for Amended CECP

Dear Mr. Moore:

On behalf of Carlsbad Energy Center LLC, Sierra Research is pleased to submit the following responses to the information requested in Section B of the SDAPCD's May 29, 2014 letter regarding the Authority to Construct (ATC) application package for the Amended Carlsbad Energy Center Project (CECP).

Request 1: For the NOx best available control technology (BACT) analysis, information supporting the statement in Section 5.3.2.1 on page 5.1C4 that the proposed four startups per day would significantly shorten the lifetime of any fast-starting combined cycle combustion turbine. The District notes that, although four startups per day are proposed as a maximum, the average number of startups per day would be expected to be significantly less as 400 startups per year are being proposed.

Response: Any combined cycle plant, even a modern rapid-response combined cycle gas turbine (CCGT), will reach the end of its useful life more quickly if dispatched in a peaking mode (large number of starts, relatively low capacity factor) than when operated at intermediate or base load (relatively few starts, high capacity factor). When heavy-duty gas turbines are subjected to more frequent starts the intervals between combustor, hot gas path and major inspection events become shorter; resulting in substantially higher O&M costs due to more frequent repair and replacement of parts, and performance degradation is accelerated. The shortened life of the various component parts does not necessarily reduce the mechanical life of the gas turbine, but it does adversely impact its economic viability. In addition, rotor inspection intervals are reduced as a result of more frequent start/stop cycles. For example, a base-loaded gas turbine at 90% capacity factor might go 18 years until the first rotor inspection, while a fast start unit dispatched 300 times per year might get to the first rotor inspection in only 8 years. The impact of frequent starts on unit life is also seen in the steam cycle equipment, particularly the heat recovery steam generator (HRSG). Pressure parts in the HRSG and high energy steam system are subject to some amount of damage (life expenditure due to creep and fatigue) as a result of thermal stress every time the unit is dispatched, particularly for 10-minute non-spinning reserve events and especially when the metal is cold. The greater the number and frequency of start/stop cycles, the more rapidly the highly stressed components in the HRSG reach their design limit and require costly life extension repairs.

This reduction in the interval between maintenance events for heavy-duty gas turbines due to an increase in the number of starts is shown in the current GE heavy-duty gas turbine operating and maintenance guideline document[1]. The basic maintenance intervals are shown in Figure 44 on page 33 of this document. Hot gas path inspection intervals are either hours based (Figure 45) or starts based (Figure 46), whichever occurs first. Similarly, rotor inspection intervals are either hours based (Figure 48) or starts based (Figure 47) and combustor inspection intervals are either hours based (Figure 49) or starts based (Figure 50). Major inspections generally occur at every second hot gas path inspection.

With respect to the SDAPCD's note that the average number of startups per day would be expected to be significantly less based on 400 starts per year, while this is mathematically correct it does not account for time of day/time of year dispatch variation and other factors that tend to concentrate unit dispatch events in a relatively small percentage of days per year.

Request 2: For the NOx best available control technology (BACT) analysis, a quantitative analysis, with supporting documentation that compares the NOx emission rates, NOx emission reduction cost effectiveness, and feasibility of the proposed project to the following alternative equipment options capable of delivering comparable peaking electrical power: one or more fast-starting combined cycle combustion turbines, such as the F-class turbines already authorized for this location, for example; a combination of one or more large fast-starting combined cycle combustion turbines and one or more simple cycle combustion turbines, such as the two F-class turbines already authorized for this location and two LMS 100 turbines, for example; and six LMS 100 turbines operating in combined cycle mode. The analysis must consider the proposed potential operating scenario of up to four startups per day, 400 startups per year, and 2700 hours of operation per year. In addition, the analysis should identify any other environmental or energy impacts of such alternative equipment that should be considered by the District.

Response: The number and type of gas turbine units proposed for the Amended CECP were selected so that the project can supply anywhere from approximately 25 MW to 600 MW (nominal) of peaking power (in 25 MW increments) to the grid within a 10-minute startup window. This quick-start dispatch flexibility is a key operating/design criterion required by the utility for this project. The suggested use of F-class machines would neither have the turn down capability or incremental load flexibility of the multiple smaller units proposed for the project. For example, three 200+ MW F-class simple cycle units would be required to meet the approximately 600 MW (nominal) maximum output of the Proposed Project. With an emission compliance window for F-class machines typically ranging from 50% to 100% load, the dispatch window for the F-class design would be limited to approximately 100 MW to 600 MW in increments of approximately 100 MW. Also, if a portion of the 600 MW was supplied via steam turbine(s) in a combined cycle configuration, the utility criterion for peaking dispatch flexibility would not be met – to provide just the needed, quick ramping generation to

[1] http://www.ge-energy.com/content/multimedia/_files/downloads/GER3620L_1_Oct_19_2010_1.pdf.

support the grid. Also, the six LMS100s will feed two different switchyard loads (138 kV and 230 kV); the Proposed Project therefore provides the flexibility to dispatch up to four units as associated MW range to the 230 kV switchyard and two units and the associated MW range to the 138kV switchyard. Furthermore, to meet the approximate 600 MW by F-Class engines, there would not be sufficient space for the installation of three F-class units and the supporting ancillary facilities while meeting access requirements into and around the Proposed Project footprint. Therefore, for BACT purposes, due to this restriction in dispatch flexibility and the added problem of insufficient space available at the project site to allow for the installation of three F-class units, the installation of F-class units was not considered to be a feasible option for the Proposed Project.

Request 3: Information on any other operating periods in addition to startups and shutdowns such as periodic testing or maintenance requirements (including any FERC/WECC testing and certification, equipment tuning operations, etc.) that may necessitate operating the turbine outside of typical operating ranges for limited durations and therefore make meeting steady state BACT emission limits infeasible during these periods.

Response: Once each of the units has completed startup, commissioning and testing, including CEMS certification and compliance testing, events where a unit or units might be required to operate in a manner that does not meet steady-state BACT emissions limits are anticipated to be very infrequent. After achieving commercial operation, periodic generator resistive/reactive capability testing, exciter, voltage regulator and PSS testing under FERC and WECC guidelines would not be expected to occur more often than once every five years, and these events would not generally cause a unit to operate outside the prescribed emissions limits. In the event of a system emergency, CAISO/WECC may require the facility to operate at part load conditions which could conceivably result in one or more units operating outside of prescribed emissions limits. However, with multiple units each capable of 10-minute start and substantial load turndown within emissions compliance the likelihood of operating outside of permit limits is remote. It is likely that a unit might operate briefly outside prescribed emissions limits during startup following a major maintenance event; however, at the proposed 2700 hours per unit per year operating limit the major maintenance interval is approximately every 18.5 years. The GE LMS100PA gas turbines are fitted with conventional SAC combustors with water injection for NOx control. This engine is a mature product and the combustion and water injection systems, following initial commissioning and testing, are unlikely to require further tuning that might lead to operation outside of prescribed emissions limits.

Request 4: Any available source test data, continuous emission monitoring data, or vendor supplied information to support the exhaust stack nitrogen dioxide (NO_2) to NOx ratio used in the AQIA. The information should support the NO_2 to NOx ratio used for steady state operations and transient operations such as startups and shutdowns; and the various commissioning operations.

Response: The gas turbine exhaust NO_2 to NOx ratios used in the AQIA for the Amended CECP were provided by the SDAPCD. We do not have any additional gas turbine exhaust source test data, continuous emission monitoring data, or vendor-supplied information regarding NO_2 to NOx ratios.

Request 5: A detailed drawing(s) of the stack showing proposed location of the continuous emission measurement system (CEMS) probe(s) and sample ports for source testing in the stack. The drawing(s) should be sufficiently detailed to indicate any potential flow disturbances in the stack resulting from turning, expanding, or contracting of the exhaust flow.

Response: The drawings showing the locations of the CEMS probe and source test sample ports are provided in Attachment 5-1.

Request 6: The preliminary oxidation catalyst volume and space velocity during normal operations at 100% load and 25% load and the expected control efficiency versus catalyst temperature for CO, methane, ethane, propane, formaldehyde, and benzene or toluene at those space velocities both when new and after 20,000 hours of operation (or at the recommended catalyst replacement age, if sooner).

Response: According to General Electric, the oxidation catalyst volume will be approximately 109 cubic feet and the space velocities at 100% load and 25% load will be approximately 227,000 1/hr and 57,000 1/hr, respectively. Graphs provided by General Electric showing the expected control efficiencies versus oxidation catalyst temperature are included in Attachment 6-1.

Request 7: While the modeling files (xxxxx.ADI and xxxxx.ADO files) are in the submittal it would provide a much simpler start point for the District review and shorten the review time if the software Project Backup and Save to .ZIP features are used and all the AQIA associated project files for each modeling run are submitted.

Response: The revised AQIA modeling files with data processed as requested were included in the compact disc submitted to the SDACPD with the Applicant's June 26, 2014 data response letter.

If you have any questions or need any additional information, please do not hesitate to contact me at 916-273-5139.

Sincerely,

Tom Andrews
Principal Engineer

Attachments

ATTACHMENT 5-1

FIGURES SHOWING LOCATIONS OF CEMS AND STACK TESTING PORTS

Figure 5-1-1
Sample Port Layout

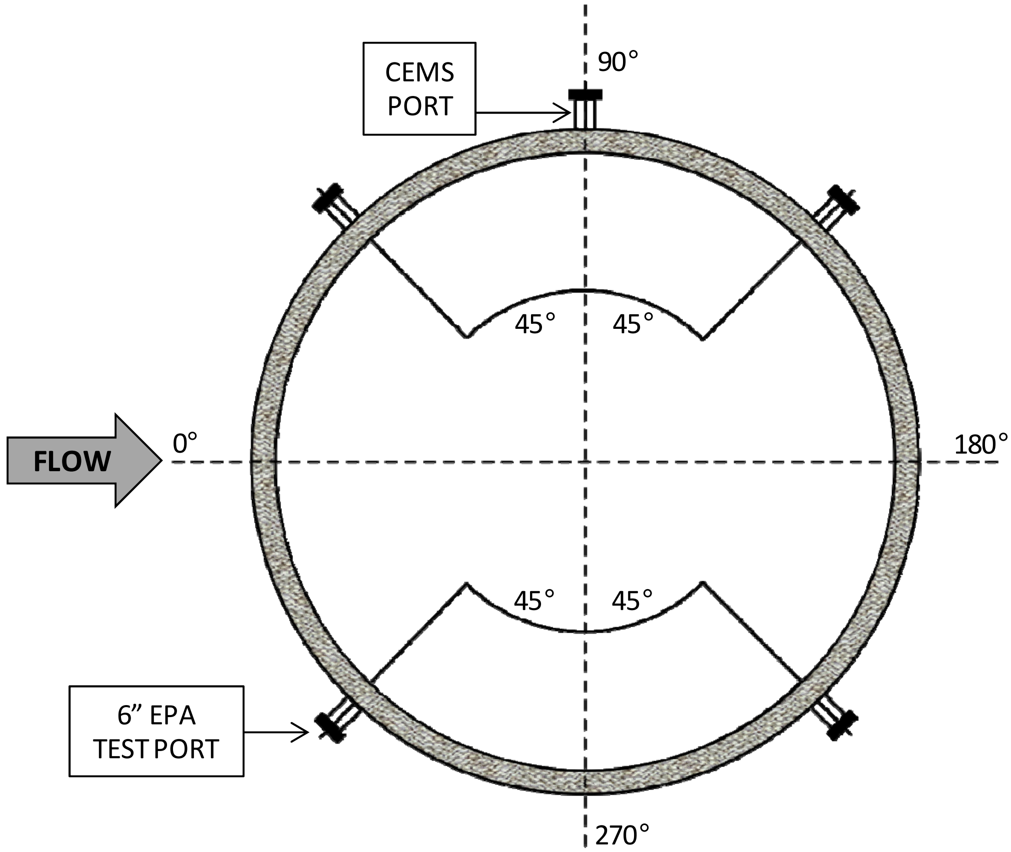
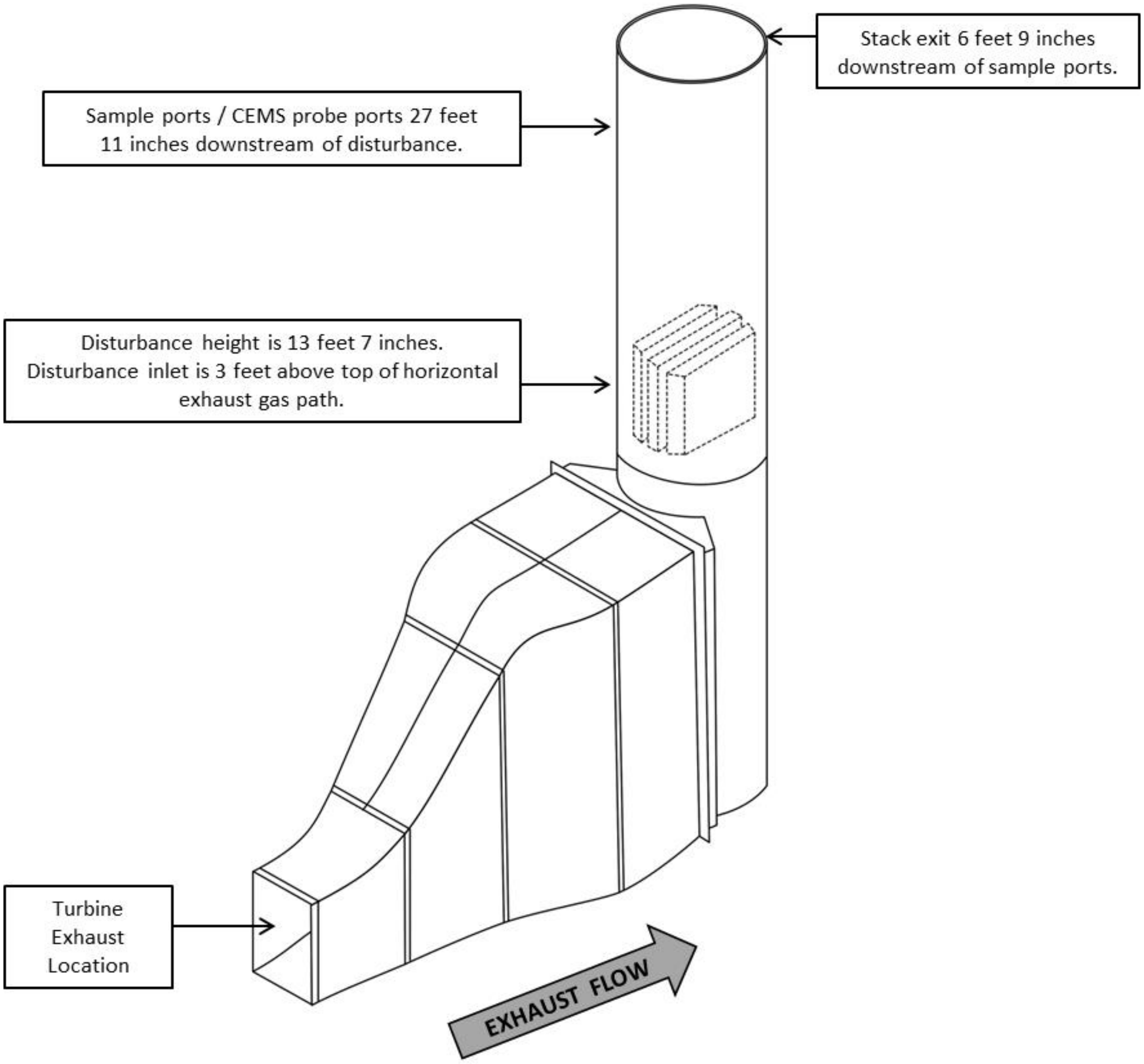


Figure 5-1-2
Stack Diagram

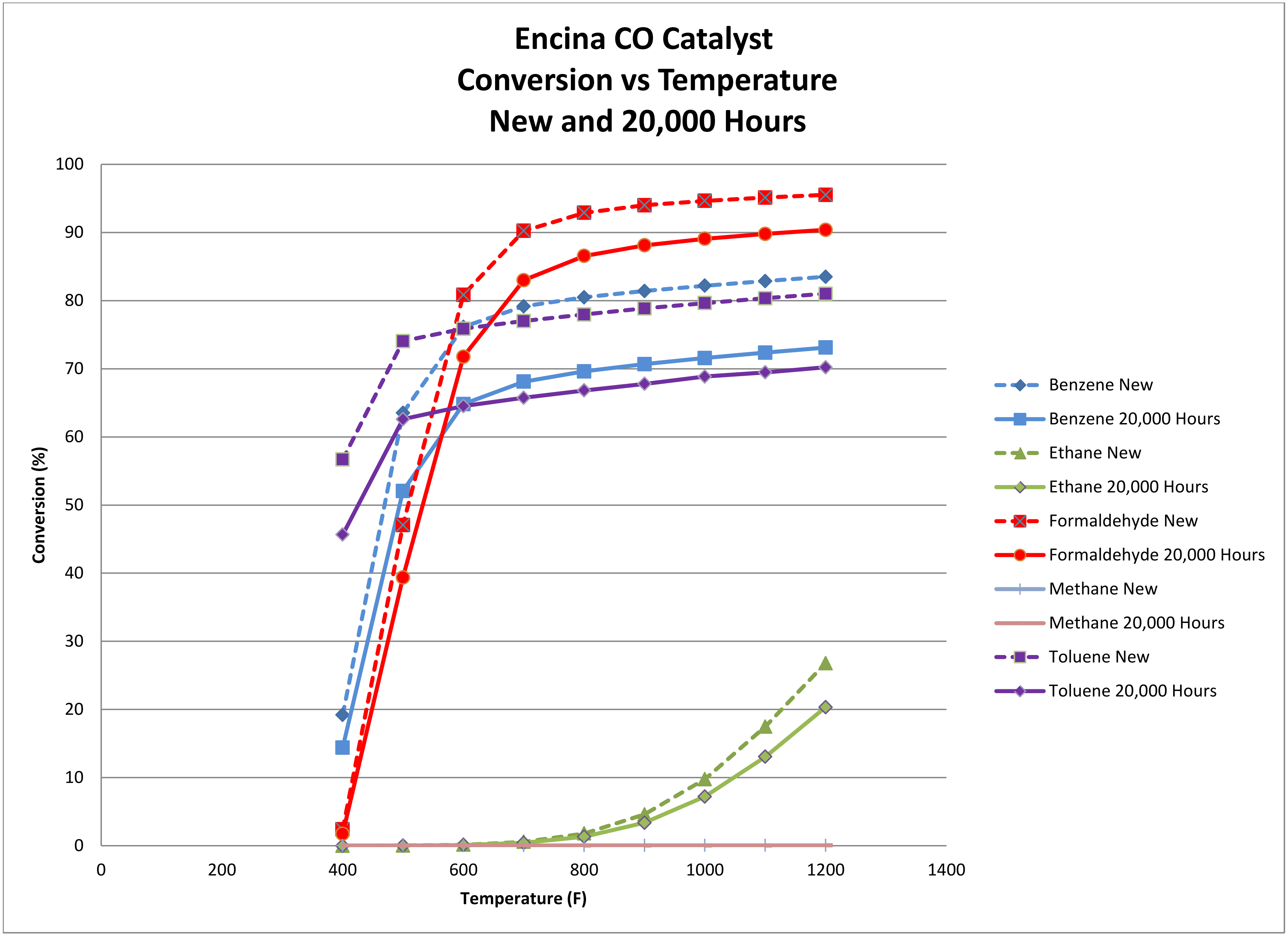


Notes:

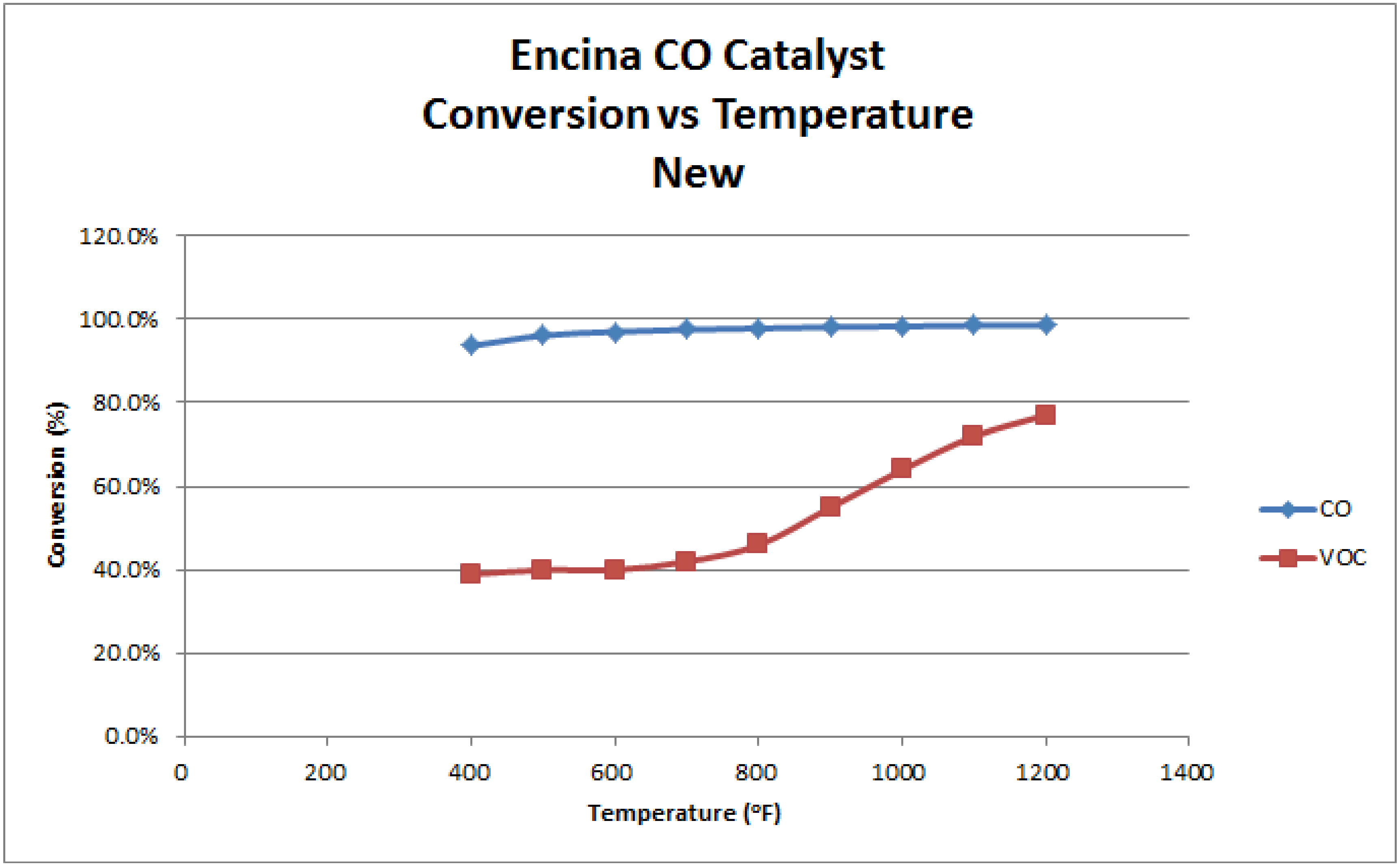
1. Stack inside diameter is 13’6”.
2. Overall stack height is 90’0”.

ATTACHMENT 6-1

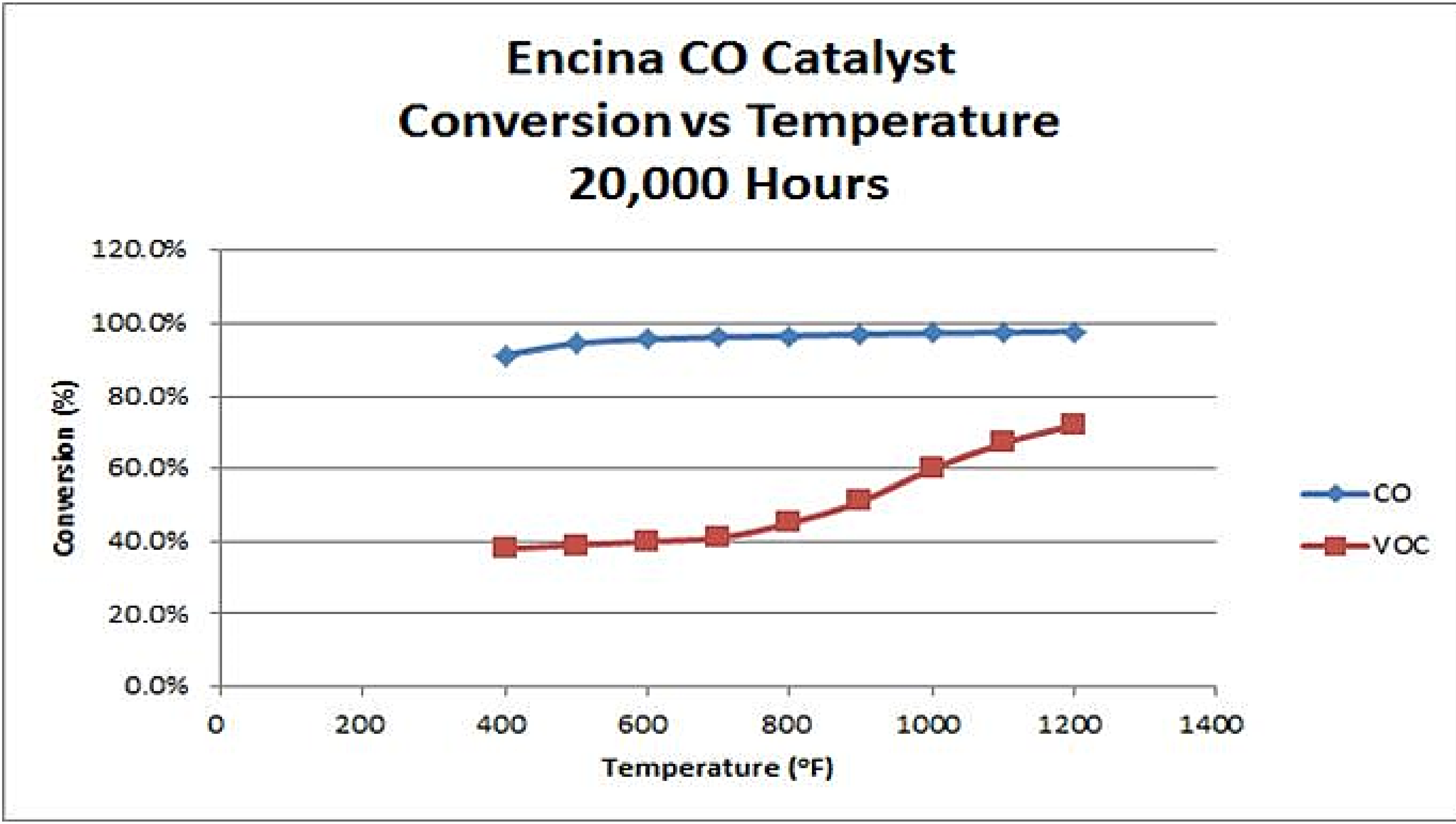
FIGURES SHOWING OXIDATION CATALYST CONTROL LEVELS VERSUS CATALYST TEMPERATURE



Encina CO Catalyst
Conversion vs Temperature
New and 20,000 Hours
Conversion (%)
Temperature (F)
0
10
20
30
40
50
60
70
80
90
100
0
200
400
600
800
1000
1200
1400
Benzene New
Benzene 20,000 Hours
Ethane New
Ethane 20,000 Hours
Formaldehyde New
Formaldehyde 20,000 Hours
Methane New
Methane 20,000 Hours
Toluene New
Toluene 20,000 Hours



Encina CO Catalyst
Conversion vs Temperature
New
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Conversion (%)
0
200
400
600
800
1000
1200
1400
Temperature (°F)
CO
VOC



Encina CO Catalyst
Conversion vs Temperature
20,000 Hours
120.0%
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Conversion (%)
0
200
400
600
800
1000
1200
1400
Temperature (°F)
CO
VOC