UC Davis - Facilities O&M
Cogeneration Plant Bid Package
October, 2007

I. Cogeneration Plant Overview

The University has owned and operated a cogeneration system since 1981, though nearly all of the original system components have been replaced. All inspections and maintenance have been performed under successive agreements with Rolls Royce Engine Services (formerly U.S. Turbine) and all maintenance records have been retained.

Although the gas turbine and electric generator are capable of producing at least 3.5 MW, the equipment has operated far below that level. Restrictions imposed by the Air Quality Management District limited electrical output to 2.8 MW, significantly reducing the thermal stresses that result from high firing temperatures. Furthermore, the plant has been dispatched as a base load facility, which avoided the degradation common to cyclical operations.

Key stats for the package:

66,772 skid hours with existing engine
78,515 skid hours on original engine
= 145,287 total skid hours

- 344 starts on the existing engine (2241 starts on the original engine/skid)

- Dec, 2004, discontinued operation.

- May, 2004, Replaced 1st stage vane assembly (p/n 23075009.
  Replaced all Nozzles (p/n 23039873).
  Replaced Transition piece (p/n 23076564).
  Replaced Barrel assembly (p/n 23077467).
  Replace combustion liners (style 3.2)

- 2001, major bearings replaced.

- 1999, replaced all compressor section vanes.

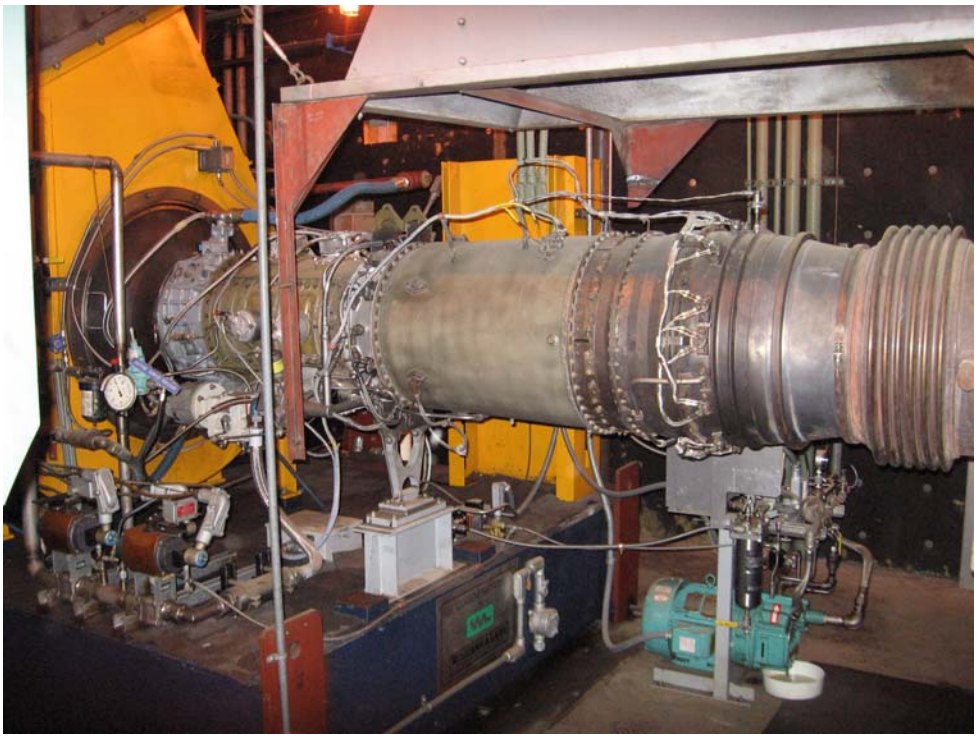
- 1996, installed a new Allison 501-KB5 engine.

- 1995, U.S. Turbine designed, fabricated and installed a new control system.

- 1990, replaced the original HRSG (no duct burning).

II. Components

Engine



The **Allison 501-KB5S** engine weights approximately 1,300 pounds, is 8 feet in length, has a maximum mechanical limit of 25,000 lb. in. output torque, and operates in a speed range of 12,350 to 14,500 rpm. Engine rotation is counterclockwise as viewed from the exhaust end. The lubrication system includes a main and scavenge oil pump.

The following are the simple cycle performance data for the Allison 501-KB5. These ratings are based on burning natural gas and operating at the maximum power turbine inlet temperature. The generator ratings include all mechanical losses, standard inlet and exhaust pressure drops, measured at the terminals of the generator at ISO conditions:

Engine rotor speed	14,200	RPM
Power Out put	5,263	hp
Exhaust Temperature	987	^{0}F

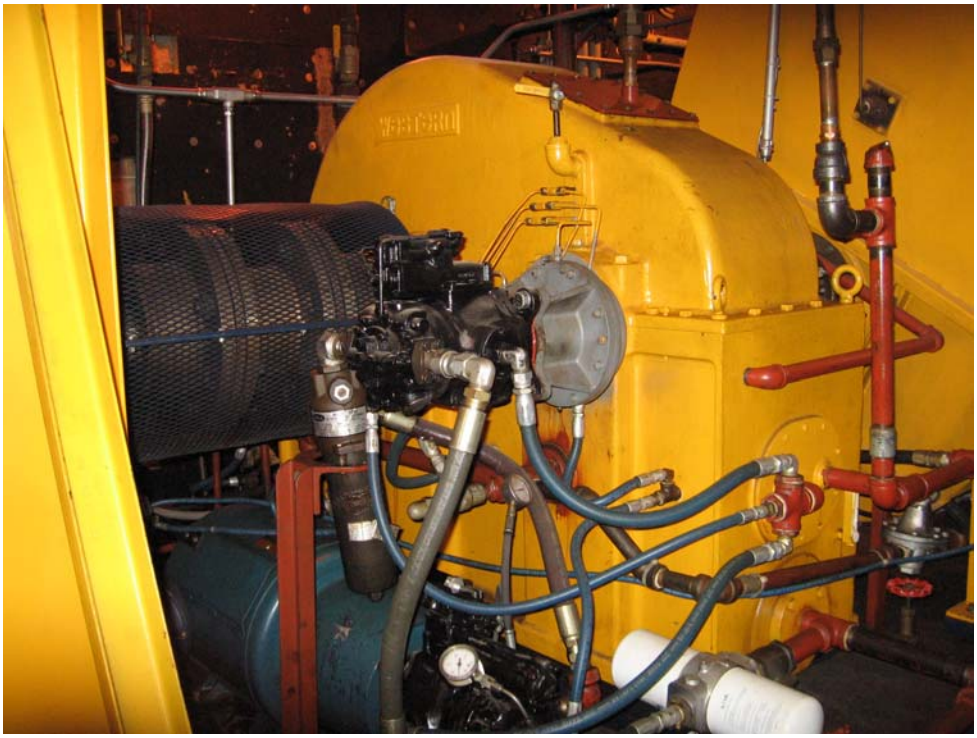
Turbine Inlet Temp (CTIT)	1,895	^{0}F @ 14.7 psia and 59 ^{0}F
Manufactured:	1996	
Combustor replaced:	2004	

Compressor

The compressor rotor assembly is a 14-stage, axial flow, single spool design. The pressure ratio across the compressor is approximately (9.3:1). The rotor is supported at the front by a roller bearing. At the aft end it is supported and axially positioned by a split inner race ball bearing. The fourteen wheels in the rotor are broached on their circumferences with dovetail slots for mounting compressor blades. Compressor blades are retained axially in their respective wheels number one wheel blades by a lug, which contacts the front face of number one wheel. A retainer ring secures this lug type blade against the wheel rim on the rear side. Number two through five wheel blades by a stepped diameter pin entering a slot in the base of each blade. Number six through fourteen wheel blades by a straight pin entering a slot in the base of each blade.

Manufactured:	1996
Refurbished:	1999

Gearbox



A gearbox is provided near the front of the compressor to drive the accessories critical to operation. Power for the high speed gearbox is extracted through a radial drive shaft at the forward end of the compressor. The 3.27 MW of shaft power are those produced in excess of the power needed to drive the axial compressor. This high speed gearbox reduces the speed to 1800 RPM and runs a (KATO) brushless, three-phase synchronous generator at 4160 volts. This electrical power is fed into a 12,000 KVA substation adjacent to the plant. Unit includes lube oil pump and filters, pad for hydraulic start motor (2.5:1 ratio), and pads for vibration pickup mounting

Nameplate:
Western Model 250 HSA 100s
Serial No. 3076
Simple Reduction Type (8.0513:1 ratio)
Input: 14,500 RPM
Output: 1,800 RPM
5,144 HP w/service factor of 1.39
Manufactured: 1980

Control System

Designed, fabricated and programmed by Rolls Royce Engine Services. Major components include:

Turbine/HRSG Sequencing and Control:
Allen Bradley PLC 5/30, Panelview Touch screen HMI

Speed and Sync controls:
Woodward model 2301 speed control
Woodward model SPM-A synchronizer

Start Sequence controls:
Basler Model MOC2 Control

Generator

KATO brushless alternator

Nameplate:

Serial Number 75236
Rated at 3,510 kW
3,900 kVA @ 0.9 PF
2,400/4,160 volts
3 Phase, 4 Wire, 60 Hz
1,800 RPM
Manufactured: 1980

Two bearing type including a PM generator, inlet and exhaust air ducts, 480 V space heater, 2 bearing 676 Ohm RTD's, and with an outlet box on the right hand side of drive end.

HSRG (Heat Recovery Steam Generator)

The HRSG is manufactured by:

Energy Recovery Inc.
P.O. Box 80404
Lincoln, Nebraska 68501
(402) 434-2006

Model #S2-1716
SN W-2761
MAWP: 150 psig
Steam rate: 20,000 pound per hour
Manufactured: 1990

The Heat Recovery Steam Generator operates continuously together with the Allison 501-KB5 gas turbine. The HRSG receives exhaust gases "produced" by the gas turbine. It generates anywhere from 16,000 to 20,000 pounds per hour (pph) of high pressure steam, depending on the load on the gas turbine generator.

Major System Components - The HRSG (E R I, S2-1716) consists of the following major components or sections

A) Inlet Transition Duct	LMC
B) Steam Generator	ERI S2-1716
C) Feed water loop controller	Bailey A0537
D) Feed water control valve	Fisher 667
E) Safety steam relief valves	Consolidated 1511
F) Blow down valves	Yarway 1.5”
G) Water Column system	Reliance EA-4
H) Non-return valve	Crane
I) Economizer Section	ERI TJM-1897
J) Exhaust Stack	

Guaranteed Performance (under specified conditions):

A) HP Steam Pressure (Design)	250 psig
B) HP Steam Pressure (Operating)	150 psig
C) HP Steam Temperature	358 ^{0}F
D) HP Steam Flow	20,000 lbs/hr
E) HRSG furnace heating surface	13,870 Sq. Ft.
F) Water capacity when flooded	1,216 gallons
G) Water capacity at operating level	908 gallons
H) Total tubes	272 x 2” OD

HRSG System Protection - The high pressure steam piping and the steam drum are protected from over pressure by Consolidated pressure safety valves, model # 1511J with the following characteristics:

<u>First safety valve</u> (HRSG steam drum outlet)
Set at 180 psig
Capacity = 11,627 lbs/hr
Max allowable pressure to lift = 180 psig
Re-set down pressure = 178 psig

<u>Second safety valve</u> (HRSG steam drum outlet)
Set at 185 psig
Capacity = 11,926 lbs/hr
Max allowable pressure to lift = 185 psig
Re-set down pressure = 183 psig

III. Maintenance History

The engine presently has 60,772 hours of operation. All quarterly and annual inspections have been performed by Rolls Royce Engine Services, as well as all planned maintenance.

Engine

Turbine Section
1st Stage vanes replaced 06/06/04
2nd - 4th Stage Vanes Replaced 08/24/01
1st - 4th Stage Blades Replaced 08/24/01

Bearings
#1 Compressor Replaced 08/24/01
#2 Compressor Replaced 08/24/01
#3 Turbine Replaced 08/24/01
#4 Turbine Replaced 08/24/01
PTO Mid Span Bearing Replaced 05/01/03
Rear Turbine Bearing Support Replaced 08/24/01
Tail Cone Replaced 08/24/01
Extension Shaft Bearing Replaced 08/24/01

Compressor Assembly
1st – 14th Stage Vanes Replaced 3/99
1st – 14th Stage Blades Replaced 3/99

Combustion
Liners upgraded from 3.0 to 3.2 on 06/06/04
Fuel Nozzles Replaced on 06/06/04

Gearbox
Replaced starter motor & pump 06/06/04

Generator
No major repair work.

Boiler (HSRG)
No major repair work. Boiler is currently in dry lay up.