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Transmittal Form

TO: Cathy Sellers
Moyle Flanigan Katz Kolins Raymond & Sheehan
The Perkins House, 118 North Gadsden St.
Tallahassee, FL 32301

DATE 11/3/00	PROJECT NO.
RE: CPV Gulfcoast Project	

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REMARKS: Per request of Larry Labrie

SIGNED: [signature]
Scott Sumner, P.E.

cc: S. Nelson
C. Gallagher
B. Oleman, Env. Mgt
M. Bottlaffer ...
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Responses to Florida DEP Comments on CPV Gulfcoast Power Generation Facility

DEP File No. 0810194-001-AC (PSD-FL-300)

Prepared by:

TRC
Boott Mills South
Foot of John Street
Lowell, MA 01852
(978) 970-5600

November 3, 2000

Responses to Florida DEP Comments on CPV Gulfcoast Power Generation Facility

DEP File No. 0810194-001-AC (PSD-FL-300)

1. *Process flow diagram.*

A process flow diagram is contained in Attachment 1. This diagram presents the typical operation of the combined cycle power generation equipment at the site average ambient temperature of 72°F and 100% load with power augmentation.

2. *Combustion Turbine: Is this combustion turbine equipped with evaporative inlet air cooling system (foggers)? Will the unit operate while both fogging and power augmenting? Please explain. Will this turbine always operate in the combined cycle mode? What is the heat rate of this project (Btu/kwh)? Submit General Electric performance data sheets for this turbine.*

The combustion turbine is not equipped with evaporative coolers.

The turbine will always operate in a combined cycle mode. No provisions are made in the design to bypass the HRSG.

The heat rate is 6,542 Btu/kW at an ambient temperature of 72°F and 100% load with power augmentation as shown in Attachment 1.

3. *Heat Recovery Steam Generator: Is the HRSG supplementally-fired? If so, what, is the heat input of the duct burner. What is the model and manufacturer of the duct burner and HRSG if already selected? Submit the manufacturer performance sheets if available. How much steam is produced at this unit?*

The HRSG will not include duct burners.

The HRSG manufacturer has not been selected.

Steam production is provided on the process flow diagram contained in Attachment 1 for typical plant operation.

4. *Power Augmentation: How much extra power is produced in the power augmentation mode? Provide a schematic of the power augmentation operation mode. What is the manufacturer's maximum recommended period (hr/year, hr/month) for operation in the power augmentation mode.*

Power augmentation (PA) increases maximum combustion turbine output from 162,100 kW without PA to 177,300 kW with PA at typical operating conditions (see Attachment 1). There is no limit to operating in the PA mode (steam injection mode) as long as the ambient operating restrictions are followed. Steam injection is restricted to periods when the ambient temperature is above 59°F.

5. *Automated Control System: What type of control system is recommended by the combustion manufacturer (i.e. Mark V control system, etc).*

The new power generation equipment will include a SPEEDTRONIC Mark V Triple Modular Redundant microprocessor gas turbine control system. A detailed description of this system is contained in Attachment 2, Section 5.3 Gas Turbine-Generator Controls and Electric Auxiliaries.

6. *Storage Tanks: What are the capacities of the tanks associate with this plant?*

Facility storage tanks include:

- Fire Water Storage (300,000 gallons, Diameter: 50 feet, Height: 20 feet)
- Demineralized Water Storage (1,500,000 gallons, Diameter: 75 feet, Height: 48 feet)
- Fuel Oil Storage (1,000,000 gallons, Diameter: 65 feet, Height: 48 feet)
- Ammonium Hydroxide Storage (12,000 gallons, Diameter: 12 feet, Height: 14 feet)

7. *Ancillary Equipment: The application only lists the CT, HRSG and the Cooling Tower. Would this plant include an Emergency Generator and Diesel Fired Pump, gas heaters, or any other ancillary equipment?*

Ancillary equipment will include:

- One diesel fired 250 hp fire water pump and
- One 500 kW emergency generator for safe shutdown.

8. *Selective Catalytic Reduction (SCR) system:*
   - *The application states that GE does not recommend operation of the SCR during distillate fuel operation. However a 30 days at full load while burning oil and a 10 ppm NO_X limit is being proposed. Please explain.*
   - *What is the ammonia slip proposed for this project (ppm)?*
   - *Submit the environmental and energy impact analysis for this project while using SCR.*

SCR operation when firing distillate causes an increase in ash (ammonia bisulfate) buildup and corrosion on the surfaces downstream of the SCR that is much greater than with natural gas firing. The GE recommendation is based on the need for increased maintenance, not on the inability of the combined cycle unit to fire distillate.

The proposed ammonia slip limit is 5 ppmvd @ 15% O_2.

Environmental and energy impact analyses are contained in Attachment 3.

9. *Estimate emissions of hazardous air pollutants (HAPs). Show basis. Indicate if HAPs emissions from this project are less than 25 ton/yr for all HAPs and less than 10 ton/yr for a single HAP.*

The HAP annual emission calculations based on AP-42 Emission Factors are contained in Attachment 4. The maximum individual HAP annual emissions are less than 10 tons per year and the combined HAP annual emission estimate is less than 25 tons per year.

10. *Page twenty one of the application states that there is a graphic showing the location of the stacks and buildings in Appendix D-1, however, this graphic is absent from the appendix. Please provide this graphic along with the BPIP input file.*

The graphic showing the stack and plant structures and the BPIP input file are contained in Attachment 5.

11. *Please provide information that shows that the site boundary used in the impact modeling will be land owned or controlled by CPV Gulfcoast, Ltd. with a physical barrier to public access.*

Access to the site will be restricted by fence located along the site boundary as shown in Attachment 6. The model receptor net work was developed to identify the maximum air quality impact of the power generation equipment and cooling tower emissions consistent with this restricted access site boundary.

12. *The table entitled 'Gulfcoast-Single CT Firing Oil (150-foot stack)' in Appendix D identifies the 97/50 operating scenario as the worst case impact scenario for PM_{10}. However, this was not the scenario that was used in the PM_{10} modeling that included the cooling towers. Please re-evaluate the PM_{10} Class II SIL modeling by using the 97/50 operating scenario.*

The cooling tower will be equipped with automatic controls that will turn off one or more cooling fans at reduced load and/or in cool weather when the full capacity of the cooling tower is not required. Operation of the fan(s) will be based on the temperature of the cooling water returned to the condenser and a fan may be turned on and off as required to modulate the temperature. No more than 3 fans will operate at any time when the combustion turbine operates at 50 % load.

The cooling tower drift rate and associated particulate emissions are directly proportional to the number of operating fans. The unit impact of the cooling tower particulate emissions (air quality impact per unit of emissions) is greater than the combustion turbine due to the lower release height, less buoyancy, and greater downwash effects. Accordingly, the 40% reduction in emissions from the cooling tower (five cells to three cells) associated with the combustion turbine operating at 50% load causes a net reduction in total facility air quality impact when compared with the power generation equipment and cooling tower operating at maximum load.

13. *The set of 13 discrete receptors for the Chassahowitzka NWR that the Department provided to TRC were intended for use in a regular CALPUFF analysis. If the applicant proposes to show compliance with modeling requirements by using the CALPUFF LITE screening method, then a ring of receptors as described on pages 6-8 in the IWAQM Phase 2 Summary Report should be utilized to show compliance with both increment consumption and regional haze requirements.*

Based on the memorandum contained in Attachment 7 from Ellen Porter (U.S. Fish & Wildlife Service, Air Quality Branch), dated September 27, 2000, no response is required.

14. *Please provide the meteorological files that were utilized in the CALPUFF LITE modeling analysis, and a listing of the parameters that were used to create them.*

Based on the memorandum contained in Attachment 7 from Ellen Porter (U.S. Fish & Wildlife Service, Air Quality Branch), dated September 27, 2000, no response is required.

15. *Class I increment and regional haze modeling should be conducted by using the worst case operating load for each pollutant (i.e. 100% load at 25°F for NO_x and SO_2, and 50% load at 25°F for PM_{10}).*

Based on the memorandum contained in Attachment 7 from Ellen Porter (U.S. Fish & Wildlife Service, Air Quality Branch), dated September 27, 2000, no response is required.

Scott Sumner, P.E.

Date: 11/2/00

ATTACHMENT 1

CPV - Gulfcoast - STAG ternational, Inc.

IPS#

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proprietary information to the GE Company and
ept with written permission of the GE Company.

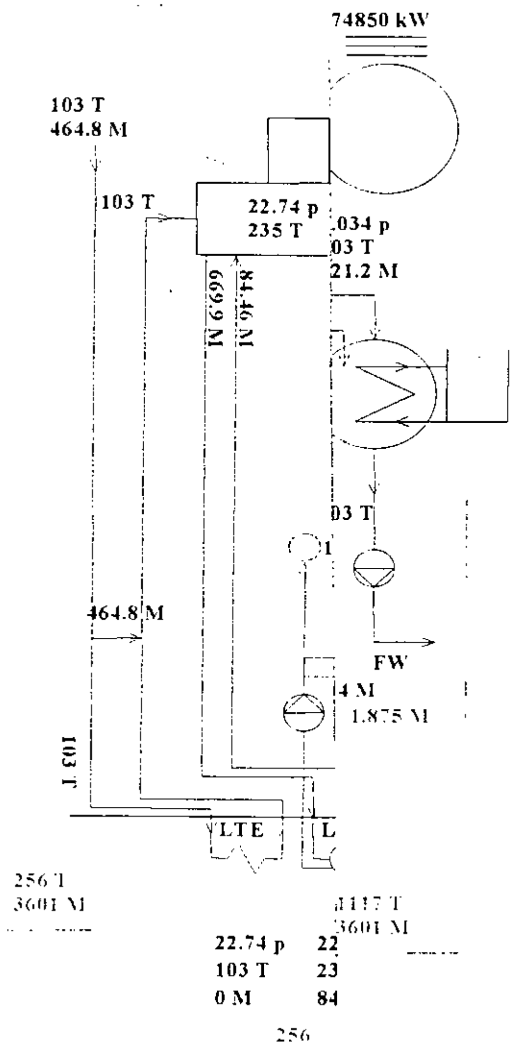
Ba

GT MASTER 9.1 GE

14.69 p
72 T
74 %RH
3407 m
19 ft elev.

kW
Wh

2+Ar
2
O2+SO2
2O



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Thursday, October 26, 2000

DEP File No. 0810194-001-AC (PSD-FL-300) 11/03/00

ATTACHMENT 2

5. Typical Gas Turbine-Generator Description

5.1 Gas Turbine Systems

5.1.1 Gas Turbine

The MS7001(FA) gas turbine has a single shaft, bolted rotor with the generator connected to the gas turbine through a solid coupling at the compressor or "cold" end. This configuration improves alignment control and provides an axial exhaust–optimal for combined cycle or waste heat recovery applications. The major features of the MS7001(FA) gas turbine are described below:

5.1.2 Compressor Section

The axial flow compressor has 18 stages with modulating inlet guide vanes and provides a 15.2 to 1 pressure ratio. Interstage air extraction is used for cooling and sealing air for turbine nozzles, wheelspaces, and bearings, and for surge control during start up.

5.1.2.1 Compressor Rotor

The compressor rotor consists of a forward stub shaft with the stage zero rotor blades, a sixteen blade and wheel assembly for stages 1 to 16, and an aft stub shaft with the stage 17 rotor blades. Rotor blades are inserted into broached slots located around the periphery of each wheel and wheel portion of the stub shaft. The rotor assembly is held together by fifteen axial bolts around the bolting circle. The wheels are positioned radially by a rabbeted fit near the center of the discs. Transmission of torque is accomplished by face friction at the bolting flange.

Selective positioning of the wheels is made during assembly to reduce the rotor balance correction. The compressor rotor is dynamically balanced after assembly and again after the compressor and turbine rotors are mated. They are precision balanced prior to assembly into the stator.

5.1.2.2 Compressor Blade Design

The airfoil shaped compressor rotor blades are designed to compress air efficiently at high blade tip velocities. Compressor blades are made from high corrosion resistance material which eliminates the need for a coating. These forged blades are attached to their wheels by dovetail connections. The dovetail is accurately machined to maintain each blade in the desired location on the wheel.

Stator blades utilize square bases for mounting in the casing slots. Blade stages zero through four are mounted by axial dovetails into blade ring segments. The blade ring segments are inserted into circumferential grooves in the casing and are secured with locking rings. Stages 5 through 16 are mounted on individual rectangular bases that are inserted directly into circumferential grooves in the casings. Stage 17 and the exit guide vanes are cast segments.

5.1.2.3 Compressor Stator

The casing is composed of three major subassemblies: the inlet casing, the compressor casing, and the compressor discharge casing. These components in conjunction with the turbine shell, exhaust frame/diffuser, and combustion wrapper form the compressor stator.

The casing bore is maintained to close tolerances with respect to the rotor blade tips for maximum aerodynamic efficiency. Borescope ports are located throughout the machine for component inspection. In addition all casings are horizontally split for ease of handling and maintenance.

5.1.2.3.1 Inlet Casing

The primary function of the inlet casing, located at the forward end of the gas turbine, is to direct the air uniformly from the inlet plenum into the compressor. The inlet casing also supports the number 1 thrust bearing assembly and the variable inlet guide vanes, located at the aft end.

5.1.2.3.2 Compressor Casing

The compressor casing contains compressor stages zero through 12. Extraction ports in the casing allow bleeds to the exhaust plenum during start-up and extraction of air to cool the second and third stage nozzles.

5.1.2.3.3 Compressor Discharge Casing

The compressor discharge casing contains 13th- through 17th- stage compressor stators and one row of exit guide vanes. It also provides an inner support for the first-stage turbine nozzle assembly and supports the combustion components. Air is extracted from the compressor discharge plenum to cool the stage one nozzle vane, retaining ring, and shrouds.

Similarly, air extracted from the compressor discharge plenum is used to provide the following:

- Atomizing air for liquid fuel
- Fuel system purge air
- Inlet bleed heat
- Compressor surge control

The compressor discharge casing consists of two cylinders connected by radial struts. The outer cylinder is a continuation of the compressor casing and the inner cylinder surrounds the compressor aft stub shaft. A diffuser is formed by the tapered annulus between the outer and inner cylinders. The compressor discharge casing is joined to the combustion wrapper at the flange on its outermost diameter.

5.1.3 Turbine Section

In the three stage turbine section, energy from hot pressurized gas produced by the compressor and combustion section is converted to mechanical energy. The turbine section is comprised of the combustion wrapper, turbine rotor, turbine shell, exhaust frame, exhaust diffuser, nozzles and diaphragms, stationary shrouds, and aft (number 2) bearing assembly.

5.1.3.1 Turbine Rotor

The turbine rotor assembly consists of a forward shaft, three turbine wheels, two turbine spacer wheels, and an aft turbine shaft which includes the number 2 journal bearing. The forward shaft extends from the compressor rotor aft stub shaft flange to the first stage turbine wheel. Each turbine wheel is axially separated from adjacent stage(s) with a spacer wheel. The spacer wheel faces have radial slots for cooling air passages, and the outer surfaces are machined to form labyrinth seals for interstage gas sealing.

Selective positioning of rotor members is performed during assembly to minimize balance corrections of the assembled rotor. Concentricity control is achieved with mating rabbets on the turbine wheels, spacers, and shafts. Turbine rotor components are held in compression by bolts. Rotor torque is accomplished by friction force on the wheel faces due to bolt compression.

The turbine rotor is cooled by air extracted from compressor stage 17. This air is also used to cool the turbine first- and second-stage buckets plus the rotor wheels and spacers.

5.1.3.2 Turbine Bucket Design

The first-stage buckets use forced air convection cooling in which turbulent air flow is forced through integral cast-in serpentine passages and discharged from holes at the tip of the trailing edge of the bucket. Second-stage buckets are cooled via radial holes drilled by a shaped tube electromechanical machining process. Third-stage buckets do not require air cooling.

Second- and third-stage buckets have integral tip shrouds which interlock buckets to provide vibration damping and seal teeth that reduce leakage flow. Turbine buckets are attached to the wheel with fir tree dovetails that fit into matching cutouts at the rim of the turbine wheel. Bucket vanes are connected to the dovetails by shanks which separate the wheel from the hot gases and thereby reduce the temperature at the dovetail. All turbine buckets are coated to provide corrosion resistance.

The turbine rotor assembly is arranged to allow buckets to be replaced without having to unstack the wheels, spacers and stub shaft assemblies. Similarly, buckets are selectively positioned such that they can be replaced individually or in sets without having to rebalance the wheel assembly.

5.1.3.3 Turbine Stator

The turbine stator is comprised of the combustion wrapper, turbine shell, and the exhaust frame. Like the compressor stator, the turbine stator is horizontally split for ease of handling and maintenance.

5.1.3.3.1 Combustion Wrapper

The combustion wrapper, located between the compressor discharge casing and the turbine shell, facilitates removal and maintenance of the transition pieces and stage one nozzle.

5.1.3.3.2 Turbine Shell

The turbine shell provides internal support and axial and radial positions of the shrouds and nozzles relative to the turbine buckets. This positioning is critical to gas turbine performance. Borescope ports are provided for inspection of buckets and nozzles.

5.1.3.3.3 Exhaust Frame

The exhaust frame is bolted to the aft flange of the turbine shell and consists of an outer and an inner cylinder interconnected by radial struts. The inner cylinder supports the number 2 bearing. The tapered annulus between the outer and inner cylinders forms the axial exhaust diffuser. Gases from the third-stage turbine enter the diffuser where the velocity is reduced by diffusion and pressure is recovered, improving performance.

Cooling of the exhaust frame, number 2 bearing, and diffuser tunnel is accomplished by motor-driven blowers. These motor driven blowers are located on the top of the gas turbine enclosure.

5.1.3.4 Turbine Nozzle Design

The turbine section has three stages of nozzles (stationary blades) with air cooling provided to all three stages. The first- and second-stage nozzles are cooled by a combination of film cooling (gas path surface), impingement cooling, and convection cooling in the vane and sidewall regions. The third stage uses convection cooling only.

All turbine nozzles consist of multi-vane segments. First-stage turbine nozzle segments are contained by a retaining ring which remains centered in the turbine shell. The second- and third-stage nozzle segments are held in position by radial pins from the shell into axial slots in the nozzle outer sidewall.

5.1.3.5 Bearings

The MS7001(FA) gas turbine contains two journal bearings to support the turbine rotor and one dual direction thrust bearing to maintain the rotor-to-stator axial position. The bearings are located in two housings: one at the inlet and one at the center of the exhaust frame. All bearings are pressure lubricated by oil supplied from the main lubrication oil system. The number 1 bearing (journal and thrust) is accessed by removing the top half of the compressor inlet casing. The number 2 bearing is readily accessible through the tunnel along the centerline of the exhaust diffuser. (Removal of the turbine casing is not required for bearing maintenance.) Bearing protection includes vibration sensors and drain oil temperature thermocouples.

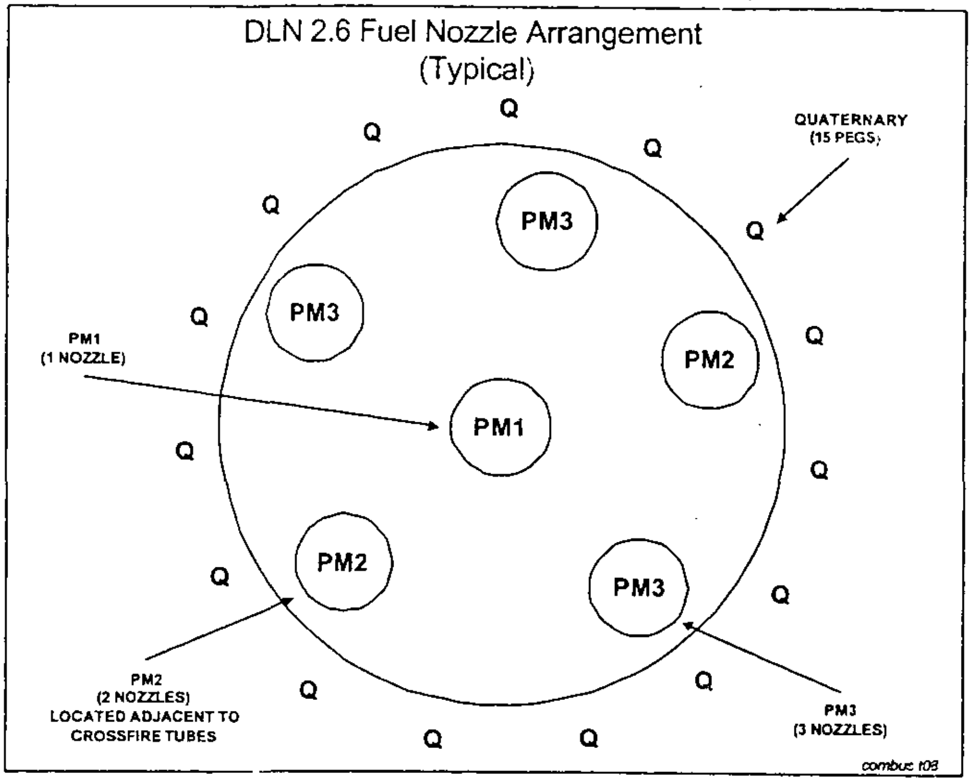
5.1.4 Combustion

5.1.5 Dry Low NOx 2.6 Combustion System

The Dry Low NOx 2.6 combustor was designed to minimize emissions when operating on gas fuel but is capable of operation with either gas or liquid fuel. Optimal emissions are achieved through the regulation of fuel distribution to a multi-nozzle, total premix combustor arrangement. The fuel flow distribution to each fuel nozzle assembly is calculated to maintain unit load and fuel split which optimizes turbine emissions.

5.1.5.1 Fuel Nozzle Arrangement

The DLN 2.6 combustion system consists of six fuel nozzles per combustion can, each operating as a fully premixed combustor. One fuel nozzle is located in the center of the combustion can with five nozzles located radially from the first as shown in the illustration below. The center nozzles is identified as PM1 (Pre Mix 1). Two outer nozzles located adjacent to the crossfire tubes are identified as PM2 (Pre Mix 2). The remaining three outer nozzles are identified as PM3 (Pre Mix 3). Another fuel passage is located in the airflow upstream of the premix nozzles, circumferentially around the combustion can. This passage is identified as the quaternary fuel pegs.



Fuel flow to the six fuel nozzles and quaternary pegs is controlled by independent control valves, each controlling flow split and unit load. The gas fuel system consists of the gas fuel stop/ratio valve, gas control valve one (PM1), gas control valve two (PM2), gas control valve three (PM3), and gas control valve four (Quat).

The stop/ratio valve (SVR) is designed to maintain a predetermined pressure at the inlet of the gas control valves. Gas control valves one through four regulate the desired gas fuel flow delivered to the turbine in response to the command signal fuel stoke reference (FSR) from the gas turbine control panel. The DLN 2.6 control system is designed to ratio FSR into a Flow Control Reference. The flow control philosophy is performed in a cascading routine, scheduling a percentage flow reference for a particular valve, and driving the remainder of the percentage to the next valve reference parenthetically downstream in the control software.

5.1.5.2 Chamber Arrangement

The gas turbine employs fourteen combustors designated as combustion chambers. There are two spark plugs and four flame detectors in selected chambers with crossfire tubes connecting adjacent chambers. Each combustor consists of a six nozzle/endcover assembly, forward and aft combustion casings, flow sleeve assembly, multi-nozzle cap assembly, liner assembly and transition piece assembly. A quaternary nozzle arrangement penetrates the circumference of the combustion chamber, porting fuel to casing injection pegs located radially around the casing.

5.1.5.3 Spark Plug Ignition System

Two spark plugs located in different combustion chambers are used to ignite fuel flow. These spark plugs are energized to ignite fuel at firing speed during start-up only. Flame is propagated to those combustion chambers without spark plugs through crossfire tubes connecting adjacent combustion chambers around the gas turbine.

5.1.5.4 Flame Detectors

Reliable detection of flame location in the DLN 2.6 system is critical to the control of the combustion process and to protection of the gas turbine hardware. Four flame detectors are mounted in separate combustion chambers around the gas turbine to detect flame in all modes of operation. The signals from these flame detectors are processed in control logic and used for various control and protection functions.

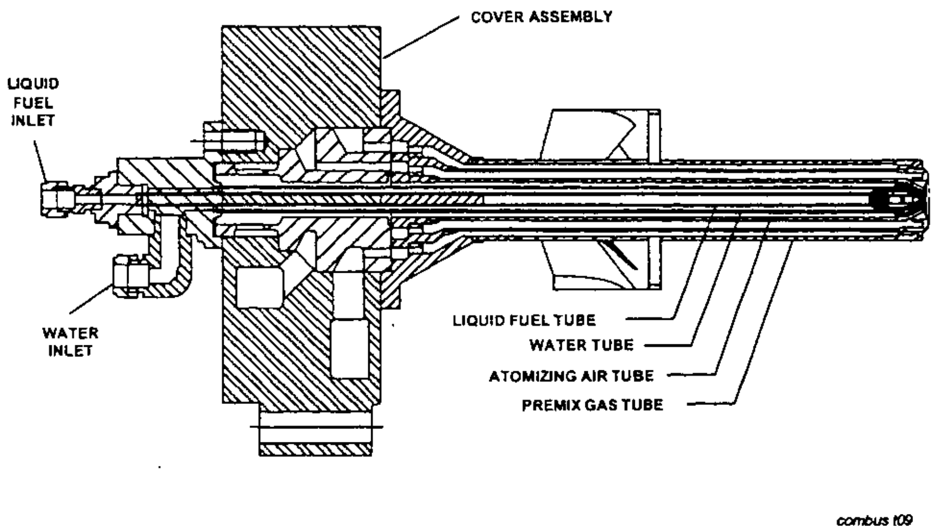
5.1.5.5 Gas Fuel Operation

The DLN 2.6 fuel system operation is fully automated, sequencing the combustion system through a number of staging modes prior to reaching full load. The primary controlling parameter for fuel staging is the calculated combustion reference temperature. Other DLN 2.6 operation influencing parameters available to the operator are inlet guide vane (IGV) temperature control "ON" or "OFF" and inlet bleed heat "ON" or "OFF". To achieve maximum exhaust temperature, as well as an expanded load range for optimal emissions, both IGV temperature control and inlet bleed heat should be selected "ON".

5.1.5.5.1 Liquid Fuel Operation

Because liquid fuel injection occurs at the tips of the outer five fuel nozzle only, operation on liquid fuel is always in diffusion mode. A water injection passage, which is integral to the fuel nozzle as illustrated below, is used for NOx abatement while operating on liquid fuel.

Fuel Nozzle
(Typical)



5.1.5.6 Inlet Guide Vane Operation

The DLN 2.6 combustor emission performance is sensitive to changes in fuel/air ratio. The combustor was designed according to the airflow regulation scheme used with IGV temperature control. Optimal combustor operation is dependent upon proper operation along the predetermined temperature control scheme. Controlled fuel scheduling is dependent upon the state of IGV temperature control.

IGV temperature control "ON" is also referred to as a combined cycle operation while IGV temperature control "OFF" is referred to as simple cycle operation.

5.1.5.7 Fuel Flow Monitoring Equipment

The following fuel flow equipment is provided for integration by the customer into the fuel supply line:

- Gas
  - Meter tube and orifice with delta P transducers for flow indication
  - Transmitter for supply temperature indication
  - Static pressure transducer
- Distillate

- Fuel flowmeter

  Flowmeter is installed on the fuel forwarding skid.

5.1.5.8 Water Injection System

The water injection system consists of pumping and metering equipment for supplying water to the combustion system for:

- NOx emission control

All piping and components which come into contact with water are stainless steel. The control system provides the above using minimum water injection and minimum degradation in heat rate by modulating the water injection rate proportional to fuel consumption.

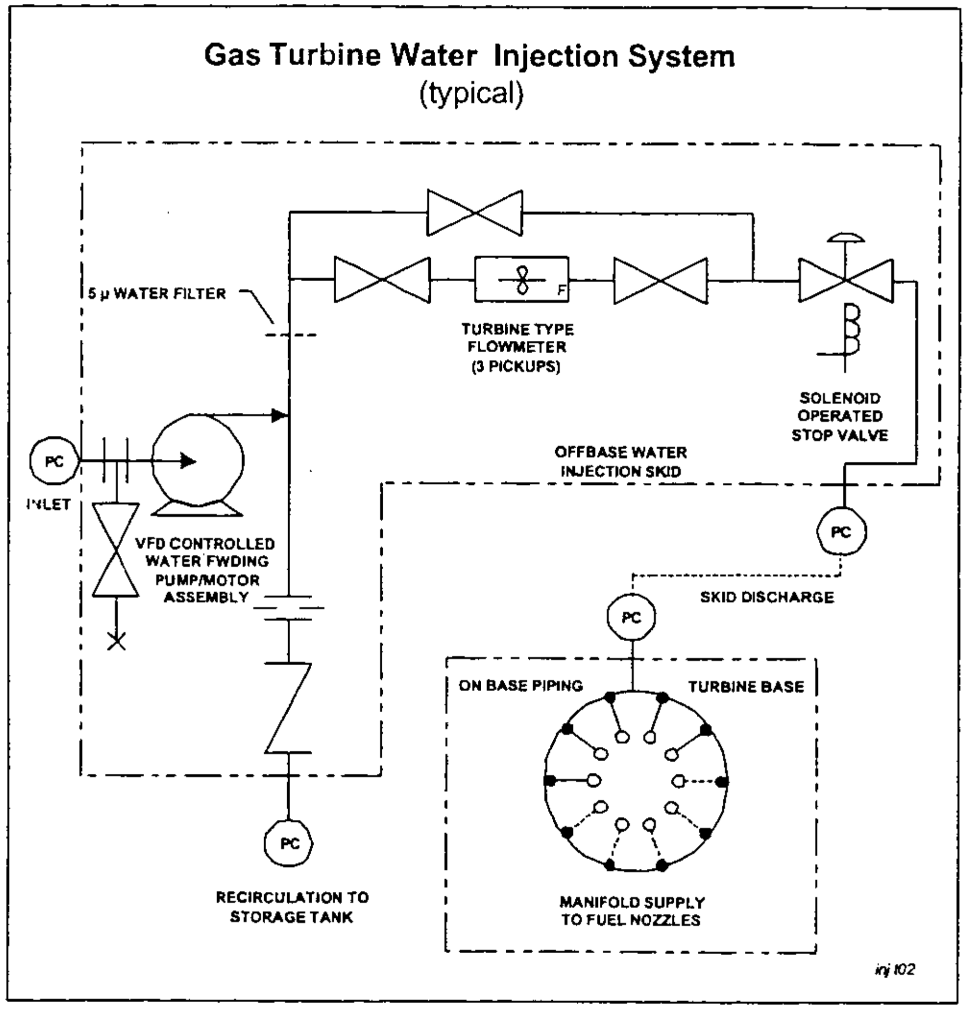
5.1.5.8.1 On-Base Equipment

The on-base equipment includes water supply manifold(s), water injection spray nozzles built into the fuel nozzles, and a piping connection to the off-base water supply.

Also located on-base are the controls for the water injection system consisting of automatic sequencing and flow rate control and operator interfaces for monitoring and recording of the water to fuel ratio and fuel flow.

5.1.5.8.2 Off-Base Water Injection Skid

The water injection skid is a self-contained system used to transport treated water from the customer's storage facility to the gas turbine at the proper pressure and flow rate. The skid includes the following components as illustrated in the diagram below:



5.1.5.8.2.1 Inlet Water Strainer

An inlet Y-strainer removes particles from the water before entering the injection pump. An inlet water pressure switch is included to monitor the differential across the strainer and signal an alarm through the gas turbine control system when cleaning is required.

5.1.5.8.2.2 Water Injection Pump

A single motor driven, high pressure centrifugal water injection pump is used to deliver the water to the gas turbine. The pump includes a variable frequency drive with pump/motor speed feedback. A pressure transmitter is supplied to monitor the water pressure at the pump discharge. The pump motor includes a space heater for anti-moisture condensation.

5.1.5.8.2.3 Water Filter

After exiting the pump, the water is cleaned using a five micron nominally rated filter. A differential pressure switch is included to signal through the gas turbine control system when filter cleaning is needed.

5.1.5.8.2.4 Water Flowmeter

Water usage is recorded by a turbine flowmeter with three identical pick-ups/transmitters and downstream strainer.

5.1.5.8.2.5 Solenoid Stop Valve

A water actuated solenoid stop valve is installed at the outlet connection of the water injection skid. The system also includes an actuation pressure regulator, actuation pressure relief valve, quick release valve, and actuation last-chance filter.

5.1.5.8.2.6 Electrical Equipment

Interconnecting wiring, conduit, junction box, and motor control center are included for the equipment mounted on the skid.

5.1.5.8.2.7 Skid Features

The skid includes a structural steel base, interconnecting piping for the skid mounted equipment, check valves, pressure gauges, inlet water temperature gauge, and manual isolation valves.

5.1.5.8.2.8 Enclosure

A weatherproof enclosure with ventilation fan and lighting is provided.

A space heater with controlling thermostat is supplied with the enclosure to guard against freezing.

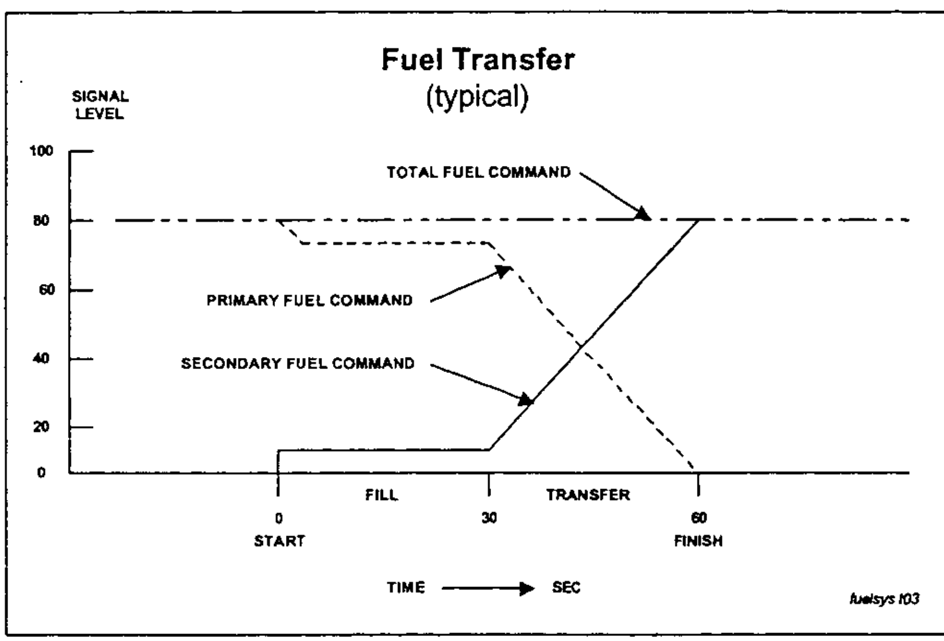
5.1.6 Fuel System

5.1.6.1 Dual Fuel System

The dual fuel system allows the gas turbine to operate on either gas or distillate fuel. Either may be used for start up. Transfers from one fuel to the other may be initiated by the operator prior to start up or at any time after completion of the starting sequence. Transfers from distillate to gas may be required to be made within a load range which results in completing the fuel transfer without staging from one gas fuel combustion mode to another.

Since gas is typically the primary fuel and distillate the backup fuel, transfers from gas to distillate are automatically initiated on low gas supply pressure, provided that liquid fuel is available and provided there is adequate time to start the fuel forwarding pump. Transfer back to the primary fuel is by operator initiation only in order to ensure the integrity of the fuel supply and to prevent oscillatory operation if the gas supply pressure is marginal at the transfer initiation pressure. The operator should confirm the availability of the primary fuel supply prior to initiating the transfer.

A typical fuel transfer is illustrated below. During fuel transfer, the energy equivalent of fuel flow as a function of the fuel command is matched between the two fuels to insure that equal fuel commands will result in equal energy release in the gas turbine combustors.



The transfer sequence is divided into two parts: a line filling period and the actual transfer. During the first period, the incoming fuel command increases to a level that will allow filling of the system in about thirty seconds, and the outgoing fuel command decreases by an equivalent amount. After fuel has reached the fuel nozzles, the incoming fuel is ramped up to equal the total fuel demand, and the outgoing fuel is ramped down to zero. Since total energy to the gas turbine is held reasonably constant, load variations are minimal—generally less than five percent of nameplate rating (for a properly matched and tuned system).

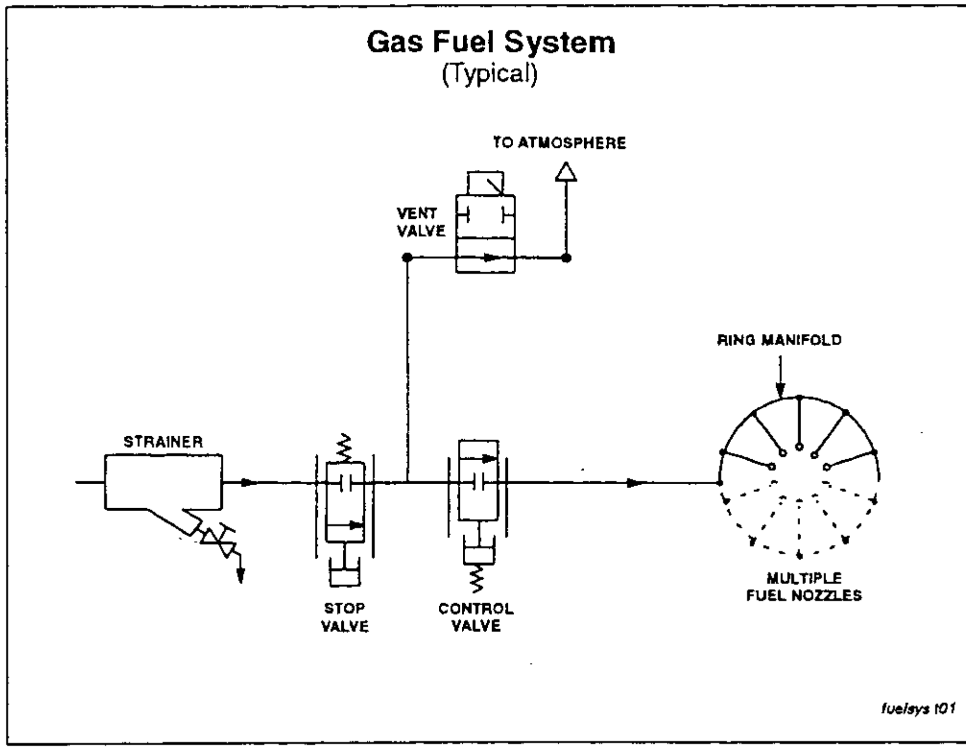
The next step in fuel transfer is purging the inactive fuel system and verifying proper operation. During purge of the inactive fuel system, the purge process introduces a limited amount of additional fuel injected into the turbine. The purge sequencing is designed to minimize this effect of this additional fuel flow. Purging of liquid fuel nozzles is initiated during the fuel transfer which causes random opening of purge check valves and significantly reduces load spikes.

If diluent injection is used to for emissions control, the fuel transfer is completed before diluent injection is initiated.

The gas and liquid fuel systems components are described in the sections which follow.

5.1.6.2 Gas Fuel System

The gas fuel system modulates the gas fuel flow to the turbine. Proper operation of the gas fuel system requires that the gas be supplied to the gas fuel control system at the proper pressure and temperature. The pressure is required to maintain proper flow control. The fuel gas temperature must ensure that the required hydrocarbon superheat is maintained. For discussion of fuel gas supply requirements in the Reference Documents - Process Specification Fuel Gases for Combustion in Heavy-Duty Gas Turbines. Major system components, as shown in the illustration which follows, are described below.



5.1.6.2.1 Strainer

A single strainer is used to remove impurities from the gas. A pressure switch which monitors the differential across the strainer will signal an alarm through the gas turbine control system when the pressure drop across the strainer indicates cleaning is required.

5.1.6.2.2 Fuel Gas Stop/Speed Ratio and Control Valves

The fuel gas stop/speed ratio and control valves allow fuel flow when the turbine starts and runs, control the fuel flow, and provide protective fuel isolation when the turbine is shut down. In systems with multiple control valve configuration, the control valves also maintain the fuel split among the fuel nozzles.

5.1.6.2.3 Vent Valve

When the gas fuel system is shut off, both the stop valve and the control valve(s) are shut. A vent valve is opened between the stop valve and the control valve(s). The vent valve permits the fuel gas to exit to the atmosphere when the turbine is shut down or switched to an alternate fuel.

5.1.6.2.4 Flow Measurement System

The gas fuel flow measurement system uses a flow metering tube with precision orifice. The pressure drop across the orifice is used to determine the fuel flow. To accommodate the large flow turndown, two delta-pressure transducers with different, but over-lapping ranges, are used.

5.1.6.2.5 Fuel Manifold and Nozzles

The fuel manifold connects the gas fuel nozzles which distribute the gas fuel into the combustion chambers. For staged combustion systems, more than one manifold is used.

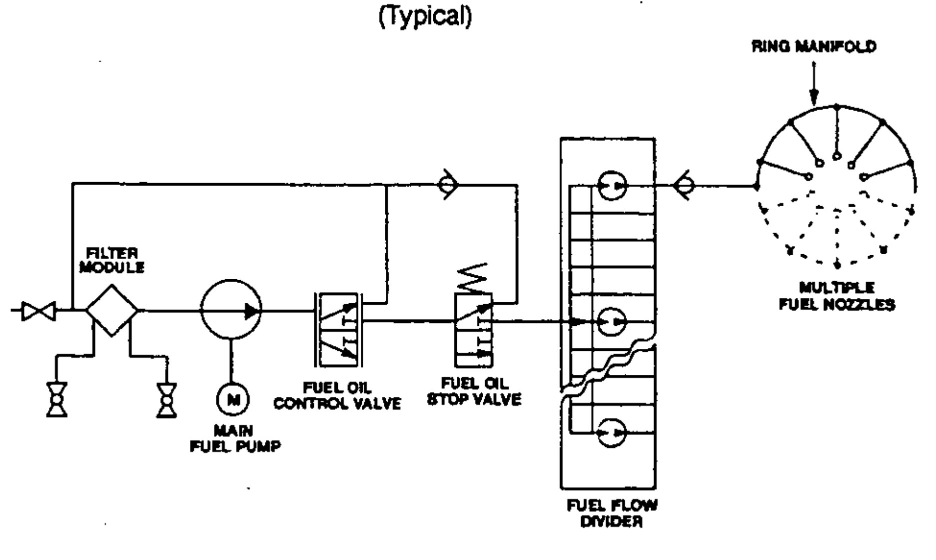
5.1.6.2.6 Piping

The gas fuel system uses stainless steel fuel gas piping with carbon steel flanges.

5.1.6.3 Liquid Fuel System

The liquid fuel system delivers the fuel oil from the fuel forwarding system to the gas turbine combustion chambers. The system filters the fuel and controls the fuel flow to each of the nozzles in the gas turbine combustion chambers. Major system components, as shown in the illustration which follows, are described below.

Liquid Fuel System
(Typical)



5.1.6.3.1 Liquid Fuel Filter

Duplex low pressure fuel oil filters remove particles from the fuel before it reaches the main fuel oil pump. Pressure switches monitor the differential across each filter will signal an alarm through the gas turbine control system when transfer or changeout is required.

5.1.6.3.2 Fuel Oil Stop Valve

The on-base fuel oil stop valve allows fuel flow when the turbine starts and runs and provides protective fuel isolation when the turbine is shutdown.

5.1.6.3.3 Main Liquid Fuel Pump

A single 100% capacity motor-driven main fuel pump supplies high pressure fuel oil for normal start and operation of the gas turbine.

5.1.6.3.4 Bypass Valve

The liquid fuel system pumps fuel to the flow divider. Between the pump and the flow divider, a return line back to fuel storage permits some of the pump flow to be subtracted so that all of the pump output does not go to the turbine. An electro-hydraulically controlled valve uses flow subtraction to maintain proper fuel flow to the turbine combustion system.

5.1.6.3.5 Fuel Flow Divider

A mechanical fuel flow divider metering system distributes the liquid fuel flow equally to the gas turbine combustion chambers. The fuel flow divider includes magnetic pick-ups which detect the speed of rotation of the flow divider and provide feedback to the control system.

5.1.6.3.6 Fuel Nozzles

Fuel nozzles distribute the fuel into the combustion chambers. A selector valve assembly is included for reading individual fuel nozzle pressure at the output of the flow divider.

5.1.6.3.7 Atomizing Air System

The atomizing air system is used to atomize the liquid fuel for combustion.

The system uses a single air to water U-tube heat exchanger located on the turbine base to cool turbine compressor discharge air for entry into the atomizing air compressor. The air is filtered before it is used to atomize the liquid fuel for combustion.

A motor driven atomizing air compressor atomizes the liquid fuel for combustion. A throttling valve is included to reduce the atomizing air compressor outlet pressure for purging liquid fuel nozzles.

The atomizing air equipment is mounted on a combined Liquid Fuel/Atomizing Air Skid which includes a gauge/switch panel, and a weatherproof enclosure.

5.1.6.3.8 Piping

The liquid fuel system uses stainless steel fuel oil piping with carbon steel flanges.

5.1.6.4 Distillate Fuel Forwarding System

The distillate fuel forwarding system is a factory assembled pumping unit. It is a common system used to transfer the distillate fuel oil from the fuel storage tanks to two gas turbines at the proper pressure, temperature and flow rate. The skid, which includes a structural steel base and carbon steel piping, is designed for outdoor operation without an enclosure. Major system components are described below.

5.1.6.4.1 Inlet Isolation Valve

The inlet isolation valve allows the unit to be isolated and shut down for maintenance.

5.1.6.4.2 Duplex Strainer

The system includes a duplex-type strainer with cleanout drains to remove particles from the fuel before it reaches the fuel pump. A pressure switch which monitors the differential across the strainers will signal an alarm through the gas turbine control system when cleaning is required.

5.1.6.4.3 AC Motor-Driven Fuel Pumps

Dedicated ac motor driven fuel pumps supply the on-base high pressure main fuel oil pump for normal start and operation of each gas turbine. Fuel pump operation continues until the gas turbine is shut down or tripped out at which time system operation is stopped automatically by the gas turbine control system.

5.1.6.4.4 Backup AC Motor-Driven Fuel Pump

A single backup pump is included to provide protection against main fuel pump failure for either turbine. The main and backup pumps are driven by separate ac motors in a lead-lag relationship to balance the number of starts on each. Check valves in the discharge piping of each pump prevent backflow through the non-operating pump.

5.1.6.4.5 Fuel Heating

Distillate fuel oil is pumped to heaters which contain electric resistance heating elements and fuel passages arranged inside a welded steel shell. Thermostats control the temperature of the heaters to maintain the fuel temperature within the viscosity range limits required for proper atomization by the fuel nozzles in the combustion system. The heaters will not operate unless the ac pump is running.

Fuel heaters and accessories are mounted on a separate heater skid due to the size of the heaters required.

5.1.6.4.6 Relief Valve

The fuel heater vessel is protected against excessive pressure by a relief valve in the event of fluid thermal expansion with the isolation valves closed. The relief valve discharges into a piping bypass leading to the customer's connection for return to the storage tank. An over-temperature switch is also located in the piping bypass. The switch will signal an alarm through the gas turbine control system if the distillate fuel oil temperature exceeds its setting.

5.1.6.4.7 Pressure Regulating Valve

A pressure regulating valve is used to maintain the fuel pressure at the customer's connection within the limits required for the on-base turbine fuel system.

5.1.6.4.8 Flowmeter

A flowmeter with mechanical readout is installed in the fuel forwarding skid piping to record the amount of fuel being used per turbine.

5.1.6.4.9 Pulse Generator

Pulse generators are included to provide indication of distillate fuel flow rate at a remote location such as the plant distributed control system (DCS).

5.1.6.4.10 Solenoid Stop Valve

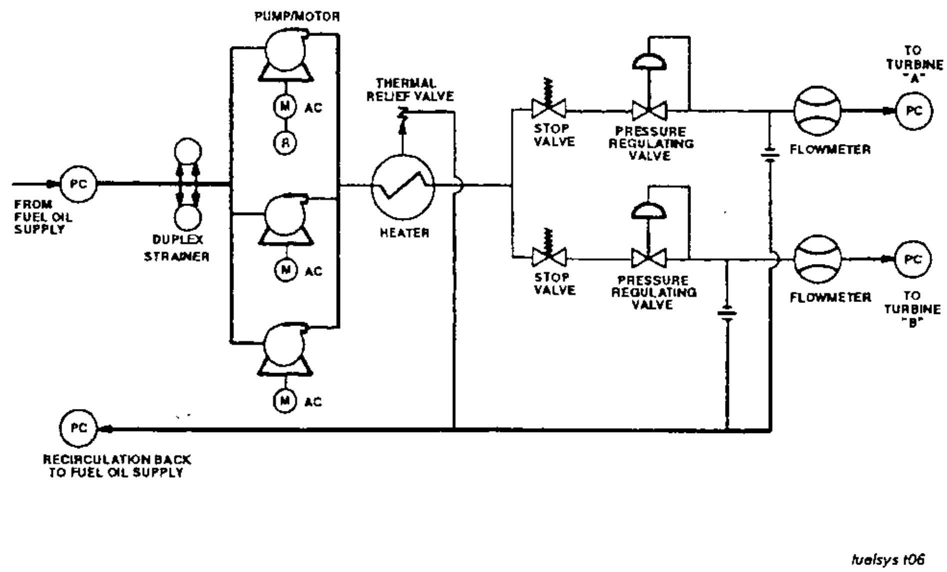
A normally closed, solenoid stop valve is installed at the outlet connection of the forwarding skid. This stop valve operates in conjunction with the on-base fuel oil stop valve to shut off fuel flow when the turbine is shut down. A constant recirculation loop from the downstream side of the pressure regulating valve to the storage tank is provided to prevent deadheading of the pump when the solenoid stop valve is closed.

5.1.6.4.11 Distillate Fuel Forwarding Skid Enclosure

While the fuel forwarding skid is designed for outdoor operation, a weatherproof enclosure is provided to protect against harsh weather conditions in areas subject to very low ambient temperature or heavy rains.

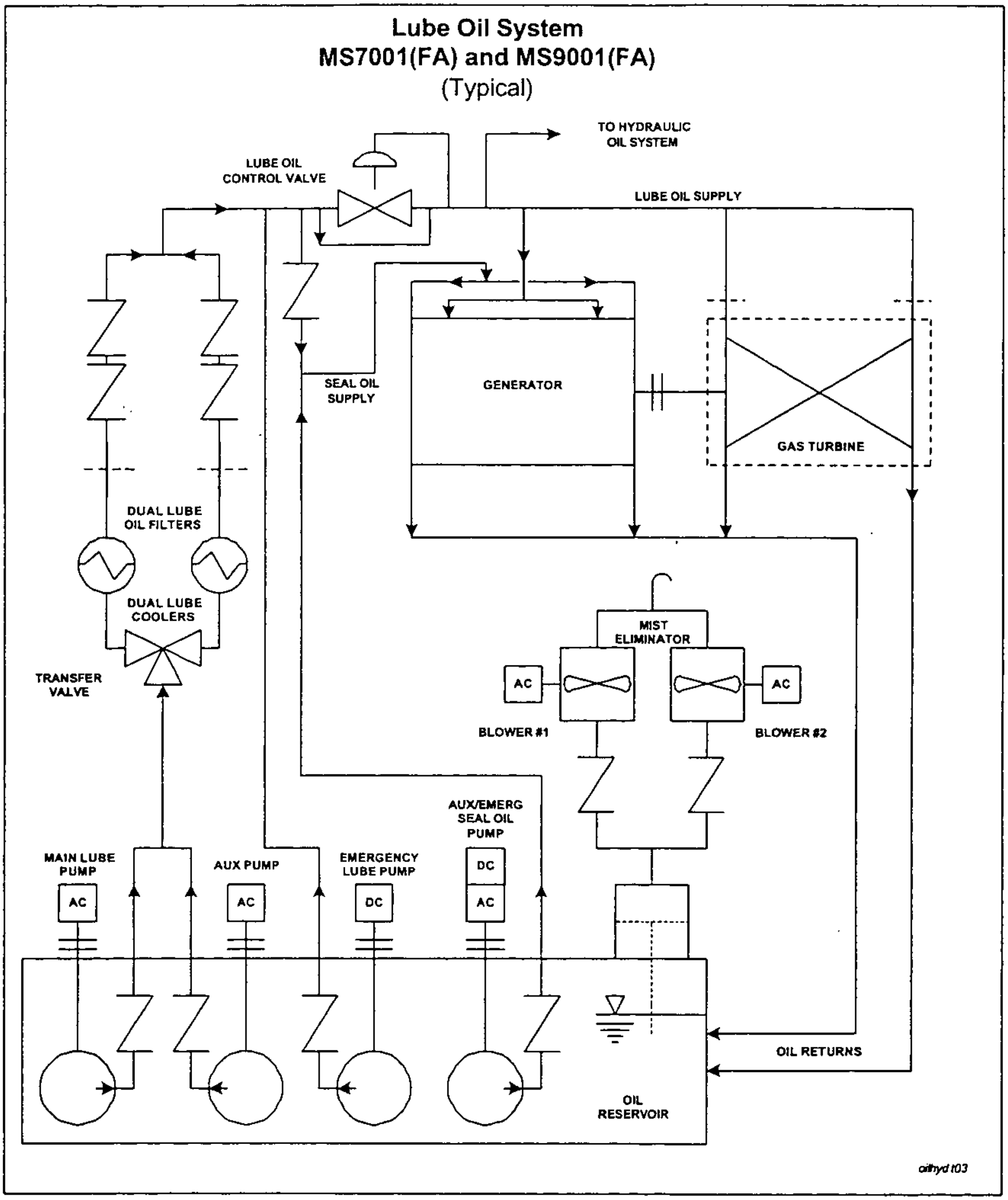
The enclosure is made up of steel panels that fit over the entire fuel forwarding skid, including the roof. Equipment can be easily maintained and removed via access doors and removable panels in the enclosure. Convenience lighting, receptacles and air vents with dust shields are also included.

Liquid Fuel Forwarding System Supplying Two Gas Turbines w/ Fuel Oil Heater
(Typical)



5.1.7 Lubricating and Hydraulic Systems

The lubricating provisions for the turbine and generator are incorporated into a common lubrication system. Oil is taken from this system, pumped to a higher pressure, and used in the hydraulic system for all hydraulic oil control system components. The lubrication system includes oil pumps, coolers, filters, instrumentation and control devices, a mist elimination device and an oil reservoir as shown in the system illustration below. Following the illustration is a brief description of the major system components.


Lube Oil System
MS7001(FA) and MS9001(FA)
(Typical)
TO HYDRAULIC OIL SYSTEM
LUBE OIL CONTROL VALVE
LUBE OIL SUPPLY
SEAL OIL SUPPLY
GENERATOR
GAS TURBINE
DUAL LUBE OIL FILTERS
DUAL LUBE COOLERS
TRANSFER VALVE
MIST ELIMINATOR
AC
AC
BLOWER #1
BLOWER #2
AUX/EMERG SEAL OIL PUMP
MAIN LUBE PUMP
AUX PUMP
EMERGENCY LUBE PUMP
AC
AC
DC
DC
AC
OIL RETURNS
OIL RESERVOIR
oilhyd t03

5.1.7.1 Pumps

The lubrication system relies on several pumps to distribute oil from the oil reservoir to the systems which need lubrication. Similarly, redundant pumps are used to distribute high pressure oil to all hydraulic oil control system components. These and other oil pumps are listed below.

- Lubrication oil pumps
  - Dual redundant ac motor-driven main lubrication oil pumps are provided.
  - A partial flow, dc motor-driven, emergency lubrication oil centrifugal pump is included as a back up to the main and auxiliary pumps.
- Hydraulic pumps
  - Dual redundant ac motor-driven variable displacement hydraulic oil pumps are provided.
- Seal oil pump
  - An auxiliary generator seal oil pump driven by piggyback ac/dc motors is provided as backup to distribute seal oil to the generator.
- Oil Pump for pressure lift journal bearings
  - Oil for the pressure lift bearings is provided by the hydraulic oil pump.

5.1.7.2 Coolers

The oil is cooled by dual stainless steel plate/frame oil-to-coolant heat exchangers with transfer valve. The coolers have an ASME code stamp.

5.1.7.3 Filters

Dual, full flow filters clean the oil used for lubrication. Each filter includes a differential pressure transmitter to signal an alarm through the gas turbine control system when cleaning is required. A replaceable cartridge is utilized for easy maintenance. Filters have an ASME code stamp.

Dual filters clean the oil for the hydraulic system. Each filter includes a differential pressure transmitter to signal an alarm through the gas turbine control system when cleaning is required. A replaceable cartridge is utilized for easy maintenance. Filters have an ASME code stamp.

5.1.7.4 Mist Elimination

Lubrication oil mist particles are entrained in the system vent lines by sealing air returns of the gas turbine lubricating system. In order to remove the particles, a lube vent demister is used as an air-exhaust filtration unit. The demister filters the mist particles and vents the air to the atmosphere while draining any collected oil back to the oil reservoir.

The lube vent demister assembly consists of a holding tank with filter elements, motor-driven blowers, and relief valve. One assembly is provided for the vent line from the lubrication oil reservoir.

5.1.7.5 Oil Reservoir

The oil reservoir has a nominal capacity of 6200 gallons (23,470 liters) and is mounted within the accessory module. It is equipped with lubrication oil level switches to indicate full, empty, high level alarm, low level alarm, and low level trip. In addition the following are mounted on the reservoir:

- Oil tank thermocouples
- Oil heaters
- Oil filling filter
- Oil reservoir drains

5.1.8 Inlet System

5.1.8.1 General

Gas turbine performance and reliability are a function of the quality and cleanliness of the inlet air entering the turbine. Therefore, for most efficient operation, it is necessary to treat the ambient air entering the turbine and filter out contaminants. It is the function of the air inlet system with its specially designed equipment and ducting to modify the quality of the air under various temperature, humidity, and contamination situations and make it more suitable for use. The inlet system consists of the equipment and materials defined in the Scope of Supply chapter of this proposal. The following paragraphs provide a brief description of the major components of the inlet system.

5.1.8.2 Inlet Filtration

5.1.8.2.1 Inlet Filter Compartment

The self-cleaning inlet filter compartment utilizes high efficiency media filters which are automatically cleaned of accumulated dust, thereby maintaining the inlet pressure drop below a preset upper limit. This design provides single-stage high efficiency filtration for prolonged periods without frequent replacements. Appropriate filter media is provided based on the site specific environmental conditions.

Dust-laden ambient air flows at a very low velocity into filter modules which are grouped around a clean-air plenum. The filter elements are pleated to provide an extended surface. The air, after being filtered, passes through venturis to the clean air plenum and into the inlet ductwork.

As the outside of the filter elements become laden with dust, increasing differential pressure is sensed by a pressure switch in the plenum. When the setpoint is reached, a cleaning cycle is initiated. The elements are cleaned in a specific order, controlled by an automatic sequencer.

The sequencer operates a series of solenoid-operated valves, each of which controls the cleaning of a small number of filters. Each valve releases a brief pulse of high pressure air into a blowpipe which has orifices located just above the filters. This pulse shocks the filters and causes a momentary reverse flow, disturbing the filter cake. Accumulated dust breaks loose, falls, and disperses. The cleaning cycle continues until enough dust is removed for the compartment pressure drop to reach the lower setpoint. The design of the sequencer is such that only a few of the many filter elements are cleaned at the same time. As a consequence, the airflow to the gas turbine is not significantly disturbed by the cleaning process.

The filter elements are contained within a fabricated steel enclosure which has been specially designed for proper air flow management and weather protection.

Self-cleaning filters require a source of clean air for pulse-cleaning. Compressor discharge air is used as the pulse air source for filter cleaning. It is reduced in pressure, cooled and dried. This air is already clean because it has been filtered by the gas turbine's inlet air filter. When compressor discharge air is used to pulse the filter, cleaning is possible only when the gas turbine is running.

5.1.8.3 Inlet System Instrumentation

5.1.8.3.1 Inlet System Differential Pressure Indicator

Standard pressure drop indicator (gauge) displays the pressure differential across the inlet filters in inches of water.

5.1.8.3.2 Inlet System Differential Pressure Alarm

When the pressure differential across the inlet filters reaches a preset value, an alarm is initiated. This alarm may signify a need to change the filter elements.

5.1.9 Exhaust System

The exhaust system arrangement includes the exhaust diffuser. After exiting the last turbine stage, the exhaust gases enter the exhaust diffuser section in which a portion of the dynamic pressure is recovered as the gas expands. The gas then flows axially into the exhaust system.

5.1.10 Gas Turbine Packaging

5.1.10.1 Enclosures

Gas turbine enclosures consist of several connected sections forming an all weather protective housing which may be structurally attached to each compartment base or mounted on an off-base foundation. Enclosures provide thermal insulation, acoustical attenuation, and fire extinguishing media containment. For optimum performance of installed equipment, compartments include the following as needed:

- Ventilation
- Heating
- Cooling

In addition, enclosures are designed to allow access to equipment for routine inspections and maintenance.

5.1.10.2 Acoustics

Measuring procedures will be in accordance with ASME PTC 36 (near field) and/or ANSI B133.8 (far field).

For acoustic guarantees, please refer to the Performance Guarantees section of the proposal.

5.1.10.3 Painting

The exteriors of all compartments and other equipment are painted with alkyd or epoxy primer prior to shipment. The exterior surfaces of the inlet compartment and inlet and exhaust duct are painted with one coat of inorganic zinc primer.

Interiors of all compartments are painted as well with the turbine compartment interior receiving high-temperature paint. The interior and exterior of the inlet system are painted with zinc rich paint.

5.1.10.4 Lighting

AC lighting on automatic circuit is provided in the turbine and accessory compartments. When ac power is not available, a dc battery-operated circuit supplies a lower level of light automatically.

Fluorescent lighting is also provided in the PEECC.

5.1.10.5 Wiring

The gas turbine electrical interconnection system includes on-base wiring, terminal boards, junction boxes, etc. as well as compartment interconnecting cables. Junction boxes are selected to meet the environmental requirement of the Customer but are, in general, of steel or cast aluminum construction. Terminal boards within junction boxes are of the heavy duty industrial type selected for the particular environment in which the junction box is located. On-base gas turbine wire termination uses spring tongue crimped type terminals. Generator wire termination are ring type. Control panel wiring is General Electric type SIS Vulkene insulated switchboard wire, AWG #14-41 Strand SI-57275. Ribbon cables are used as appropriate.

5.1.11 Fire Protection System

Fixed temperature sensing fire detectors are provided in the gas turbine, accessory and liquid fuel/atomizing air compartments, and #2 bearing tunnel. The detectors provide signals to actuate the low pressure carbon dioxide (CO_2) automatic multi-zone fire protection system. Nozzles in these compartments direct the CO_2 to the compartments at a concentration sufficient for extinguishing flame. This concentration is maintained by gradual addition of CO_2 for an extended period.

The fire protection system is capable of achieving a non-combustible atmosphere in less than one minute, which meets the requirements of the United States National Fire Protection Association (NFPA) #12.

The supply system is composed of a low pressure CO_2 tank with refrigeration system mounted off base, a manifold and a release mechanism. Initiation of the system will trip the unit, provide an alarm on the annunciator, turn off ventilation fans and close ventilation openings.

5.1.12 Cleaning Systems

5.1.12.1 On-Line and Off-Line Compressor Water Wash

Compressor water wash is used to remove fouling deposits which accumulate on compressor blades and to restore unit performance. Deposits such as dirt, oil mist, industrial or other atmospheric contaminants from the surrounding site environment, reduce air flow, lower compressor efficiency, and lower compressor pressure ratio, which reduce thermal efficiency and output of the unit. Compressor cleaning removes these deposits to restore performance and slows the progress of corrosion in the process, thereby increasing blade wheel life.

On–line cleaning is the process of injecting water into the compressor while running at full speed and some percentage of load. Off–line cleaning is the process of injecting cleaning solution into the compressor while it is being turned at cranking speed. The advantage of on–line cleaning is that washing can be done without having to shut down the machine. On–line washing, however, is not as effective as off–line washing; therefore on–line washing is used to supplement off–line washing, not replace it.

The on–base compressor washing features are described and illustrated below.

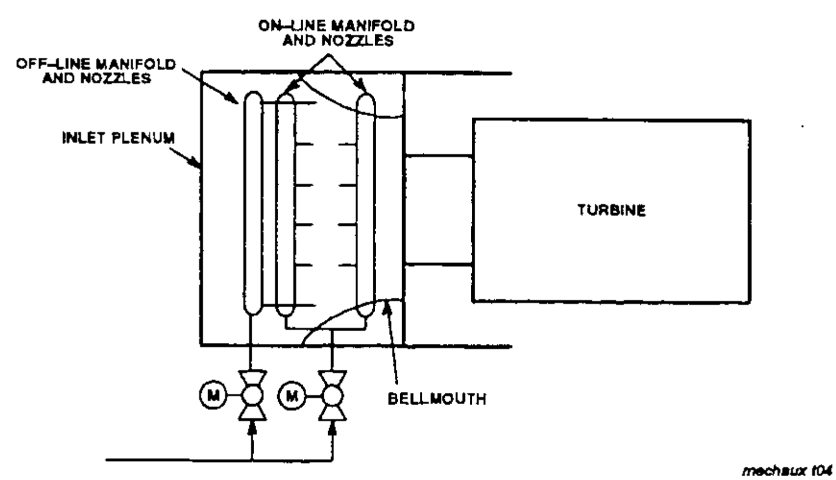
5.1.12.1.1 On–Line Manifold and Nozzles

The on–line washing components consist of two piping manifolds, spray nozzles (one in the forward bellmouth and one in the aft bellmouth), and an on/off control valve which is also controlled by the turbine control panel. The turbine control system is equipped with software to perform an automatic on–line wash by simply initiating the wash from the turbine control panel.

5.1.12.1.2 Off–Line Manifold and Nozzles

Off-line washing is a manual operation because of the large number of manual valves on the turbine which need to be manipulated in order to perform an off-line wash. During off-line washing, cleaning solution (water and/or detergent) is injected into the compressor while it is being turned at crank speed. The cleaning solution is sprayed into the compressor inlet, covering the entire circumference. This should continue until the runoff is free of contaminants.

Water Wash Off and On–Line Manifold and Nozzles
(Typical)



5.1.12.1.3 Water Wash Skid

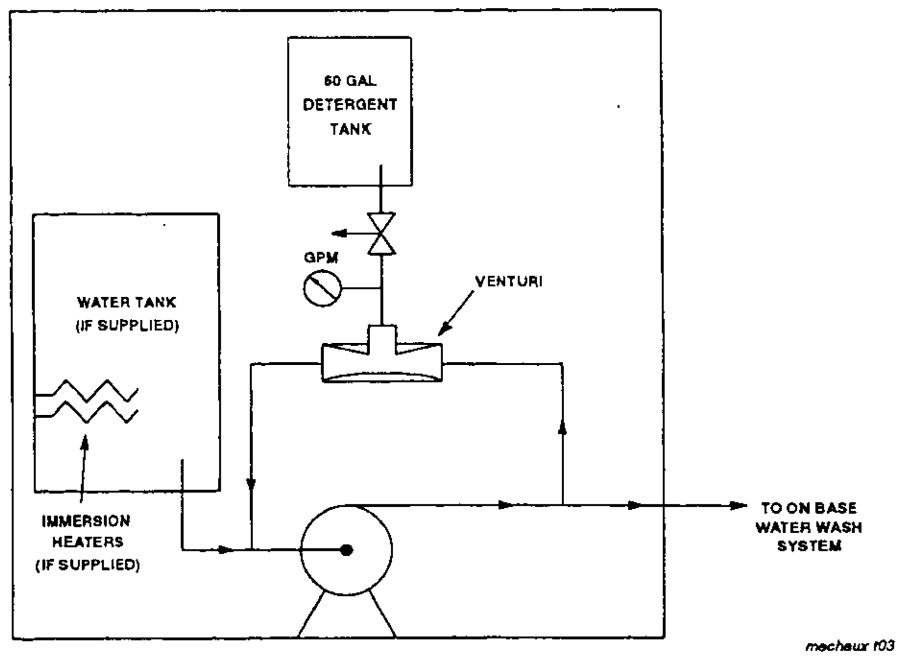
The off–base water wash skid is used for injecting cleaning solution into the compressor for off–line cleaning. The skid contains a water pump, a detergent storage tank, piping, and a venturi eductor capable of delivering solution at the proper flow, pressure and mix ratio.

In addition, the water wash skid is equipped with the following features:

- Water storage tank with freeze protection
- Enclosure for outdoor installation

Typical water wash skid features are shown in the illustration which follows.

Compressor Water Wash Skid
(Typical)



5.1.13 Starting System

5.1.13.1 Cooldown System

The cooldown system provides uniform cooling of the rotor after shutdown. A low speed turning gear with motor is used for the cooldown system.

5.1.13.2 Static Start System

5.1.13.2.1 Operation

The static start system uses a Load Commutating Inverter (LCI) adjustable frequency drive as the starting means for the gas turbine. By providing variable frequency power directly to the generator terminals, the generator is used as a synchronous motor to start the gas turbine. The generator will be turning at approximately 6 rpm, via a low speed turning gear, prior to starting. With signals from the turbine control, the LCI will accelerate or decelerate the generator to a self-sustaining speed required for purge, light-off, waterwash etc. Deceleration is a coast down function.

The system can accelerate the gas turbine-generator without imposing high inrush currents, thereby avoiding traditional voltage disturbances on the ac station service line.

Conventional three phase, 12-pulse bridge circuits are used for the rectifier and inverter and are connected through a dc link inductor. An isolation transformer is required to provide three phase power, impedance for fault protection, and electrical isolation from system disturbances to ground.

Starting excitation is provided by the generator excitation system.

5.1.13.2.2 System Protection

The drive system protective strategy is to provide a high level of fault protection for the major equipment. The rectifier inverter includes voltage surge protection and full fault suppression capability for internal faults or malfunctions. A drive system monitor and diagnostic fault indications continuously monitor the condition and operation of the LCI.

5.1.13.2.3 Equipment

5.1.13.2.3.1 Low Speed Turning Gear

The turning gear assembly is located on the collector end of the generator and is used for slow speed operation (approximately 6 rpm), cooldown and standby turning, and rotor breakaway during startup.

5.1.13.2.3.2 LCI Power Conversion Equipment

The LCI power conversion equipment is mounted in a NEMA 1 ventilated enclosure and consists of the following:

- 12-pulse converter with series redundant thyristor cells to rectify ac line power to controlled voltage dc power.

- Inverter with series redundant cells to convert dc link power to controlled frequency ac power.
- Cooling system using a liquid coolant to transfer heat from heat producing devices, such as SCRs and high wattage resistors, to a remote liquid-liquid heat exchanger. The system is closed-loop with a covered reservoir for makeup coolant. Coolant circulates from the pump discharge to the heat exchanger to the power conversion bridges and returns to the pump. A portion of the coolant bypasses to a deionizer system to maintain coolant resistivity. Redundant pumps are provided.
- LCI control panel containing microprocessor system control logic for firing, drive sequencing, diagnostics and protective functions, acceleration (ramping function), excitation system interface, and input/output signal interfacing.

  Note: The control panel is located in the LCI enclosure and includes door mounted panel meters and operator devices.

5.1.13.2.3.3 DC Link Reactor

The dc link reactor helps smooth the dc current to eliminate coupling between the frequencies of the converter and inverter and provides protection during system faults by limiting the current.

The dc link is a dry-type, air core reactor which is convection cooled. It is located in an outdoor protective enclosure and electrically connected between the converter and the inverter.

5.1.13.2.3.4 Isolation Transformer

The isolation transformer provides electrical isolation and impedance for system protection against notching and harmonic distortion. The transformer has two secondary windings and is designed for service with a three phase, six pulse power converter connected to each secondary winding. One transformer is provided for each LCI.

The transformer is a three winding, oil filled type for outdoor mounting.

5.1.13.2.3.5 Motorized Disconnect Switch

A motorized disconnect switch is provided to disconnect the static start system during normal generator operation. The disconnect switch is electrically connected between the LCI and the feed for the generator stator.

5.1.14 Miscellaneous Parts

As a service to the customer and to facilitate an efficient installation of the gas turbine, GE provides for shipment of miscellaneous parts needed during field installation.

Shipment is in a single 96" x 96" x 192" (2438 mm x 2438 mm x 4877 mm) weather-tight cargo container. The plywood container, which can be opened from one end, is outfitted with shelves and bins for parts storage. The container comprises what amounts to a "mobile stockroom" and is designed for transport by truck or rail.

Within the container, each part is packed, identified with its own label or tag, and stowed in an assigned bin or shelf. A master inventory list furnished with the container provides the location of each part for ease in locating the item.

An additional box approximately 60" x 60" x 216" (1524 mm x 1524 mm x 5486 mm) is furnished for the interconnecting piping.

5.2 Gas Turbine Generator

5.2.1 Electrical Rating

The generator is designed to operate within Class "B" temperature rise limits, per ANSI standards, throughout the allowable operating range. The insulation systems utilized throughout the machine are proven Class "F" materials.

The generator is designed to exceed the gas turbine capability at all ambient conditions between 0 and 120°F.

5.2.2 Packaging

The 7FH2 generator is designed for compactness and ease of service and maintenance. Location permitting, the unit ships with the rotor, gas shields and end shields factory assembled. The high voltage bushings, bearings, oil deflectors, hydrogen seals, and coolers are also factory assembled. The collector cab ships separately for assembly to the generator at the customer's site. Clearances of the bearings, rub rings, fans, hydrogen seals and deflectors are factory fitted and only require a minimum amount of field inspection of these components.

All generator wiring, including winding and gas RTDs, bearing metal and drain TCs, and vibration detection systems are terminated on the main unit with level separation provided.

Prior to full assembly, the generator stator receives a pressure test at 150% of operating pressure followed by a leakage test at 100% of operating pressure.

Feed piping between the bearings are stainless steel and mounted on the units in the factory to a common header. All connections to the end shields are assembled. All assembled piping is welded without backing rings and a first pass TIG weld. A full oil flush is performed prior to shipping.

Some amount of field assembly is required but should be limited to the following:

- Factory fitted bearing drain piping and bearing drain enlargement (BDE)
  - Matched, marked, and shipped separate
  - Loop seal between BDE and drain tank are stainless steel and ship loose
- Water manifolds are factory fitted and shipped separate
- Collector compartment:
  - Collector end housing and brush rigging are shipped as part of the collector compartment and require some assembly and alignment
  - Interconnecting piping from cab to generator
  - Interconnecting wiring from cab to generator

5.2.3 Frame Fabrication

The frame is a stiff structure, constructed to be a hydrogen vessel and to be able to withstand in excess of 200PSI. It is a hard frame design with its four-nodal frequency significantly above 120Hz. The ventilation system is completely self contained, including the gas coolers within the structure. The gastight structure is constructed of welded steel plate, reinforced internally by radial web plates and axially by heavy wall pipes, bars and axial braces.

A series of floating support rings and core rings are welded to keybars which in turn support the core, allowing the entire core to be spring mounted at twenty locations. This arrangement isolates the core vibration, resulting from the radial and tangential magnetic forces of the rotor, by damping the amplitude and reducing the transmissibility by 20:1 Excessive movement of the core, as may result from out of phase synchronization, is limited by the use of stop collars at certain circumferential locations around the frame. The clearance is designed to allow the spring action of the bar to be unrestricted during normal operation but to transmit the load of excessive movement through the structure prior to yielding of any of the components. This entire arrangement is in keeping with long standard practices and experience with similar frame designs which have proven to be very effective and reliable.

The stator frame is supported on four welded-on feet attached at the lower portion of the fabrication. All the weight of the unit and the operating loads are carried through the structure by the web plates and the wrapper to the feet. The machined portion of the feet are located 85" below the centerline of the unit.

5.2.4 Core

The core is laminated from grain oriented silicon steel to provide maximum flux density with minimum losses, thereby providing a compact electrical design. The laminations are coated on both sides to ensure electrical insulation and reduce the possibility of localized heating resulting from circulation currents.

The overall core is designed to have a natural frequency in excess of 170 hertz, well above the critical two-per-rev electromagnetic stimulus from the rotor. The axial length of the core is made up of many individual segments separated by radial ventilation ducts. The ducts at the core ends are made of stainless steel to reduce heating from end fringing flux. The flanges are made of cast iron to minimize losses. To ensure compactness, the unit receives periodic pressing during stacking and a final press in excess of 700 tons after stacking.

5.2.5 Rotor

The rotor is machined from a single high alloy steel forging. The two pole design has 24 axial slots machined radially in the main body of the shaft. The axial vent slots machined directly into the main coil slot are narrower then the main slots and provide the direct radial cooling of the field copper.

The two retaining rings are of the body mounted design. The rings are made of 18 Mn - 18 Cr forged material which offers excellent protection against stress corrosion cracking.

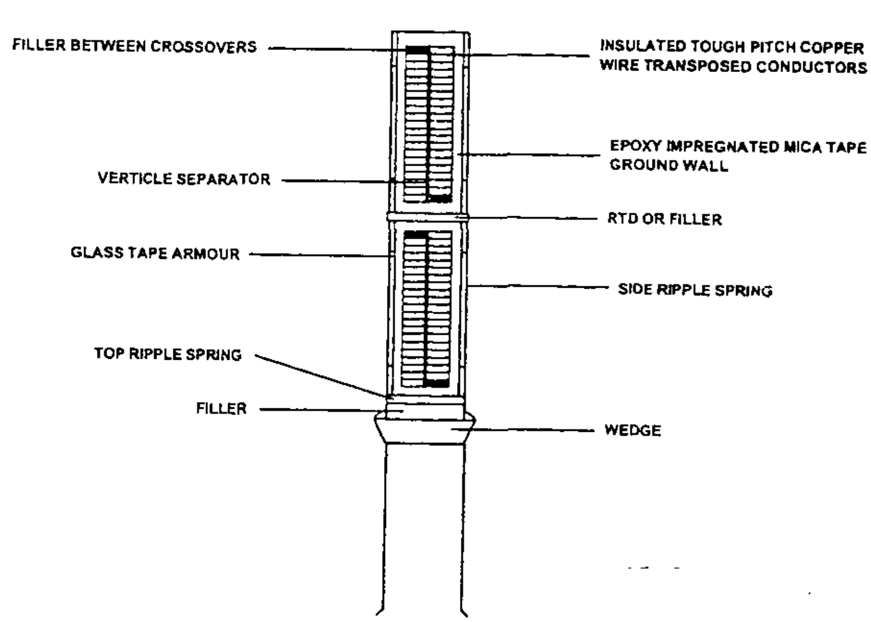
The coil wedges are segmented stainless steel. Radial holes are drilled in the wedges for ventilation passages.

A shrunk-on coupling is assembled after the collector rings are on, and provides the interface point to the flex-coupling connection to the turning gear. This arrangement is used with a static start system.

5.2.6 Field Assembly

The field consists of several coils per pole with turns made from high conductivity copper. Each turn has slots punched in the slot portion of the winding to provide direct cooling of the field.

Stator Slot Section
(Typical)



The slot armor used in the slots is a Class ""F"" rigid epoxy glass design. An insulated cover is positioned on the bottom of each slot armor and on top of the subslot vent. The cover will provide the required creepage between the lower turn and the shaft. Epoxy glass insulation strips are used between each coil turn. A pre-molded glass retaining ring insulation is utilized over the end windings and a partial amortisseur is assembled under the rings to form a low resistance circuit for eddy currents to flow. The rotor is designed to accommodate static start hardware utilizing slot amortisseurs.

The collector assembly incorporates all the features of GE proven generator packages with slip on insulation over the shaft and under the rings. The collector rings use a radial stud design to provide electrical contact between the rings and the field leads. The rings are designed to handle the excitation requirements of the design (approximately 2200 amps on cold day operation and 1900 amps at rated conditions).

The entire rotor assembly, weighing 74,000 pounds is balanced up to 20% over operating speed.

5.2.7 End Shield/Bearing

The unit is equipped with end shields on each end designed to support the rotor bearings, to prevent gas from escaping, and to be able to withstand a hydrogen explosion in the unlikely event of such a mishap. In order to provide the required strength and stiffness, the end shield is constructed from steel plate and is reinforced. The split at the horizontal joint allows for ease of assembly and removal.

The horizontal joints, as well as the vertical face which bolts to the end structure, are machined to provide a gas tight joint. Sealing grooves are machined into these joints. These steps are taken to prevent gas leakage between all the structural components for pressures up to 45 psig.

The center section of the end shields contain the bearings, oil deflectors and hydrogen seals. The lower halves of the bearings are equipped with dual element thermocouples. The leads are connected through a quick disconnect through the end shield to allow ease of bearing removal.

Vertically split inner and outer oil deflectors are bolted into the end shield and provide sealing of the oil along the shaft. The deflectors are either fabricated or cast aluminum. All faces of the deflectors have "O" ring grooves to provide additional protection from oil leaks. All annular areas formed between the set of teeth are designed to provide minimum pressure drops and have oil gutters machined in to prevent oil from backdripping on the shaft.

The hydrogen seal casing and seals, which prevent hydrogen gas from escaping along the shaft, utilize steel babbitted rings. Pressurized oil for the seals is supplied from the main oil system header to the seal oil control unit, where it is regulated. The seal oil control unit is factory assembled packaged system and is located in the collector end compartment and includes the following components:

- Differential pressure regulator valve with bypass
- Differential pressure gage (seal oil pressure vs. casing gas pressure) and two differential pressure switches: one for alarm and one for actuating the dc emergency seal oil pump
- Shut-off and isolation valves for operation and maintenance

The collector end bearing and hydrogen seals are insulated from the rotor to prevent direct electrical contact between the rotor and the end shield. Both end shields have proximity type vibration probes. These are located axially at the bearing. Mounting for velocity type vibration sensors is also provided on the surface of the bearing caps.

All exiting wiring from the temperature indication devices and the insulating test leads are brought out of the unit through gas tight conex type seals to prevent any chance of a hydrogen leak.

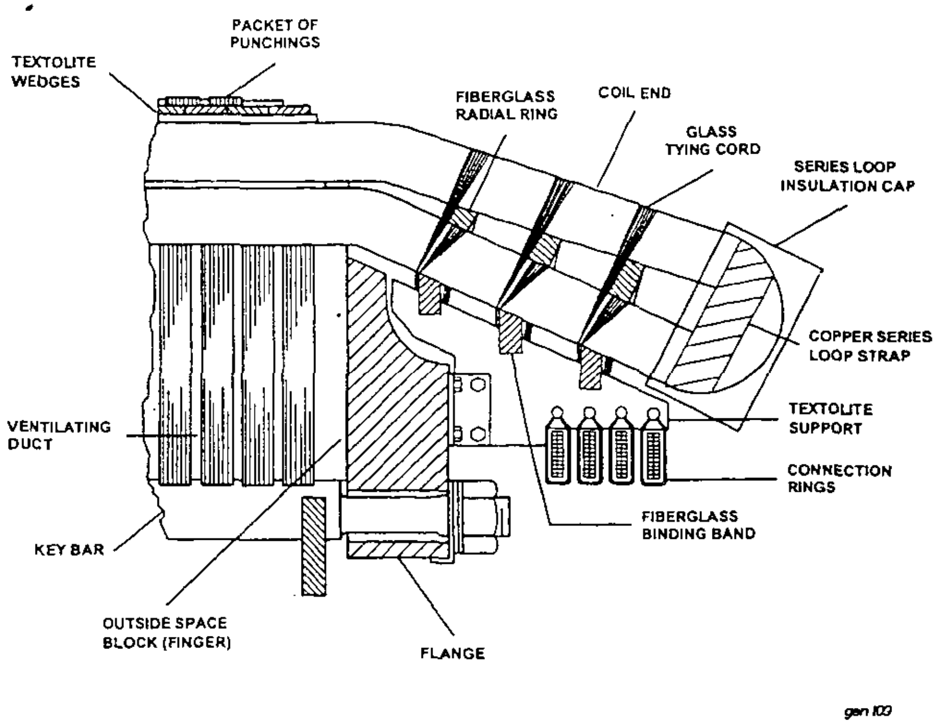
5.2.8 Winding

The armature winding is a three phase, two circuit design consisting of "Class F" insulated bars. The stator bar stator ground insulation is protected with a semi-conducting armor in the slot and GE's well proven voltage grading system on the end arms.

The ends of the bars are pre-cut and solidified prior to insulation to allow strap brazing connections on each end after the bars are assembled. An epoxy resin filled insulation cap is used to insulate the end turn connections.

The bars are secured in the slot with side ripple springs (SRS) to provide circumferential force and with a top ripple spring (TRS) for additional mechanical restraint in the radial direction. The end winding support structure consists of glass binding bands, radial rings, and the conformable resin-impregnated felt pads and glass roving to provide the rigid structure required for system electrical transients.

Stator End Winding Structure
(Typical)



5.2.9 Lead Connections

All the lead connection rings terminate at the top of the excitation end of the unit and the six high voltage bushings (HVBs) exit at the top of the frame.

Each of the circuits are connected to the high voltage bushings (HVBs.) The bushings, which provide a compact design for factory assembly and shipment, are positioned in the top of the frame and are offset to allow proper clearances to be maintained. This configuration also allows connections to the leads to be staggered and provides ease of bolting and insulation.

The bushings are made up of porcelain insulators containing silver plated copper conductors which form a hydrogen tight seal. The bushings are assembled to non-magnetic terminal plates to minimize losses. Copper bus is assembled to the bushings within an enclosure. Customer connections are made beyond the terminal enclosure and the specific mating arrangements are provided within the enclosure, not inside the generator.

5.2.10 Lubrication System

Lubrication for the generator bearings is supplied from the turbine lubrication system. Generator bearing oil feed and drain interconnecting lines are provided, and have a flanged connection at the turbine end of the generator package for connection to the turbine package.

5.2.11 Hydrogen Cooling System

The generator is cooled by a recirculating hydrogen gas stream cooled by gas-to-water heat exchangers. Cold gas is forced by the generator fans into the gas gap, and also around the stator core. The stator is divided axially into sections by the web plates and outer wrapper so that in the center section cold gas is forced from the outside of the core toward the gap through the radial gas ducts, and in the end section it passes from the gas gap toward the outside of the core through the radial ducts. This arrangement results in substantially uniform cooling of the windings and core.

The rotor is cooled externally by the gas flowing along the gap over the rotor surface, and internally by the gas which passes over the rotor and windings, through the rotor ventilating slots, and radially outward to the gap through holes in the ventilating slot wedges.

After the gas has passed through the generator, it is directed to five horizontally mounted gas-to-water heat exchangers. After the heat is removed, cold gas is returned to the rotor fans and recirculated.

5.2.12 Hydrogen Control Panel

To maintain hydrogen purity in the generator casing at approximately 98 percent, a small quantity of hydrogen is continuously scavenged from the seal drain enlargements and discharged to atmosphere. The function of the hydrogen control panel is to control the rate of scavenging and to analyze the purity of the hydrogen gas. The panel is divided into two compartments, the gas compartment and the electrical compartment, which are separated by a gas-tight partition.

5.2.12.1 Control Panel Functions

The GE hydrogen control panel is designed for use on hydrogen cooled generators with scavenging systems. The panel functions are described below:

- The hydrogen control panel allows manual control of the continuous scavenging rate, both turbine end and collector end, via metering valves.
- Hydrogen from the generator turbine end and generator collector end is continuously monitored for purity. At predetermined time intervals, the purity of the generator core gas is also checked. Two independent, switchable, triple range hydrogen purity analyzers are used, thus providing total redundancy, for two out of two voting. Each display and control panel will include three digital displays providing real time readout of gas purity, gas temperature and the status of the analyzers operating parameters. All information is provided to the station DCS via contact inputs and 4-20 milliamp analog signals.
- In the event that one of the analyzers detect a drop in purity, a confirmation by the other gas analyzer is performed. Time for the measurement, which requires reconfiguration of the valves, as well as the handling of possible disagreements in measurement results, is also negotiated between the analyzers.
- In the event that either analyzer indicates a low purity alarm, the rate of scavenging is increased automatically and an alarm is annunciated.
- All components used in the hydrogen control panel are specifically designed and / or third party approved for use in an Class I, Division I, Group B environment.

5.2.12.2 Control Panel Devices

5.2.12.2.1 Differential Pressure Gas Transmitter

The differential pressure gas transmitter measures the generator fan differential gas pressure. It provides a 4-20 mA DC signal proportional to differential gas pressure and includes a 316L stainless steel diaphragm all housed in a Factory Mutual approved explosion proof enclosure.

5.2.12.2.2 Differential Gas Pressure Gage

The differential gas pressure gage provides local indication of the generator fan differential gas pressure. The gage is flush mounted, waterproof, dual range and stainless steel movements.

5.2.12.2.3 Gas Pressure Transmitter

The gas pressure transmitter measures the generator core gas pressure or machine gas pressure as it is sometimes called. It provides a 4-20 mA DC signal proportional to gas pressure and includes a 316L stainless steel diaphragm all housed in a Factory Mutual approved explosion proof enclosure.

5.2.12.2.4 Gas Pressure Gage

The gas pressure gage provides local indication of the generator core gas pressure. The gage is flush mounted, water proof, dual range and stainless steel movements.

5.2.12.2.5 Total Gas Flowmeter

The total gas flowmeter provides local indication of the total flow of scavenged gas. The flowmeter is a flush mounted, in line, direct read flowmeter with stainless steel body.

5.2.12.2.6 Gas Analyzer Flowmeters (2)

Gas analyzer flowmeters provide local indication and control of the gas flow through each of the gas analyzers. Each flowmeter is a flush mounted, in line, direct read flowmeter with stainless steel body.

5.2.12.2.7 Gas Purifiers (3)

Gas purifiers remove oil, water and foreign particles from each of the gas sampling lines (turbine end, collector end and core gas).

5.2.12.2.8 Moisture Indicators (3)

Moisture indicators provide local indication relating to the operating condition of the gas purifiers in each of the gas sampling lines (turbine end, collector end and core gas).

5.2.12.2.9 Control Cabinet

The standard cabinet is NEMA 1 rated and mounted in the collector compartment.

5.2.12.2.10 Solenoid Valves

All solenoid valves have stainless steel bodies with class H temperature rated coils. The solenoids are also third party approved for use in a Class 1, Division 1, Group B environment.

5.2.12.2.11 Gas Analyzers

The gas purity analyzer utilizes the principle of fixed geometry diffused flow thermal conductivity to measure the purity of a known component of a binary gas mixture. Digital acquisition at the sensor level by precision components, rather than the previous Wheatstone bridge arrangement, increases measurement accuracy. A novel aspect of the analyzer is its ability to operate in a redundant configuration; the two, identical, microcontroller based subsystems which comprise the analyzer are interconnected by a communications channel to enable the analyzer to confirm an alarm condition, (i.e. two out of two voting). This communications channel also allows the analyzer to negotiate and report possible malfunctions in the measurement system.

5.2.12.3 Fault Detection and Reporting

Each subsystem within the analyzer is self-supervising and continuously checks itself for acceptable processor functioning, internal voltages, analog to digital conversion accuracy, integrity of cabling and relay operation. Any faults are immediately annunciated at the cabinet and a contact signal indicating analyzer trouble is opened. A faults log, which maintains a date/time stamp of detected failures can be viewed at any time. The analyzer can also execute detailed self-diagnostics.

5.2.13 Hydrogen Control Manifold

Hydrogen is admitted to the generator casing through the use of the hydrogen gas manifold. The following instrumentation is provided and is located in the collector compartment:

- Generator gas pressure gage
- High and low generator gas pressure switches

5.2.14 Carbon Dioxide Control Manifold

A carbon dioxide system is used for purging the generator casing of air before admitting hydrogen, and also to purge hydrogen before admitting air. The following instrumentation is provided:

- Purging control valve assembly
- Relief valve

5.2.15 Detraining System

The air-side seal oil and the generator bearing oil drain to a bearing drain enlargement mounted under the generator casing. This bearing drain enlargement is a detraining chamber and provides a large surface area for detraining the oil before it is returned to the main oil tank.

Two seal drain enlargements are provided for removing entrained hydrogen from the oil which drains from the hydrogen-side seal rings. They are drained through a common line to a float trap which then drains to the bearing drain enlargement for further detraining. A high liquid level alarm switch is provided to detect abnormal oil level in the seal drain enlargement.

Piping is factory fitted and the system is well-proven to assure that no hydrogen can enter into the oil system.

5.2.16 Generator Collector Compartment

An exciter-end, enclosure is provided with the generator. It will contain the following assemblies:

- Hydrogen control panel
- Seal oil control unit, regulator and flowmeter
- Seal oil drain system, float trap and liquid level detector
- H2 and CO2 feed and purge system, valves and gauges
- Switch and gauge, block and porting system
- Collector housing and brush rigging assembly
- Collector filters and silencers
- Level-separated electrical junction boxes
- Turning gear

The above items are packaged in the enclosure. The completed enclosure is assembled to the generator at the customer site. The enclosure has been designed to simplify interconnecting wiring and piping between the enclosure and the generator.

The enclosure is designed with a removable end wall section and roof to allow ease of rotor removal without moving the housing. Position of all the above hardware is spaced to allow easy access for maintenance and to prevent any unnecessary disassembly during rotor removal. Two doors are provided on the end wall to allow access from either side. Safety latches are provided on the inside of the doors to provide easy exit from the enclosure. AC lighting is standard.

5.2.17 Generator Terminal Enclosure

The Generator Terminal Enclosure (GTE) is a reach–in weather–protected enclosure made of steel and/or aluminum and is located on the generator. The GTE is convection cooled through ventilation louvers to the outside of the enclosure. The louvers are designed to inhibit debris from entering into the compartment.

The GTE houses the following major electric components:

- Neutral current transformers (CTs)
- Line CTs
- Lightning arresters
- Neutral grounding transformer with secondary resistor
- Fixed voltage transformers (VT)
- 89SS LCI disconnect switch
- Motor operated neutral disconnect switch

5.2.17.1 Interface Points

The primary interface points to the GTE are:

- The line bus exits the GTE on the right side as viewed from the collector end of the generator
- The orientation of the line bus is right-center-left as viewed from the side of the GTE from which the bus exits

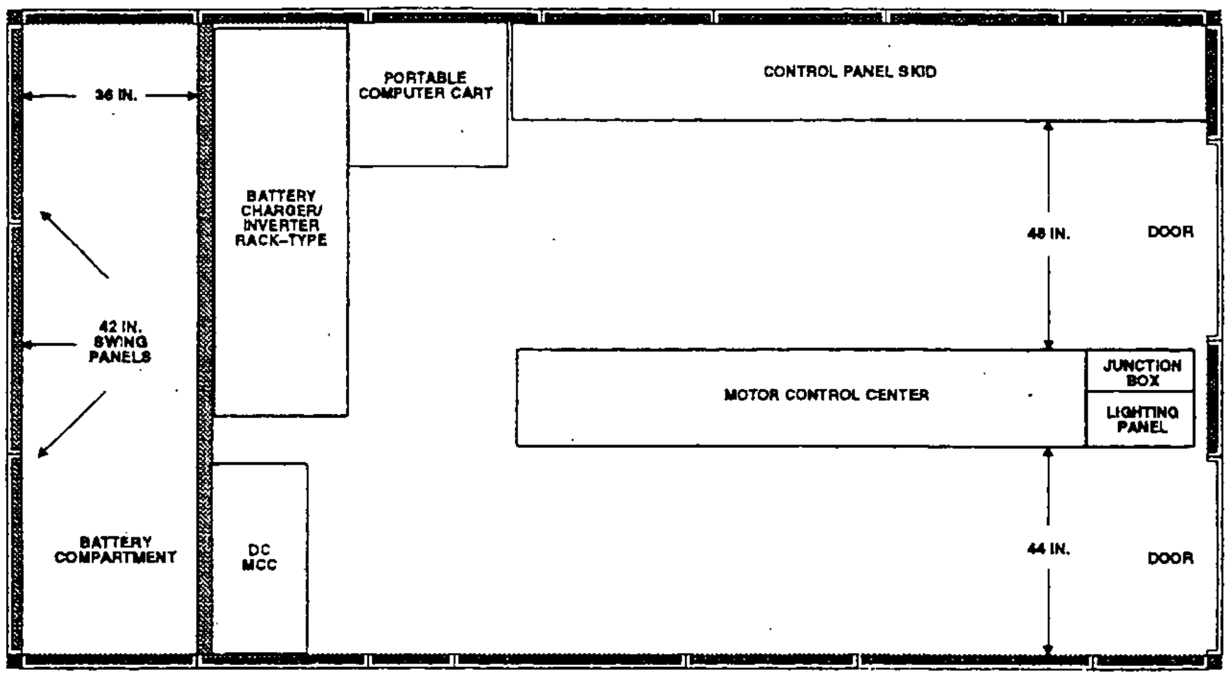
5.3 Gas Turbine-Generator Controls and Electric Auxiliaries

5.3.1 Packaged Electronic and Electrical Control Compartment (PEECC)

The PEECC is a completely enclosed compartment suitable for outdoor installation. Heating, air conditioning, compartment lighting, power outlets, temperature alarms, and smoke detectors are provided for convenience and protection of the equipment in the PEECC.

Electrical monitoring and control of the unit are accomplished by the turbine control panel and the generator control panel, which are mounted on a common skid and located in the PEECC. The customer control local interface HMI is also located in the PEECC. In addition to the control systems, the PEECC also houses the gas turbine motor control centers and batteries, rack and charger (s). The arrangement of the equipment is shown in the typical compartment layout below.

Packaged Electronic and Electrical Control Compartment (PEECC)
(Typical)



5.3.2 SPEEDTRONIC™ Mark V Gas Turbine Control System

The gas turbine control system is a state–of–the–art Triple Modular Redundant (TMR) microprocessor control system. The core of this system is the three separate but identical controllers called <R>, <S>, and <T>. All critical control algorithms, protective functions, and sequencing are performed by these processors. In so doing, they also acquire the data needed to generate outputs to the turbine. Protective outputs are routed through the <P> protective module consisting of triple redundant processors <X>, <Y>, and <Z>, which also provide independent protection for certain critical functions such as overspeed.

The three control processors, <R>, <S>, and <T>, acquire data from triple–redundant sensors as well as from dual or single sensors. All critical sensors for

™ A trademark of the General Electric Company continuous controls, as well as protection, are triple–redundant. Other sensors are dual or single devices fanned out to all three control processors. The extremely high reliability achieved by TMR control systems is due in considerable measure to the use of triple sensors for all critical parameters.

5.3.2.1 Electronics

All of the microprocessor–based controls have a modular design for ease of maintenance. Each module or controller contains up to five cards, including a power supply. Multiple microprocessors reside in each controller which distribute the processing for maximum performance. Individual microprocessors are dedicated to specific I/O assignments, application software communications, etc., and the processing is performed in a real–time, multi–tasking operating system. Communication between the controller's five cards is accomplished with ribbon cables and gas–tight connectors. Communication between individual controllers is performed on high–speed Arcnet links.

5.3.2.2 Shared Voting

Software Implemented Fault Tolerance (SIFT) and hardware voting are utilized by the SPEEDTRONIC Mark V TMR control system. At the beginning of each computing time frame, each controller independently reads its sensors and exchanges these data with the data from the other two controllers. The median value of each analog input is calculated in each controller and then used as the resultant control parameter for that controller. Diagnostic algorithms monitor a predefined deadband for each analog input to each controller, and if one of the analog inputs deviates from this deadband, a diagnostic alarm is initiated to advise maintenance personnel.

Contact inputs are voted in a similar manner. Each contact input connects to a single terminal point and is parallel wired to three contact input cards. Each card optically isolates the 125 or 24 V dc input, and then a dedicated 80196 processor in each card time stamps the input to within 1 ms resolution. These signals are then transmitted to the <R>, <S>, and <T> controllers for voting and execution of the application software. This technique eliminates any single point failure in the software voting system. Redundant contact inputs for certain functions such as low lube oil pressure are connected to three separate terminal points and then individually voted. With this SIFT technique, multiple failures of contact or analog inputs can be accepted by the control system without causing an erroneous trip command from any of the three controllers as long as the failures are not from the same circuit.

Another form of voting is accomplished through hardware voting of analog outputs. Three coil servos on the valve actuators are separately driven from each controller, and the position feedback is provided by three LVDTs. The normal position of each valve is the average of the three commands from <R>, <S>, and <T>. The resultant averaging circuit has sufficient gain to override a gross failure of any controller, such as a controller output being driven to saturation. Diagnostics monitor the servo coil currents and the D/A converters in addition to the LVDTs.

5.3.2.3 PC Based Operator Interface

The operator interface, HMI, consists of a PC, color monitor, cursor positioning device, keyboard, and printer. The keyboard is primarily used for maintenance such as editing application software or alarm messages. While the keyboard is not necessary, it is convenient for accessing displays with dedicated function keys and adjusting setpoints by entering a numeric value rather than issuing a manual raise/lower command. Setpoint and logic commands require an initial selection which is followed by a confirming execute command.

5.3.2.4 Direct Sensor Interface

Input/output (I/O) is designed for direct interface to turbine and generator devices such as thermocouples, RTDs and vibration sensors, flame sensors, and proximity probes. Direct monitoring of these sensors eliminates the cost and potential reliability factors associated with interposing transducers and instrumentation. All of the resultant data are visible to the operator from the SPEEDTRONIC Mark V operator interface.

5.3.2.5 Built–in Diagnostics

The control system has extensive built–in diagnostics and includes "power–up", background and manually initiated diagnostic routines capable of identifying both control panel, sensor, and output device faults. These faults are identified down to the board level for the panel, and to the circuit level for the sensor or actuator component. On–line replacement of boards is made possible by the triply redundant design and is also available for those sensors where physical access and system isolation are feasible.

5.3.2.6 Generator Interface and Control

The primary point of control for the generator is through the operator interface. However, the control system is integrated with the digital static bus fed excitation system over an Arcnet local area network (LAN). The SPEEDTRONIC Mark V is used to control megawatt output and the digital excitation system is used to control megavar output. The generator control panel is used to provide primary protection for the generator. This protection is further augmented by protection features located in the digital excitation system and the SPEEDTRONIC Mark V.

5.3.2.7 Synchronizing Control and Monitoring

Automatic synchronization is performed by the <X>, <Y>, and <Z> cards in conjunction with the <R>, <S>, and <T> controllers. The controllers match speed and voltage and issue a command to close the breaker based on a predefined breaker closure time. Diagnostics monitor the actual breaker closure time and self–correct each command.

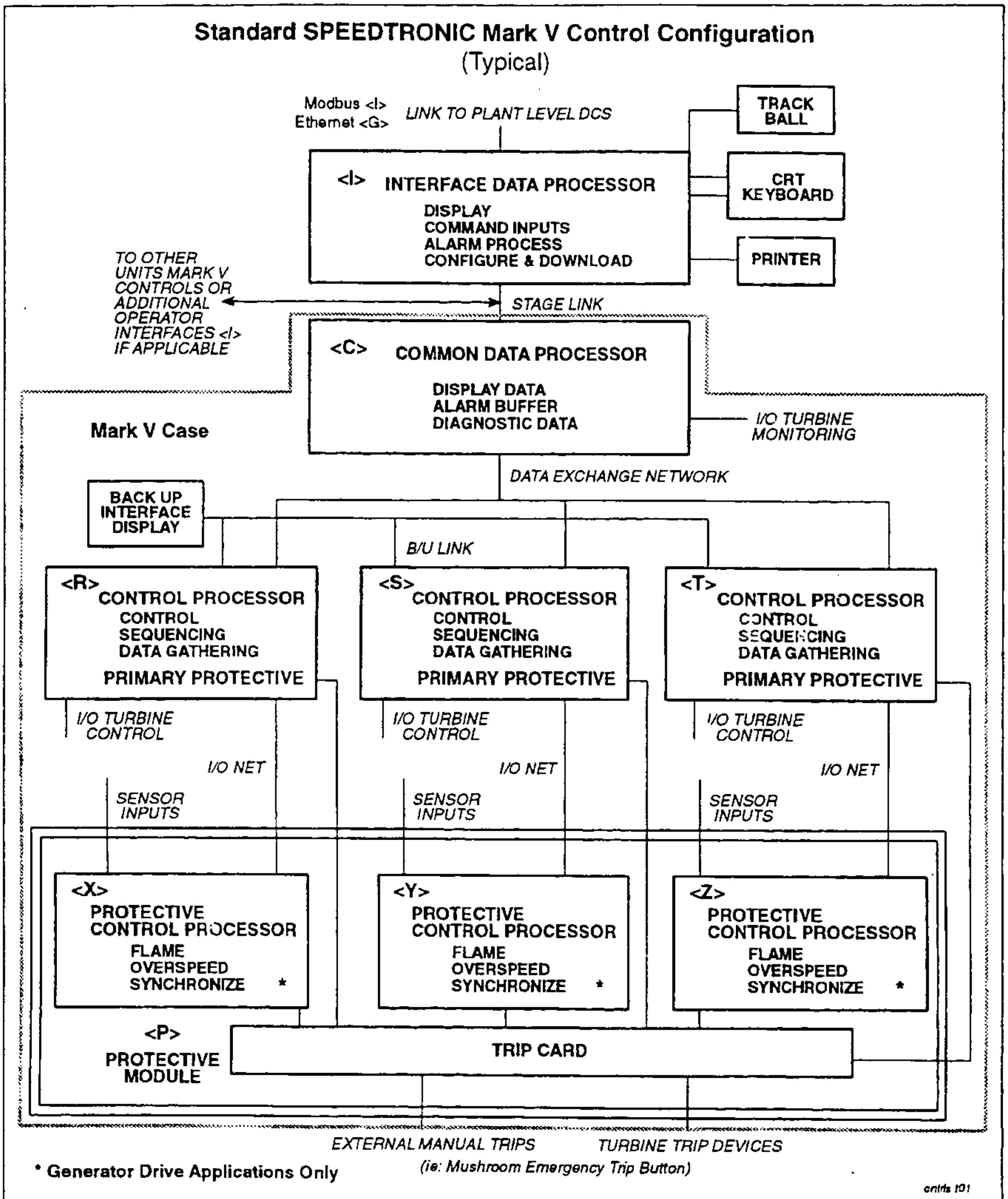
Another feature of the system is the ability to synchronize manually via the operator interface instead of using the traditional synchroscope on the generator protective panel. Operators can choose one additional mode of operation by selecting the monitor mode, which automatically matches speed and voltage, but waits for the operator to review all pertinent data on the CRT display before issuing a breaker close command.

5.3.2.8 Architecture

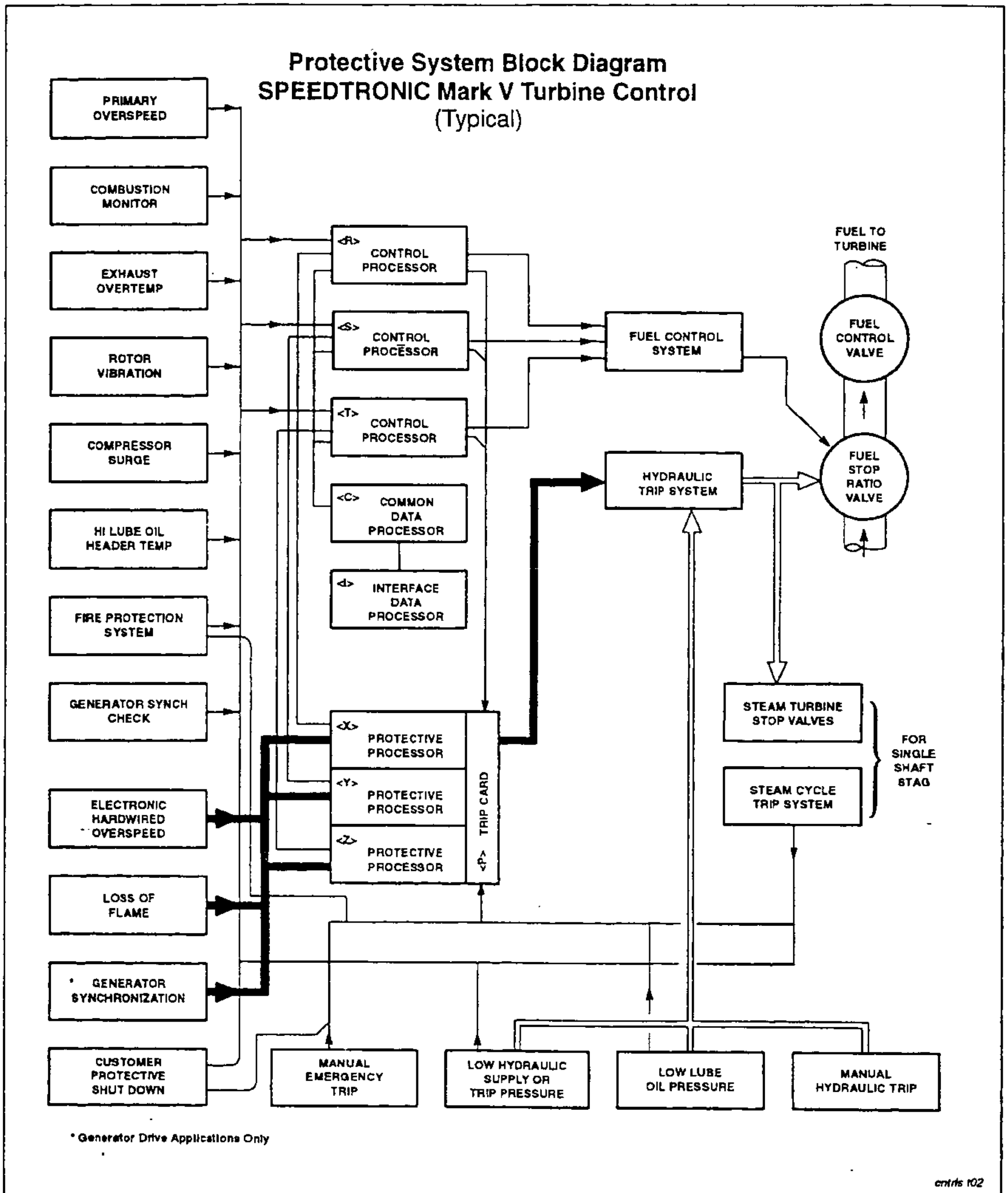
The SPEEDTRONIC Mark V control configuration diagram depicts several advantages for increased reliability and ease of interface. For example:

- Multiple unit control from a single HMI
- Back–up display wired directly to <R>, <S>, and <T> controllers
- Hard wire protective signal from <R> <S> <T> controllers
- Additional protective processors <X>, <Y>, <Z>

The protective block diagram shows the built-in redundancy/reliability of the SPEEDTRONIC Mark V control system. For example, if there is an overspeed condition requiring a trip of the unit, the first line of defense would be the primary overspeed protection via the <R>, <S>, and <T> controllers. All three trip signals then pass to the <P>protective module trip card where two out of three voting occurs prior to sending the automatic fuel supply trip signal. The secondary overspeed protection is via the <X>, <Y>, and <Z> protective control processor cards which similarly send their independent trip signals to the <P>protective module trip card for voting.



Standard SPEEDTRONIC Mark V Control Configuration
(Typical)
Modbus <I>
Ethernet <G>
LINK TO PLANT LEVEL DCS
TRACK BALL
<I> INTERFACE DATA PROCESSOR
DISPLAY
COMMAND INPUTS
ALARM PROCESS
CONFIGURE & DOWNLOAD
CRT KEYBOARD
PRINTER
TO OTHER UNITS MARK V CONTROLS OR ADDITIONAL OPERATOR INTERFACES <I> IF APPLICABLE
STAGE LINK
<C> COMMON DATA PROCESSOR
DISPLAY DATA
ALARM BUFFER
DIAGNOSTIC DATA
I/O TURBINE MONITORING
Mark V Case
DATA EXCHANGE NETWORK
BACK UP INTERFACE DISPLAY
B/U LINK
<R> CONTROL PROCESSOR
CONTROL
SEQUENCING
DATA GATHERING
PRIMARY PROTECTIVE
<S> CONTROL PROCESSOR
CONTROL
SEQUENCING
DATA GATHERING
PRIMARY PROTECTIVE
<T> CONTROL PROCESSOR
CONTROL
SEQUENCING
DATA GATHERING
PRIMARY PROTECTIVE
I/O TURBINE CONTROL
I/O NET
SENSOR INPUTS
<X> PROTECTIVE CONTROL PROCESSOR
FLAME
OVERSPEED
SYNCHRONIZE *
<Y> PROTECTIVE CONTROL PROCESSOR
FLAME
OVERSPEED
SYNCHRONIZE *
<Z> PROTECTIVE CONTROL PROCESSOR
FLAME
OVERSPEED
SYNCHRONIZE *
<P> PROTECTIVE MODULE
TRIP CARD
EXTERNAL MANUAL TRIPS
TURBINE TRIP DEVICES
(ie: Mushroom Emergency Trip Button)
* Generator Drive Applications Only
cntls f01


Protective System Block Diagram
SPEEDTRONIC Mark V Turbine Control
(Typical)
PRIMARY OVERSPEED
COMBUSTION MONITOR
EXHAUST OVERTEMP
ROTOR VIBRATION
COMPRESSOR SURGE
HI LUBE OIL HEADER TEMP
FIRE PROTECTION SYSTEM
GENERATOR SYNCH CHECK
ELECTRONIC HARDWIRED OVERSPEED
LOSS OF FLAME
* GENERATOR SYNCHRONIZATION
CUSTOMER PROTECTIVE SHUT DOWN
<R> CONTROL PROCESSOR
<S> CONTROL PROCESSOR
<T> CONTROL PROCESSOR
<C> COMMON DATA PROCESSOR
<D> INTERFACE DATA PROCESSOR
<X> PROTECTIVE PROCESSOR
<Y> PROTECTIVE PROCESSOR
<Z> PROTECTIVE PROCESSOR
<P> TRIP CARD
FUEL CONTROL SYSTEM
HYDRAULIC TRIP SYSTEM
FUEL TO TURBINE
FUEL CONTROL VALVE
FUEL STOP RATIO VALVE
STEAM TURBINE STOP VALVES
STEAM CYCLE TRIP SYSTEM
FOR SINGLE SHAFT STAG
MANUAL EMERGENCY TRIP
LOW HYDRAULIC SUPPLY OR TRIP PRESSURE
LOW LUBE OIL PRESSURE
MANUAL HYDRAULIC TRIP
* Generator Drive Applications Only
cntrls t02

5.3.2.9 Scope of Control

The SPEEDTRONIC Mark V control system provides complete monitoring control and protection for gas turbine–generator and auxiliary systems. The scope of control is broken down into three (3) sections: Control, Sequencing and Protection.

- Control
  - Start–up control
  - Speed/load setpoint and governor
  - Temperature Control
  - Guide vane control
  - Fuel control
  - Generator excitation setpoints
  - Synchronizing control (speed/voltage matching)
  - Emissions control
- Sequencing
  - GT auxiliary systems (MCC starters)
  - Start–up, running and shutdown
  - Purge and ignition
  - Fuel changeover
  - Alarm management
  - Synchronizing
  - Turning gear
  - Static start
  - H2 sequencing
  - Maintain starts, trips and hours counters
  - Event counters
    - Manually initiated starts
    - Fired starts
    - Fast load starts
    - Emergency trips
  - Time meters
  - Fired time
  - Time in premix

- Protection
  - Overspeed, redundant electronic
  - Overtemperature (including generator)
  - Vibration
  - Loss of flame
  - Combustion monitor
  - Redundant sensor CO2 fire protection
  - Low lube oil pressure, high lube oil temperature, etc.

5.3.2.10 Communications

5.3.2.10.1 Internal Communications

Internal communications consist of a high speed Arcnet link. The SPEEDTRONIC Mark V's internal Arcnet communication link is isolated from external communication links at the HMI processor.

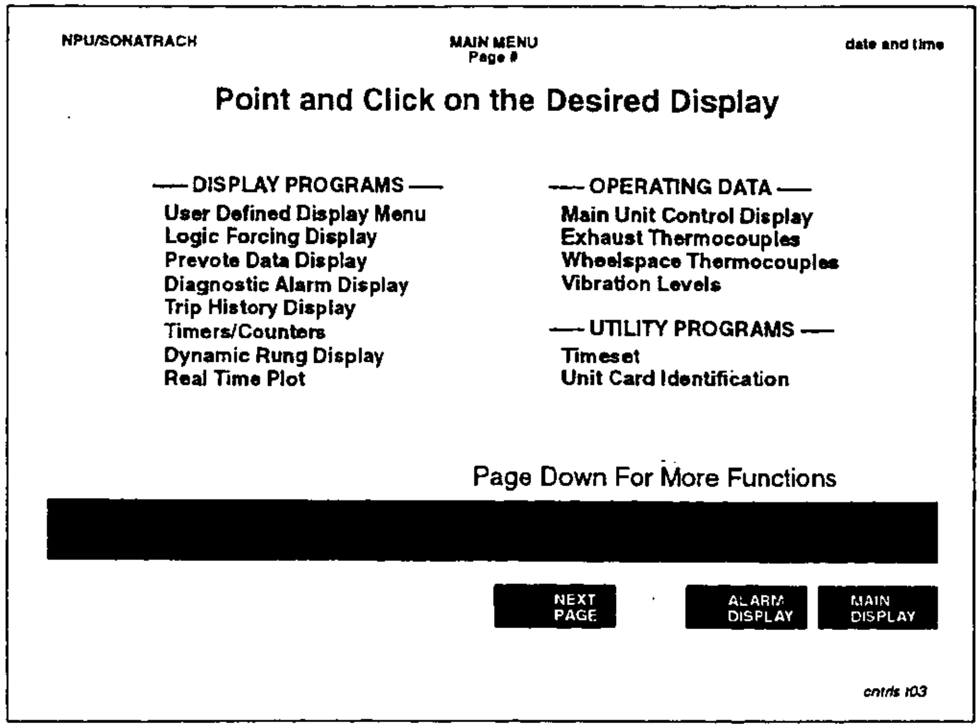
5.3.2.10.2 External Communications

The open architecture of the HMI processor facilitates a wide range of external communication links.

5.3.2.11 Operator Displays

Two (2) out of the typical forty (40) available displays are shown on the following pages. The first screen is the main menu display. From the main menu all operation/maintenance and user defined screens can be reached. The main menu screen is made up of three (3) major areas:

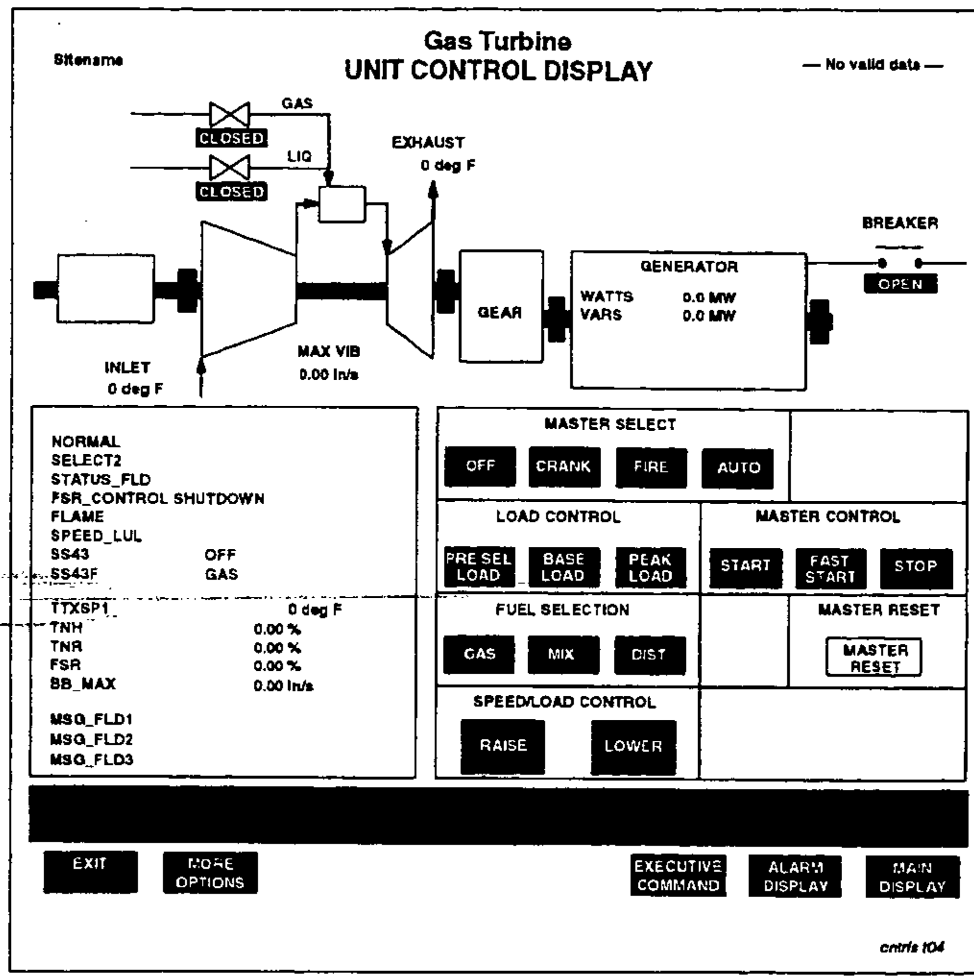
- List of available displays
- Alarm field shows the three (3) latest unacknowledged alarms (Black band near bottom of the screen)
- Function control keys (bottom of screen)



The second screen shown is a typical operating screen. Note that the alarm list and function control key fields are also shown below the primary display field on this screen. Control target values are shown in the primary display field. Selecting and executing commands is simple. For example, to go to baseload, you would move the cursor to the "Baseload" target and click on it. Then before the control times out, you would move the cursor to the "Execute Command" target and click on it. The "Execute Command" step protects against accidental activation of the wrong command that might occur with a one step (point/click) command. Signals that require an Execute command in order to be activated are:-

- Start
- Stop
- Operation Selection
  - Off
  - Crank
  - Fire
  - Auto
  - Remote

- Fuel Selection
- Load Selection
  - Preselected Load
  - Base
- Guide Vane Control
  - Temp Control Off
  - Temp Control On
- Governor Type Selection
  - Droop (nominal 4%)



5.3.2.12 Backup Interface

In the unusual event that the operator interface becomes unavailable, a small backup interface is provided on the SPEEDTRONIC Mark V cabinet door. It uses a liquid crystal display with two (2) lines of forty (40) characters per line to display key control parameters and alarms. The control panel accepts operator commands from this backup interface.

5.3.2.13 Printer

The standard operator interface printer has these convenient features:

- Alarm logging
- Event logging
- Historical trip display printing capability
- User defined display printing capability
- Periodic log display printing capability
- CRT screen copy

Each alarm and event is logged with a high resolution time tag. Contact inputs are logged to 1 millisecond. Separate alarm queues are maintained for turbine/generator system alarms and for SPEEDTRONIC Mark V internal self–diagnostic alarms. System alarms can be silenced, acknowledged and reset locally. Any intermittent alarms can be locked out with a permanent lockout message residing in the alarm queue.

If a trip occurs, the historical trip display automatically captures in memory all key control parameters and alarm messages at the time of the trip and at several time intervals preceding the trip. The operator can print the historical trip display when required. A start signal triggers the display to start collecting new data and all previous data is deleted from the current log. Display logs can be saved at any time to a memory buffer.

A user–defined display allows selection of any desired data for viewing or printing. The periodic log allows a user to define points to be collected and printed periodically to a printer. The period of each list is defined in minutes, from 1 to 10,080 (one week).

5.3.2.14 Human Machine Interface (HMI)

The Human Machine Interface is a single powerful, flexible and user friendly operator interface which brings together all of the displays and functions needed for real-time control and monitoring of turbomachinery processes, auxiliary equipment, driven devices and process alarms associated with power plant control.

The HMI system provides the infrastructure needed to meet the demanding requirements of delivering process information from a broader spectrum of controllers and compute platforms as well as accessing and delivering information to a customer's business enterprise system and balance of plant control system.

Designed with an open system concept, the system uses standard open hardware and operating system software. The HMI's software system uses the Windows NT client-server architecture from Microsoft which provides built-in multi-tasking, networking and security features. The ability to run the system on conventional PC based platforms minimizes cost, promotes open interfaces, permits system scalability, and ensures longevity of investment and future enhancement.

5.3.2.14.1 HMI Product Structure

GE Fanuc's CIMPLICITY HMI system serves as the basic core system, which is enhanced by the addition of power plant control hardware and software from GE Industrial Systems. The HMI configuration consists of several distinct elements:

- HMI Server - The server is the hub of the system and provides data support and system management. The HMI server also has the responsibility for device communication for both internal and external interchanges. The gas turbine control system can have redundant communications with two HMI servers.

5.3.2.14.2 HMI Product Features

- Graphics - The key functions of the HMI system are performed by its graphic system, which provides the operator with process visualization and control in a real-time environment. In the HMI system this important interface is accomplished using CimEdit, a graphics editing package, and CimView, a high performance runtime viewing package.
- Alarm Viewer - The alarm management functions of the HMI system are provided by Alarm Viewer. Alarm Viewer handles routing of alarms to the proper operator and alarm sorting and filtering by priority, plant unit, time, or source device.

- Trending - HMI trending, based on object linking and embedding technology, provides powerful data analysis capabilities. Trending capabilities include graphing collected data and making data comparisons between current and past variable data for quick identification of process problems.

- Point Control Panel - The HMI point panel provides a listing of points in the system with dynamically updating point values and alarm status. Operators have the ability to view and set local and remote points, enable and disable alarm generation, modify alarm limits, and filter and sort points selectively.

- Basic Control Engine - The basic control engine allows users to define control actions to take in response to system events. It monitors event occurrence and executes configured actions in response. The basic control engine is supported by an event editor for defining actions in response to system events and a program editor for programming more complex actions.

- User Roles and Privileges - CIMPLICITY allows configuration of system users to control access and privileges.

- DDE Application Interface - The DDE Interface allows other Windows applications that use Microsoft standard and Advanced DDE to obtain easy access to HMI point data. Users can integrate software that supports DDE to monitor, analyze, report or modify the HMI point data. In addition the HMI provides advances DDE client communication for data collection from third party devices.

5.3.2.14.3 Operator Functions

- Display Management - Display management provides overall display functions to meet the needs of the turbine plant. Displayed data is a combination of data received over Ethernet from GE third party servers and over the Stage Link from gas turbine controllers. Alarm display includes both connection to gas turbine alarm queues and external PLC systems.

- Hold List Display - The hold list is a set of conditions which must be met at certain times, speeds and operating modes in the turbine startup for systems which have Automatic Turbine Startup functions. The HMI provides for creation, modification, display, printing, down and uploading, compiling and reverse translation of a hold list of up to 64 points.

- Timer, Counter, Accumulator Display - This function shows the settings and totals in the turbine controllers.

- Screen Copy - Screen copy makes a copy of screen image and stores it in the Window clipboard for display, printing, directing to a file, or electronic transmission
- Trip History - Trip history data collected from each turbine controller can be plotted, printed as tabular data, or transmitted electronically for remote analysis.
- Process Alarm Management - The features of process alarm management help the operator to make a proper response to alarms and include the following:
  - Alarm queue display for each turbine unit controller
  - Main alarm display including all plant alarms
  - Alarm lockout for toggling alarm conditions
  - Alarm notepad function for adding explanatory notes to each active alarm drop number for each panel
  - Linking alarms to pre-selected display screens
  - Alarm help utilities for storing more detailed descriptions of alarms and their intended functions
  - Distinguishing display of control system diagnostic alarms from regular alarm or events

5.3.2.14.4 Hardware

- Intel based PC with 266 MHz Pentium II processor (or better)
- 64 MB RAM with 512 KB cache memory
- Hard drive 4.3GB or greater
- Floppy drive 1.44 MB
- Video card with 2 MB DRAM
- 17 inch monitor
- CD- 24x (or better), with multi-read capability
- 2 serial and 1 parallel port
- Windows NT operating system
- Keyboard and mouse
- Modems on HMI servers

5.3.2.14.5 Communications Interfaces

The HMI uses Stage Link as its mechanism for communication with GE turbine controllers and ancillary equipment. Stage Link allows the HMI to be located remotely and enables a single HMI to communicate with up to eight turbine controllers.

The HMI allows Modbus interfaces with other systems such as DCS.

5.3.3 Bently Nevada 3500 Monitoring System

The gas turbine and generator are equipped with orthogonal proximity probes at each bearing to detect radial motion of the shaft relative to the bearing. Axial position of the gas turbine rotor is sensed by two axial position proximity probes. Each probe is connected to a proximitor.

The Bently Nevada 3500 Monitor is a 19 in., sixteen position (fourteen available), panel mount rack containing four proximitor cards each of which can accept up to four channels. (The cards must be programmed for the application.) The system has one monitor card for each of the two turbine rotor axial position probe inputs, one monitor card for the radial X-Y probes from the two turbine bearings and one monitor card for the radial X-Y probes from the two generator bearings. The radial bearing monitor provides values for the overall amplitude, 1X amplitude, 1X phase, 2X amplitude and 2X phase.

Features of the system include:

- Alert and danger relay outputs – one pair for the axial position monitor and one pair which is shared by all the radial monitors
- A communication card for serial data interface to the GE on-site monitor
- AC power supply
- KeyPhasor card
- Rack configuration software for programming the rack functions including a serial interface cable for connecting the RIM card to the customer's computer. (A customer-supplied Microsoft Windows based computer is required.)
- A local display panel is provided at the 3500 rack

5.3.4 Performance Monitoring Package

In conjunction with a centralized control system, the performance monitoring package provides signals which are used to compare turbine airflow versus performance. These data can be used to determine the need for maintenance such as compressor water wash. The package is connected to a control compartment wall-mounted cabinet which contains transducers for 4-20 ma signals.

The following equipment is provided:

- Barometer
- Compressor inlet total pressure and static pressure probes
- Compressor discharge pressure probe
- Exhaust pressure probe
- Algorithms provided via the Mark V control panel
- Natural gas flow measurement
- Barometric pressure transmitter (96AP)
- Compressor bellmouth differential pressure transmitter (96BD)
- Compressor inlet air total pressure transmitter (96CS)
- Compressor discharge pressure transmitter (96CD)
- Exhaust pressure transmitter (96EP)
- Compressor temperature inlet flange (CT-IF-3/R)

5.3.5 Motor Control Center

The motor control center contains circuit protective devices and power distribution equipment to supply electrical power to all packaged power plant devices as defined on the electrical one line diagram. The motor control center is manufactured and tested in accordance with NEMA ICS–2 and UL Standard No. 845. Vertical sections and individual units will be UL (CSA) Labeled where possible. The motor control center is located in the PEECC.

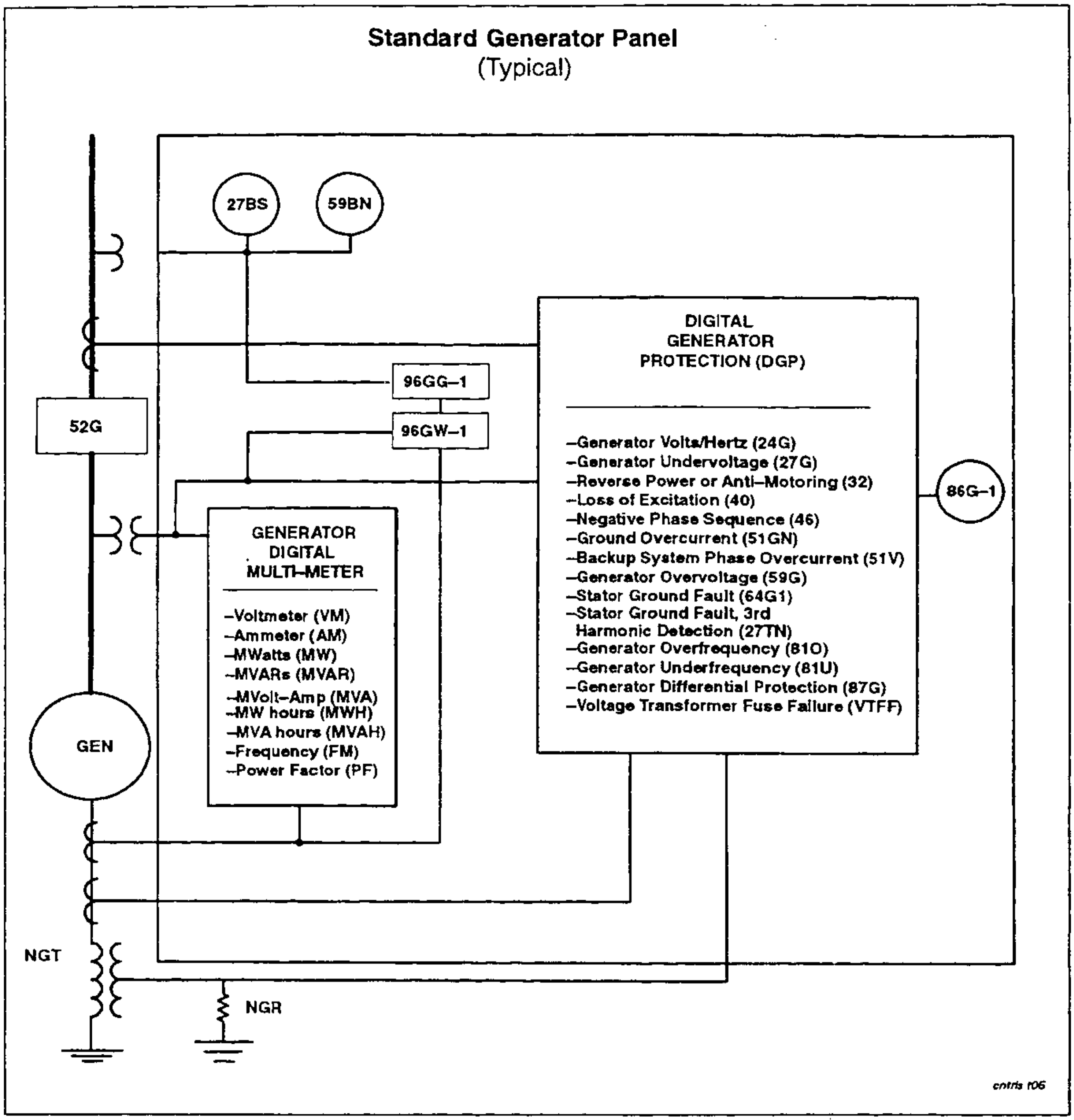
5.3.6 Generator Protection Panel

The heart of the generator protection panel is the digital multifunction relay integration with the gas turbine control system panel. The generator protection panel incorporates this feature along with generator metering and watt and VAR transducers for turbine control.

In addition, the panel includes pre-engineered protective modules for the following:

- Generator step-up transformer
- Auxiliary transformer
- Excitation transformer
- Starting transformer

The following page presents a typical one-line diagram for the generator protection panel. The diagram and the tables which follow it illustrate the digital protection features and metering. For job-specific details please refer to the oneline diagram in the drawings section of the proposal.



5.3.6.1 Digital Generator Protection (DGP) Features

Measurement	Value
Overexcitation	24

Generator Undervoltage	27G
Reverse Power / Anti-Motoring	32-1
Loss of Excitation	40-1,2
Current Unbalance / Negative Phase Sequence	46
System Phase Fault	51V
Generator Overvoltage	59
Stator Ground Detection	64G/59GN
Generator Over Frequency	81O-1,2
Generator Differential	87G
Voltage Transformer Fuse Failure	VTFF

5.3.6.2 Generator Digital Multimeter

Measurement	Value
Generator Volts	VM
Generator Amps	AM
Generator megawatts	MW
Generator megaVARs	MVAR
Generator MVA	MVA
Generator frequency	FM
Generator Power Factor	PF

5.3.6.3 Digital Generator Protection (DGP)

The digital generator protection system uses microprocessor technology to obtain a numerical relay system for a wide range of protection, monitoring, control and recording functions for the generator. Redundant internal power supplies and extensive diagnostic and self-test routines provide dependability and system security.

The DGP provides the commonly used protective functions in one package. Adaptive frequency sampling is used to provide better fault protection during off-normal frequencies such as startup.

The DGP can store in memory the last 100 sequence of events, 120 cycles of oscillography fault recording, and the last three fault reports

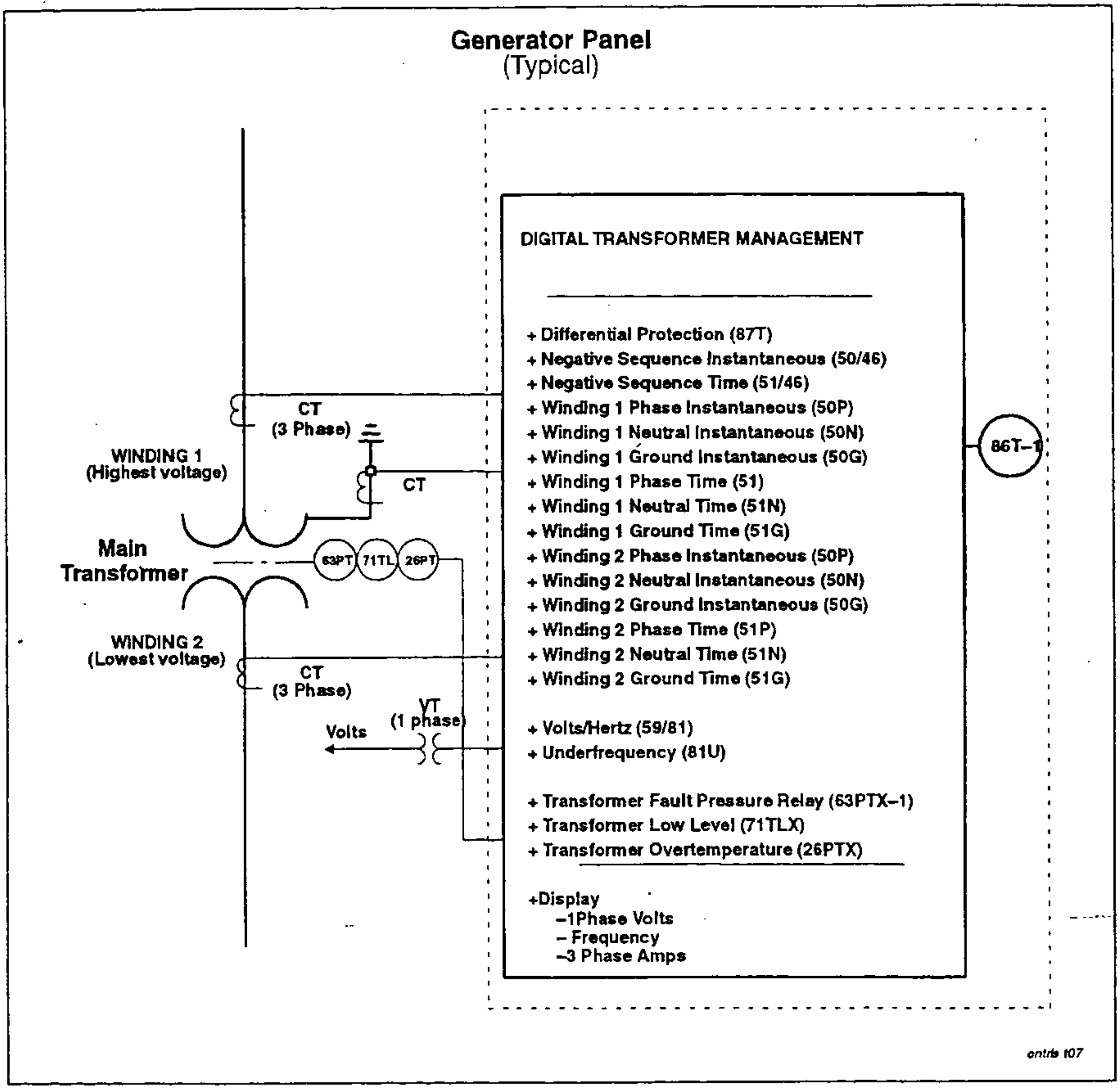
The system features a local Human-Machine Interface with integral keypad, 16 character display, and target LEDs for entering settings, displaying present values, viewing fault target information, and accessing stored data. In addition, two RS-232 serial communication ports are provided for local and remote computer access. (Please Note: The Personal Computer (PC) is not part of this offering.)

5.3.6.4 Digital Transformer Protection (DTP)

Generator step-up transformer protection is provided by a Digital Transformer Protection module. This module is a digital, three-phase current differential relay with harmonic and through-current percentage restraints. The DTP provides high speed differential protection for internal transformer faults and a high-set, unrestrained, differential overcurrent function. In addition the DTP includes oscillography, fault reporting and event recording.

Similar to the DGP, the DTP includes a human-machine interface with integral keypad, and two RS-232 serial communication ports.

A typical one-line diagram for the DTP is provided below. The digital transformer protection features are listed in Table 3. For job specific details, please refer to the oneline diagram provided in the Drawings section of the proposal.



5.3.6.5 Digital Transformer Management (SR 745)

Measurement	Value
Neutral Fault	50/51N
Transformer Fault Pressure Relay	63PTX
Transformer Low Level	71TL-3

Transformer Differential / Lockout	86T/87T

5.3.6.6 Auxiliary Transformer Protection

Auxiliary transformer protection is provided by a digital non-directional overcurrent relay which protects against overloads and faults. The module includes four measuring units, one for each of the three phase currents and one for ground or residual current. The phase and ground units contain settings for time overcurrent (TOC) and instantaneous overcurrent (IOC). In addition, the module has control inputs and outputs that can be used for a zone interlocking scheme. A local user interface is included with scrolling display and eight LEDs.

5.3.6.7 Out-of-Step Protection (78)

The out-of-step relay utilizes an impedance measuring unit and logic circuitry to evaluate the progressive change in impedance as would occur during a loss of synchronism and/or to initiate tripping when the angle between the generator and system voltages is 90 or less. Switching at this angle is generally recommended in order to minimize the duty on the circuit breaker. When properly applied, this scheme is capable of initiating tripping during the first half slip cycle of a loss of synchronism condition. Since this condition is essentially a balanced three phase phenomenon, the relay units used in the scheme are, and only need be, single phase devices. The standard relay is an LPSO digital relay.

5.3.6.8 System Backup Distance Protection (21)

Distance relays are typically used instead of overcurrent with voltage restraint when the lines leaving the station bus have distance or pilot relay protection schemes and the generator ties the station bus through a step-up transformer. This protection scheme is designed to protect the generator from faults in the adjacent system which are not cleared by the first line relays. The standard relay is an LPSO three phase digital relay with internal timing function.

5.3.6.9 Generator Breaker Failure Protection (50/62BF)

A digital breaker failure relay is used for timing and detecting current flow in conjunction with a lockout relay (86BF). The timer initiation is accomplished using an auxiliary high speed relay (94BFI) in parallel with the breaker trip coil. If the generator breaker remains closed and/or the current level detectors sense a current, the (50/62BF) relay starts timing. At the end of the time out period, the (50/62BF) relay trips the lockout relay (86BF). Contacts from this lockout are brought out to terminal boards for customer use in tripping associated breakers. Lockout relay (86BF) also trips the turbine.

Most faults involving the generator require tripping the generator breaker. Failure of the protection schemes to trip this breaker results in loss of protection to the generator. Also, if one or two poles of the breaker fail to open, the result can be a single phase load and negative sequence current on the generator stator. The purpose of the breaker failure protection is to act as a backup to any of the other generator protection schemes. This serves to protect the generator when the breaker fails to open properly.

5.3.6.10 Gas Turbine Control System Integration

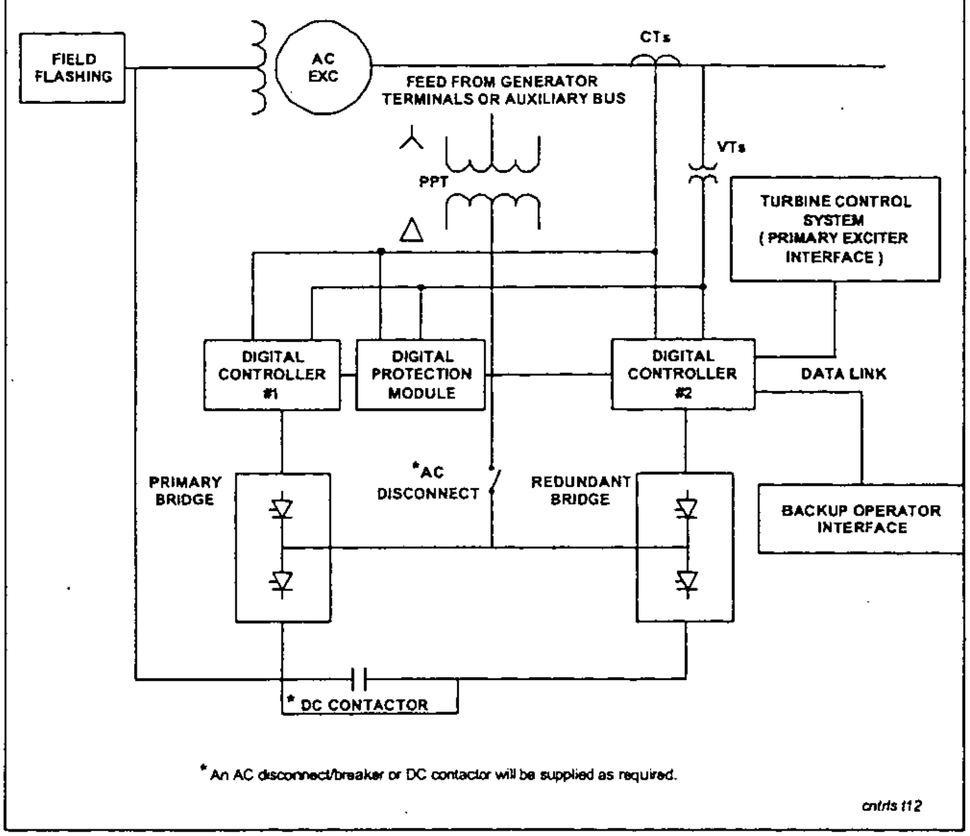
In addition to the relaying mounted in the generator protection panel, the gas turbine control system handles protective functions such as generator temperature protection, synchronizing check, backup frequency and reverse power.

Generator control and monitoring are primarily accomplished via the gas turbine control system operator interface. The operator interface handles manual and auto-synchronizing, speed raise/lower, voltage raise/lower, and generator breaker control. Also displayed are frequency and voltage for the generator and bus, breaker status, field current and voltage, along with the status of permissives.

5.3.7 Static Voltage Regulator for Bus Fed Excitation

The exciter is a digital, static, potential source excitation system. The system comes equipped with a full-wave thryristor bridge, which supplies excitation power to the rotating field winding of the main ac generator. In addition, all control and protective functions are implemented in the system software. Digital technology allows the exciter to maintain 99.98% availability. The following is a one-line diagram of the excitation system.

Static Excitation System with Redundant Bridge and Control
(Typical)



5.3.7.1 System Components

The exciter is comprised of the following four basic components as described below:

1. Power conversion module
2. Digital controller
3. Excitation transformer
4. Communication interface

5.3.7.1.1 Power Conversion Module

A three phase, full-wave thyristor bridge is the standard conversion module for the digital excitation system. The standard current capability of the bridge is 6% above the calculated rated full load field current of the generator.

The thyristor bridge assembly is forced air cooled. The cooling assemblies are all energized during normal operation. Thermostats are used to monitor the power conversion module temperature. An alarm is provided for a high temperature level and a trip is provided at a higher temperature level.

5.3.7.1.2 Excitation Transformer

The excitation transformer (power potential transformer) is separate from the exciter. The power to the transformer is obtained from a station auxiliary bus. The purpose of this transformer is to step the voltage down to the required level for the excitation system.

With the use of a regulator in the static exciter, it is not necessary to specify transformer full capacity taps above and below normal on the primary winding. The transformer rating is chosen so that the transformer can deliver the excitation required for the application at 110% rated generator terminal voltage on a continuous basis.

5.3.7.1.3 Digital Controller

The digital controller consists of several microprocessor I/O boards, and a power supply. Cell gating of the SCRs is controlled by one of the microprocessors. If redundant controls are provided, each controller section has its own power supply to ensure backup in the event of a power supply failure.

5.3.7.1.4 Communication Interface

The turbine control interface (HMI) is the primary interface with the exciter. Communication between the turbine control and exciter utilizes a single or redundant datalink. All exciter control logic and display data utilize this datalink. The exciter trip contact (94EX) is hardwired directly to the generator lockout relay and a single global alarm contact (30EX) is hardwired to the turbine control.

5.3.7.2 System Features

Following are descriptions of selected features of the exciter system. For a complete list of system features and accessories, please refer to the Scope of Supply section of the proposal.

5.3.7.2.1 **Interface with the Gas Turbine Control System**

The exciter is connected to the gas turbine control system through a digital datalink. This enables the gas turbine control system to provide a digital window into the exciter through which all pertinent variables can be monitored and controlled.

5.3.7.2.2 **Protection Controller**

The protection controller is separate from the main controller(s) and serves as a backup to the limiters located within the controller. The output of the protection controls transfer to backup control/bridge. The protection features provided are as follows:

- Volts/Hertz, dual level (24EX)
- Loss of excitation (40EX)
- Bridge ac phase unbalance (47EX)

5.3.7.2.3 **Spare Power Conversion Module as Redundant Bridge**

A complete digital controller and rectifier bridge are provided as backup to the primary controller and bridge.

If the protection module senses a condition that would normally initiate a trip signal, it will force a transfer to the redundant system before the trip contact is necessary. The transfer to the redundant system occurs with the generator on-line and does not affect generator output.

5.3.7.2.4 **Power System Stabilizer (PSS)**

The power system stabilizer function is incorporated into the exciter software. A signal representing the integral of accelerating power is introduced into the automatic voltage regulator algorithm to enable the generator to produce and transmit large power levels in a stable manner by reducing low frequency rotor oscillations

5.3.7.2.5 **Enclosure**

The exciter, located in a NEMA-1 stand-alone enclosure, contains the SCR power conversion module and regulator with all standard control and protection functions, plus auxiliary functions such as the de-excitation module and shaft voltage suppression circuit.

5.3.7.3 Related Services

5.3.7.3.1 Power System Stabilizer Tuning Study

GE provides engineering consulting services for tuning the power system stabilizer for optimal performance at the installation site. This includes studies to determine the optimum settings and producing computer models for use in transient stability analysis.

In order to complete the analyses described, GE typically requires data on the system strength at the HV bus (short circuit MVA) and data on the step-up transformer impedance. Copies of any pertinent interconnection specifications or performance requirements for the AVR/PSS should also be provided for use in determining the proper tuning.

5.3.7.3.2 Power System Stabilizer Testing

GE provides engineering services for testing of the AVR/PSS at commissioning (plant startup), or a later date. The purpose of the tests is to verify that the AVR/PSS performance meets existing specifications and requirements and to validate the calculated results from the tuning study. Sometimes this testing is required by the utility regulatory commission for acceptance of the plant performance as it relates to system interconnection requirements. A report documenting the test results compared to the performance requirements is the deliverable following testing.

ATTACHMENT 3

ENVIRONMENTAL AND ENERGY IMPACTS STUDY FOR NO_X BACT ANALYSIS

As presented in the Competitive Power Ventures (CPV) Air Permit Application, emissions of NO_x are subject to Best Available Control Technology (BACT) requirements due to the facility's ozone attainment status. BACT is defined as an emission limitation based on the maximum degree of reduction, on a case-by-case basis, taking into account energy, environmental and economic impacts.

The proposed combined cycle project includes the use of General Electric (GE) 7FA combustion turbines. GE 7FA combustion turbines are expected to emit uncontrolled NO_X emissions at a concentration of 9 ppmvd @ 15% O_2. This emission rate is achieved by the use of dry low-NO_X burners. A BACT analysis was performed, and CPV has concluded that the option of installing a selective catalytic reduction (SCR) control system will satisfy BACT requirements and achieve a controlled NO_X emission rate of 3.5 ppmvd @ 15% O_2. The option of installing a $SCONO_X$ system was addressed, and it is shown to not be economically or technically feasible, since $SCONO_X$ systems have a low cost-effectiveness for this project and have only been used on small turbines (less than 35 MW output). Even though SCR controls have been proposed, drawbacks to SCR do exist and include environmental and energy impacts. The following discussion provides additional detail of environmental and energy impacts associated with the SCR system.

Environmental Impacts of a SCR Control System

SCR is often considered BACT for NO_X emissions on natural gas-fired combined cycle combustion turbines in ozone attainment areas. It has been argued that dry low-NO_x turbines should not apply additional SCR controls as it can have a negative affect environmentally. An SCR system involves injecting anhydrous or aqueous ammonia (NH_3) into the flue gas upstream of a catalyst bed. On the catalyst surface, NH_3 reacts with NO_X contained within the air to form nitrogen gas and water. The following environmental issues are a result of the addition of SCR controls to a combustion turbine flue gas stream:

Ammonia Slip Impacts

Ammonia salts (fine particle) formation - the presence of an SCR catalyst will increase the conversion of SO_2 to SO_3, which may then react with water to form sulfuric acid, or with ammonia slip to form ammonia sulfates (fine particles), resulting in increased total particulate matter emissions. Ammonia sulfates are corrosive and can stick to the heat recovery surfaces, duct work, or the stack at low temperatures. Increased particulate emissions effect visibility (note that a Class I area, Chassahowitzka Wilderness Area, is within 200 km of the proposed facility) and can cause human health problems.

Acidifying deposition – NO_X emissions contribute to the formation of acid aerosols, while ammonia neutralizes atmospheric acidity. Once deposited, however, derivatives of both NO_X and ammonia can contribute to the acidification of terrestrial soils and surface waters.-

Eutrophication – when deposited on water surfaces, oxidized or reduced nitrogen promotes the growth of aquatic plants, such as algae, and the resulting bacteria consumes the oxygen in the water.

Possible conversion to nitrous oxide (N_2O) – once deposited on soil, a small fraction of ammonia emissions is converted by soil microbes to N_2O, which is a greenhouse gas and which depletes stratospheric ozone.

Ammonia Storage and Handling

Storage/Handling – an anhydrous or aqueous ammonia storage tank will be required at a facility utilizing SCR controls. Ammonia is identified by EPA as an extremely hazardous substance. It is toxic if swallowed or inhaled and can irritate or burn the skin, eyes, nose or throat. Additionally, ammonia vapors may form an explosive mixture with air.

Applicable requirements – facilities that handle over 10,000 pounds of anhydrous ammonia or more than 20,000 pounds of ammonia in an aqueous solution of 20% ammonia or greater must prepare a Risk Management Plan (RMP) and implement a RMP to prevent accidental releases.

Catalyst Disposal

Spent catalyst waste – the catalyst in the SCR degrades over time and needs to be replaced, about once every three years. The amount of spent catalyst waste is dependent on several factors, including the amount of catalyst used in the system, the life of the catalyst, and the amount of spent catalyst recycling that occurs.

Energy Impacts of a SCR Control System

The installation of a SCR control system in the flue gas stream has several operating effects on the combustion turbine and are listed as follows:

Pressure Drop

The SCR unit causes a pressure drop in the flue gas stream and the resultant back-pressure exerted on the combustion turbine decreases the power output.

Heat Rate Increase

The pressure drop effect will result in an increased heat rate for the turbine to supplement the power loss.

Fuel Use Increase

The increase in the heat rate of the turbine will require additional fuel usage.

Revenue Loss from Maintenance/Malfunctions

The facility may experience unplanned shutdowns for catalyst change-out, maintenance, and replacement. Downtime periods of combustion turbines result in revenue losses for a facility, since the turbines can only operate with the SCR controls working properly.

The following table is a demonstration of how the proposed SCR controls effects the performance of the GE 7FA combustion turbine:

TABLE A. ENERGY IMPACTS OF SCR CONTROLS			
Pressure Drop across SCR system (inches H_2O)	Lost Output due to Pressure Drop (kW-hr/yr)	Increased Heat Rate of Combustion Turbine (Btu/kW-hr)	Additional Fuel Consumption due to Heat Rate Increase (mmBtu/yr)
3.7	4,082,160	24.7	37,310

Notes:

1. Increased heat rate based on pressure drop. Similar project experienced a 10 Btu/kw-hr increase due to a 1.5 pressure drop from a control device.
2. Annual lost electrical output and additional fuel consumption based on 8,760 hours of operation.

ATTACHMENT 4

CPV GULFCOAST											
HAZARDOUS AIR POLLUTANTS EMISSIONS											
	DISTILLATE					NATURAL GAS					
	Emission Factor	Maximum Heat Input	Emission Rate	Operating Period	Annual Emissions	Emission Factor	Maximum Heat Input	Emission Rate	Operating Period	Annual Emissions	Total Annual Emissions
Pollutant	(lb/MMBtu)	(MMBtu/hr)	(lb/hr)	(Hours)	(TPY)	(lb/MMBtu)	(MMBtu/hr)	(lb/hr)	(Hours)	(TPY)	(TPY)
Arsenic	1.10E-05	1918	2.11E-02	720	7.60E-03						7.60E-03
Beryllium	3.10E-07	1918	5.95E-04	720	2.14E-04						2.14E-04
Cadmium	4.80E-06	1918	9.21E-03	720	3.31E-03						3.31E-03
Chromium	1.10E-05	1918	2.11E-02	720	7.60E-03						7.60E-03
Lead	1.40E-05	1918	2.69E-02	720	9.67E-03						9.67E-03
Manganese	7.90E-04	1918	1.52E+00	720	5.45E-01						5.45E-01
Mercury	1.20E-06	1918	2.30E-03	720	8.29E-04						8.29E-04
Nickel	4.60E-06	1918	8.82E-03	720	3.18E-03						3.18E-03
Selenium	2.50E-05	1918	4.80E-02	720	1.73E-02						1.73E-02
Acetaldehyde						4.00E-05	1700	6.80E-02	8040	2.73E-01	2.73E-01
Acrolein						6.40E-06	1700	1.09E-02	8040	4.37E-02	4.37E-02
1,3-Butadiene	1.60E-05	1918	3.07E-02	720	1.10E-02	4.30E-07	1700	7.31E-04	8040	2.94E-03	1.40E-02
Benzene	5.50E-05	1918	1.05E-01	720	3.80E-02	1.20E-05	1700	2.04E-02	8040	8.20E-02	1.20E-01
Ethylbenzene						3.20E-05	1700	5.44E-02	8040	2.19E-01	2.19E-01
Formaldehyde	2.80E-04	1918	5.37E-01	0	0.00E+00	7.10E-04	1700	1.21E+00	8760	5.29E+00	5.29E+00
Naphthalene	3.50E-05	1918	6.71E-02	720	2.42E-02	1.30E-06	1700	2.21E-03	8040	8.88E-03	3.31E-02
PAH	4.00E-05	1918	7.67E-02	720	2.76E-02	2.20E-06	1700	3.74E-03	8040	1.50E-02	4.27E-02
Propylene Oxide						2.90E-05	1700	4.93E-02	8040	1.98E-01	1.98E-01
Toluene						1.30E-04	1700	2.21E-01	8040	8.88E-01	8.88E-01
Xylenes						6.40E-05	1700	1.09E-01	8040	4.37E-01	4.37E-01
										Total HAPs	**8.15E+00**

Notes:

Hazardous air pollutant emission factors taken from USEPA document Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume I: *Stationary Point and Area Sources*, Section 3.1 Stationary Gas Turbines, dated 4/2000:

Table 3.1-3. Emission Factors For Hazardous Air Pollutants from Natural Gas-Fired Stationary Gas Turbines

Table 3.1-4. Emission Factors For Hazardous Air Pollutants from Distillate Oil-Fired Stationary Gas Turbines

Table 3.1-5. Emission Factors For Metallic Hazardous Air Pollutants from Distillate Oil-Fired Stationary Gas Turbines

ATTACHMENT 5

BPIP INPUT FILE

```
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'hrsg'      1        0
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4.88       6.10
4.88       28.96
-4.88      28.96
'sturb'     1        0
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19.20      34.44
64.92      34.44
64.92      64.92
19.20      64.92
'cell1'     1        0
 4        16.764
6.10      -28.35
21.34     -28.35
21.34     -13.11
6.10      -13.11
'cell2'     1        0
 4        16.764
21.34     -28.35
36.58     -28.35
36.58     -13.11
21.34     -13.11
'cell3'     1        0
 4        16.764
36.58     -28.35
51.82     -28.35
51.82     -13.11
36.58     -13.11
'cell4'     1        0
 4        16.764
51.82     -28.35
67.06     -28.35
67.06     -13.11
51.82     -13.11
'cell5'     1        0
 4        16.764
```
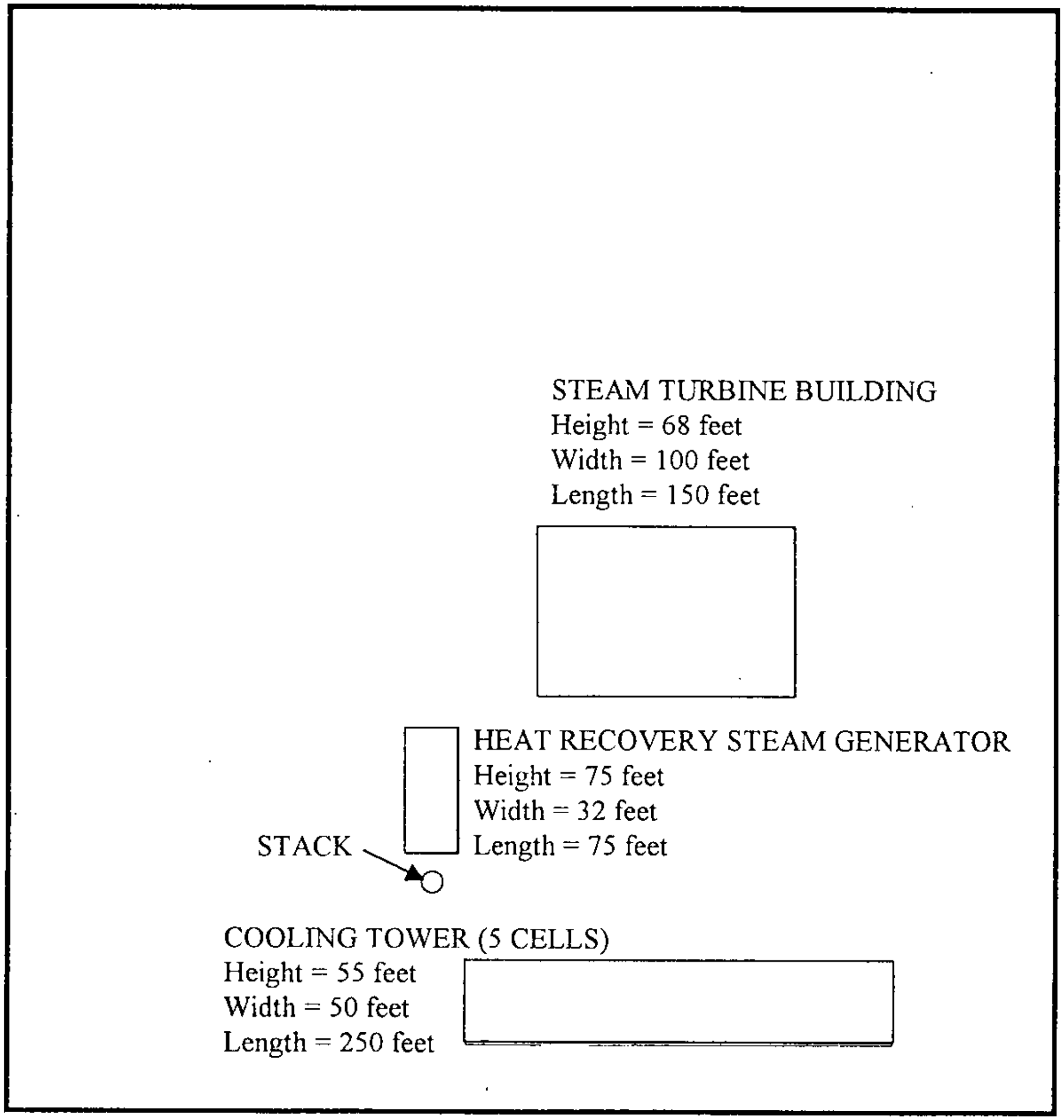

67.06	-28.35			
82.30	-28.35			
82.30	-13.11			
67.06	-13.11			
10				
'25/50 '	0	45.72	0.00	0.00
'25/75 '	0	45.72	0.00	0.00
'25F '	0	45.72	0.00	0.00
'59F '	0	45.72	0.00	0.00
'72/50 '	0	45.72	0.00	0.00
'72/75 '	0	45.72	0.00	0.00
'72F '	0	45.72	0.00	0.00
'97/50 '	0	45.72	0.00	0.00
'97/75 '	0	45.72	0.00	0.00
'97F '	0	45.72	0.00	0.00



N

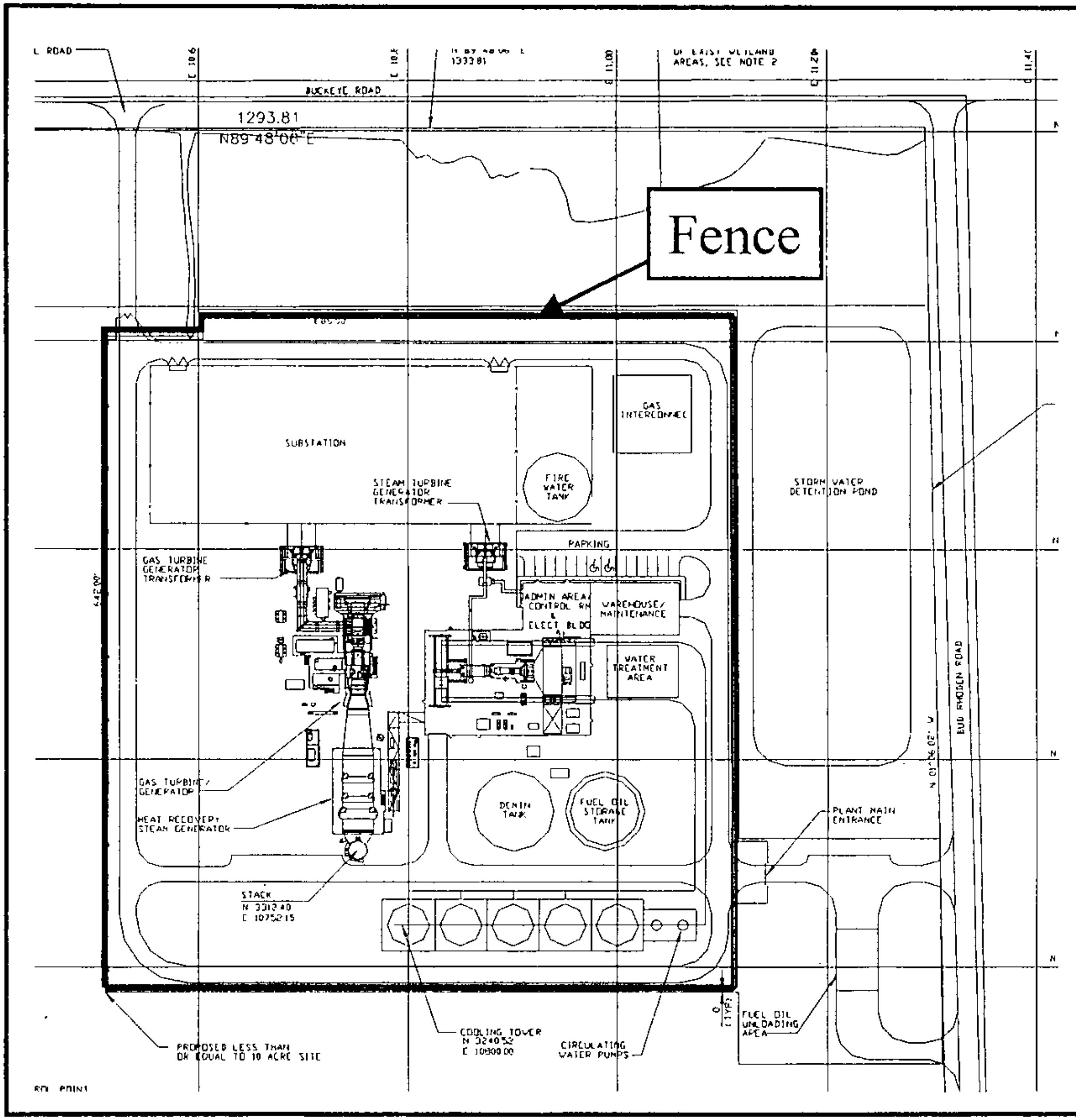
TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

BPIP STRUCTURES
COMPETITIVE POWER VENTURES
GULFCOAST PROJECT

FIGURE 1 | PROJ. NO. 28366

ATTACHMENT 6



TRC

Boott Mills South
Foot of John
Street
Lowell, MA 01852

FENCELINE

COMPETITIVE POWER VENTURES

PROJ. NO. 28366

ATTACHMENT 7

U.S.FISH&WILDLIFE SERVICE
AIR QUALITY BRANCH
P.O. BOX 25287, Denver, CO 80225-0287

Date: September 27, 2000

Telephone: (303) 969-2617
Fax: (303) 969-2822

To: Al Linero
Patty Adams
Cleve Holladay

From: Ellen Porter

Subject: CPV Gulfcoast, Ltd. PSD-FL-300

We have reviewed the Prevention of Significant Deterioration Application for CPV Gulfcoast, Ltd. Proposed combined-cycle 250 MW power generation facility in Manatee County. The facility is located 97 km south of Chassahowitzka Wilderness, a Class I air quality area administered by the U.S. Fish and Wildlife Service. Emissions increases include 126 tons per year (tpy) of nitrogen oxides (NOx), 76 tpy of sulfur dioxide, and 102 tpy of PM-10.

CPV is proposing to use selective catalytic reduction (SCR) to control NOx emissions to 3.5 ppm while burning gas and 10 ppm while burning oil. We agree that this represents best available control technology.

CPV evaluated potential impacts to Class I increments. Predicted impacts were below the significant impact levels for nitrogen dioxide, sulfur dioxide, and PM-10. CPV also evaluated its potential contribution to haze at Chassahowitzka. Their analysis, using IWAQM Phase 2, predicted a 2% change in light extinction, less than the 5% screening level recommended by FWS. However, CPV located its receptors for the analysis incorrectly, placing all receptors within Chassahowitzka instead of using the circular ring of receptors decribed in the IWAQM Phase 2 document. Because CPV's emissions are relatively low and well-controlled with

SCR, and the facility is 97 km from the Class I area, we believe that the project has low potential to contribute significantly to haze at Chassahowitzka. Therefore, we will not require CPV to revise their analysis. However, future applicants should be advised to follow the IWAQM Phase 2 recommendations.

Thank you for giving us the opportunity to comment on this project.

Department of Environmental Protection

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Jeb Bush
Governor

David B. Struhs
Secretary

October 9, 2000

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. Gary Lambert
Executive Vice President
CPV Gulfcoast, Ltd
45 Bristol Road, Suite 101
Easton, Massachussets 02375

Re: DEP File No. 0810194-001-AC (PSD-FL-300)
Proposed 244 .9 MW Combined Cycle Power Plant

Dear Mr. Lambert:

On September 11, 2000 the Department received your application and complete fee for an air construction permit for a 244.9 megawatts (MW) combined cycle power plant near Piney Point in Manatee County, Florida. The application is incomplete. In order to continue processing your application, the Department will need the additional information requested below. Should your response to any of the below items require new calculations, please submit the new calculations, assumptions, reference material and appropriate revised pages of the application form

Please submit the following information:

1. Process flow diagram.
2. Combustion Turbine: Is this combustion turbine equipped with evaporative inlet air cooling system (foggers)? Will the unit operate while both fogging and power augmenting? Please explain. Will this turbine always operate in the combined cycle mode? What is the heat rate of this project (Btu/kwh)? Submit General Electric performance data sheets for this turbine.
3. Heat Recovery Steam Generator: Is the HRSG supplementally- fired? If so, what, is the heat input of the duct burner. What is the model and manufacturer of the duct burner and HRSG if already selected? Submit the manufacturer performance sheets if available. How much steam is produced at this unit?
4. Power Augmentation: How much extra power is produced in the power augmentation mode? Provide a schematic of the power augmentation operation mode. What is the manufacturer's maximum recommended period (hr/year, hr/month) for operation in the power augmentation mode.

5. Automated Control System: What type of control system is recommended by the combustion manufacturer (i.e. Mark V control system, etc).
6. Storage Tanks: What are the capacities of the tanks associate with this plant?
7. Ancillary Equipment: The application only lists the CT, HRSG and the Cooling Tower. Would this plant include an Emergency Generator and Diesel Fired Pump, gas heaters, or any other ancillary equipment?
8. Selective Catalytic Reduction (SCR) system:
    - The application states that GE does not recommend operation of the SCR during distillate fuel operation. However a 30 days at full load while burning oil and a 10 ppm NO_X limit is being proposed. Please explain.
    - What is the ammonia slip proposed for this project (ppm)?
    - Submit the environmental and energy impact analysis for this project while using SCR.
9. Estimate emissions of hazardous air pollutants (HAPs). Show basis. Indicate if HAPs emissions from this project are less than 25 ton/yr for all HAPs and less than 10 ton/yr for a single HAP.
10. Page twenty one of the application states that there is a graphic showing the location of the stacks and buildings in Appendix D-1, however, this graphic is absent from the appendix. Please provide this graphic along with the BPIP input file.
11. Please provide information that shows that the site boundary used in the impact modeling will be land owned or controlled by CPV Gulfcoast, Ltd. with a physical barrier to public access.
12. The table entitled 'Gulfcoast-Single CT Firing Oil (150-foot stack)' in Appendix D identifies the 97/50 operating scenario as the worst case impact scenario for PM_{10}. However, this was not the scenario that was used in the PM_{10} modeling that included the cooling towers. Please re-evaluate the PM_{10} Class II SIL modeling by using the 97/50 operating scenario.
13. The set of 13 discrete receptors for the Chassahowitzka NWR that the Department provided to TRC were intended for use in a regular CALPUFF analysis. If the applicant proposes to show compliance with modeling requirements by using the CALPUFF LITE screening method, then a ring of receptors as described on pages 6-8 in the *IWAQM Phase 2 Summary Report* should be utilized to show compliance with both increment consumption and regional haze requirements.
14. Please provide the meteorological files that were utilized in the CALPUFF LITE modeling analysis, and a listing of the parameters that were used to create them.
15. Class I increment and regional haze modeling should be conducted by using the worst case operating load for each pollutant (i.e. 100% load at 25°F for NO_x and SO_2, and 50% load at 25°F for PM_{10}).

Attached are the comments from the U.S. Fish and Wildlife Service. We will send you the comments from EPA Region IV as soon as they are received.

Rule 62-4.050(3), F.A.C. requires that all applications for a Department permit must be certified by a professional engineer registered in the State of Florida. This requirement also applies to responses to Department requests for additional information of an engineering nature. Permit applicants are advised that Rule 62-4.055(1), F.A.C. now requires applicants to respond to requests for information within 90 days. If there are any questions, please call me at 850/921-9519. Matters regarding modeling issues should be directed to Chris Carlson (meteorologist) at 850/921-9537 and e-mail chris.carlson@dep.state.fl.us. Matters regarding the technical information may be directed to Teresa Heron at 850/921-9529 and e-mail teresa.heron@dep.state.fl.us

Sincerely,

A. A. Linero 10/9

A. A. Linero, P.E. Administrator
New Source Review Section

AAL/th

cc: Gregg Worley, EPA
John Bunyak, NPS
Bill Thomas, SWD
Marion Forthoffer, Manatee County
Scott Sumner, P.E.

U.S. Postal Service
CERTIFIED MAIL RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

7099 3400 0000 1453 2337

Article Sent To:

Gary Lambert

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

10/9/02 Gulfcoast

Postmark Here

Name (Please Print Clearly) (to be completed by mailer)
Mr. Gary Lambert
Street, Apt. No.; or PO Box No.
45 Bristol Rd., Ste. 101
City, State, ZIP+4
Easton MA 02375

PS Form 3800, July 1999 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Mr. Gary Lambert
Executive Vice President
CPV Gulfcoast, Ltd
45 Bristol Rd, Ste 101
Easton, MA 02375

COMPLETE THIS SECTION ON DELIVERY

A. Received by *(Please Print Clearly)*

B. Date of Delivery: 10-15

C. Signature
X Darcy Campbell ☐ Agent ☐ Addressee

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Copy from service label)*
7099 3400 0000 1453 2337

PS Form 3811, July 1999 — Domestic Return Receipt — 102595-99-M-1789

The Law Offices of
MOYLE
FLANIGAN
KATZ
RAYMOND
&SHEEHAN
P.A.

THE PERKINS HOUSE
118 NORTH GADSDEN STREET
TALLAHASSEE, FLORIDA 32301

TELEPHONE (850) 681-3828
FACSIMILE (850) 681-8788

West Palm Beach Office
Telephone (561) 659-7500
Facsimile (561) 659-1789

PETER L. BRETON
JOHN R. EUBANKS, JR.
JOHN F. FLANIGAN
MYRA GENDEL
MARTIN V. KATZ
PAUL A. KRASKER
JON C. MOYLE
JON C. MOYLE, JR.
MARSHALL J. OSOFSKY
MARK E. RAYMOND
CATHY M. SELLERS
THOMAS A. SHEEHAN, III
ROBERT J. SNIFFEN
MARTA M. SUAREZ-MURIAS
WILTON L. WHITE
BRIAN L. WOLINETZ

OF COUNSEL:
THOMAS A. HICKEY
WILLIAM J. PAYNE

VIA HAND DELIVERY

October 5, 2000

RECEIVED
OCT 05 2000
BUREAU OF AIR REGULATION

Ms. Teresa Heron
Engineer
Bureau of Air Quality Management
Department of Environmental Protection
Tallahassee, FL 32399

Re: Revised Site Maps for CPV Gulfcoast Power Generating Facility, Application for Air Permit, Document ID: CPV-GC.

Dear Ms. Heron:

Please find attached two copies each of two drawings, Figure 2-1, which is the Site Location Map, and Figure 4-1, the 3-Kilometer Radius Map, both drawings of which have been revised to accurately reflect the proposed electric power generating facility's site location. These drawings replace those previously submitted as part of the application that was filed with the Department on September 11, 2000.

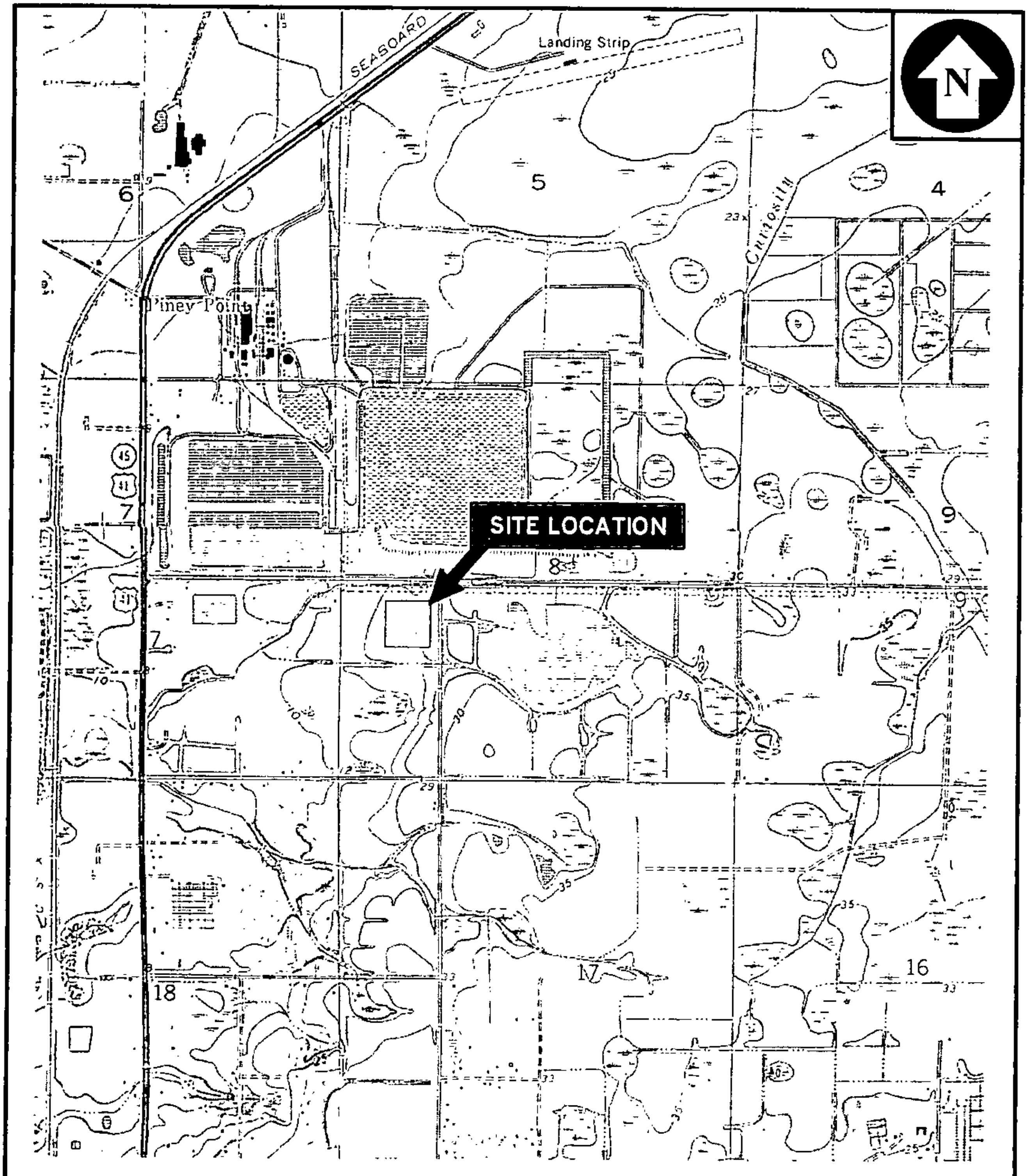
Thank you for your attention to this matter, and please call me if you have any questions.

Sincerely,

Cathy M. Sellers

Cathy M. Sellers
Attorney for CPV Gulfcoast, Ltd.

cc: Sean Finnerty
Laurence Labrie



BASE MAP IS A PORTION OF THE FOLLOWING 7.5' USGS TOPOGRAPHIC QUADRANGLES: RUSKIN, FLA, 1956, PHOTOREVISED 1987;
PARRISH, FLA, 1973, PHOTOREVISED 1987;
PALMETTO, FLA, 1964, PHOTOREVISED 1987;
COCKROACH BAY, FLA, 1956, PHOTREVISED 1981

0 2000 4000

scale in feet

QUADRANGLE LOCATION

L00-250/topo

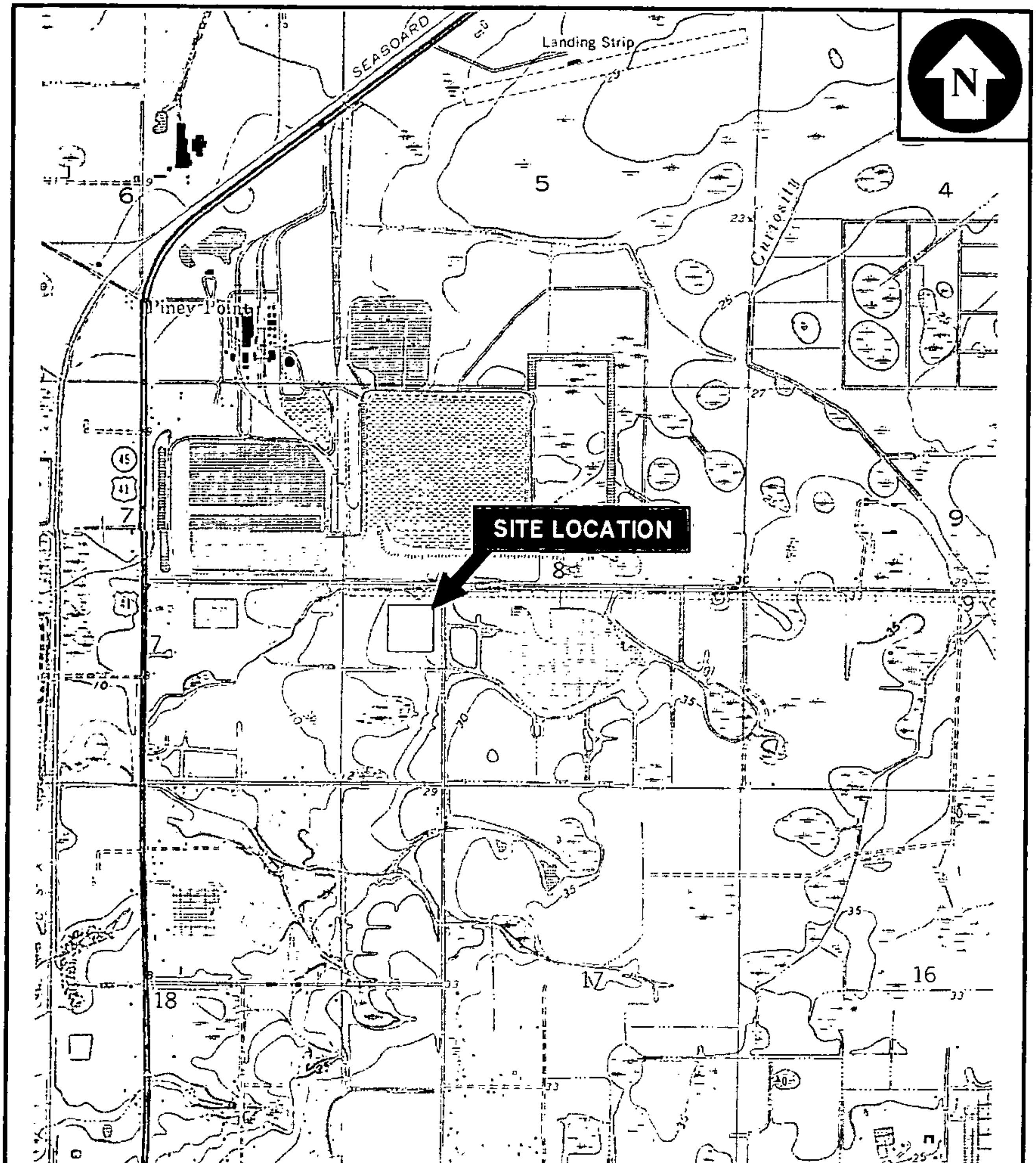
TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
978-970-5600

SITE LOCATION MAP

COMPETITIVE POWER VENTURES
GULF COAST PROJECT
PINEY POINT, FLORIDA

FIGURE 2-1	PROJ. NO. 28366



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0 2000 4000

scale in feet

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L00-250/topo

TRC
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SITE LOCATION MAP

COMPETITIVE POWER VENTURES
GULF COAST PROJECT
PINEY POINT, FLORIDA

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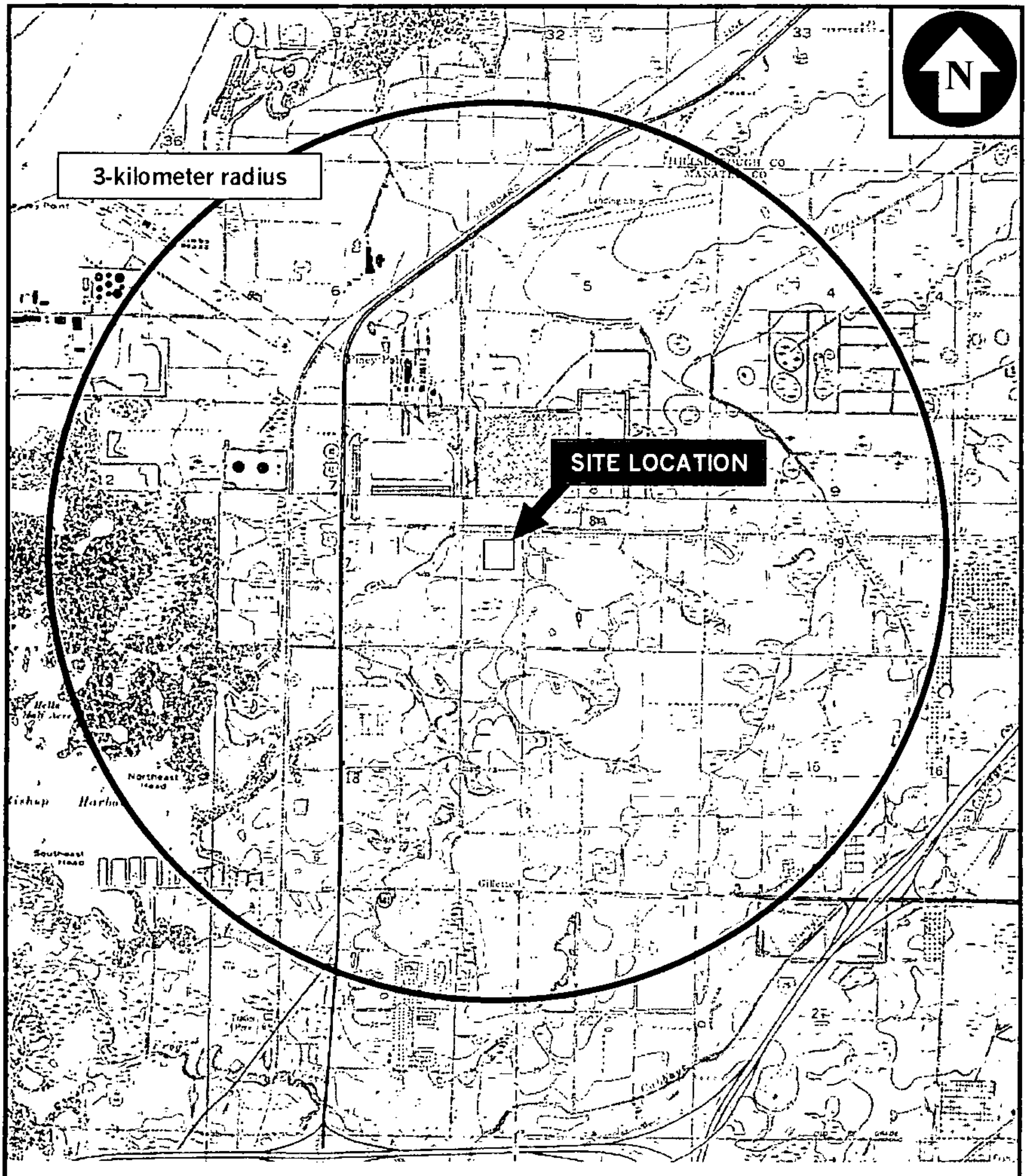

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COCKROACH BAY, FLA, 1956, PHOTREVISED 1981

0 1 2

scale in kilometers

L00-250/3 kilo

QUADRANGLE LOCATION

TRC

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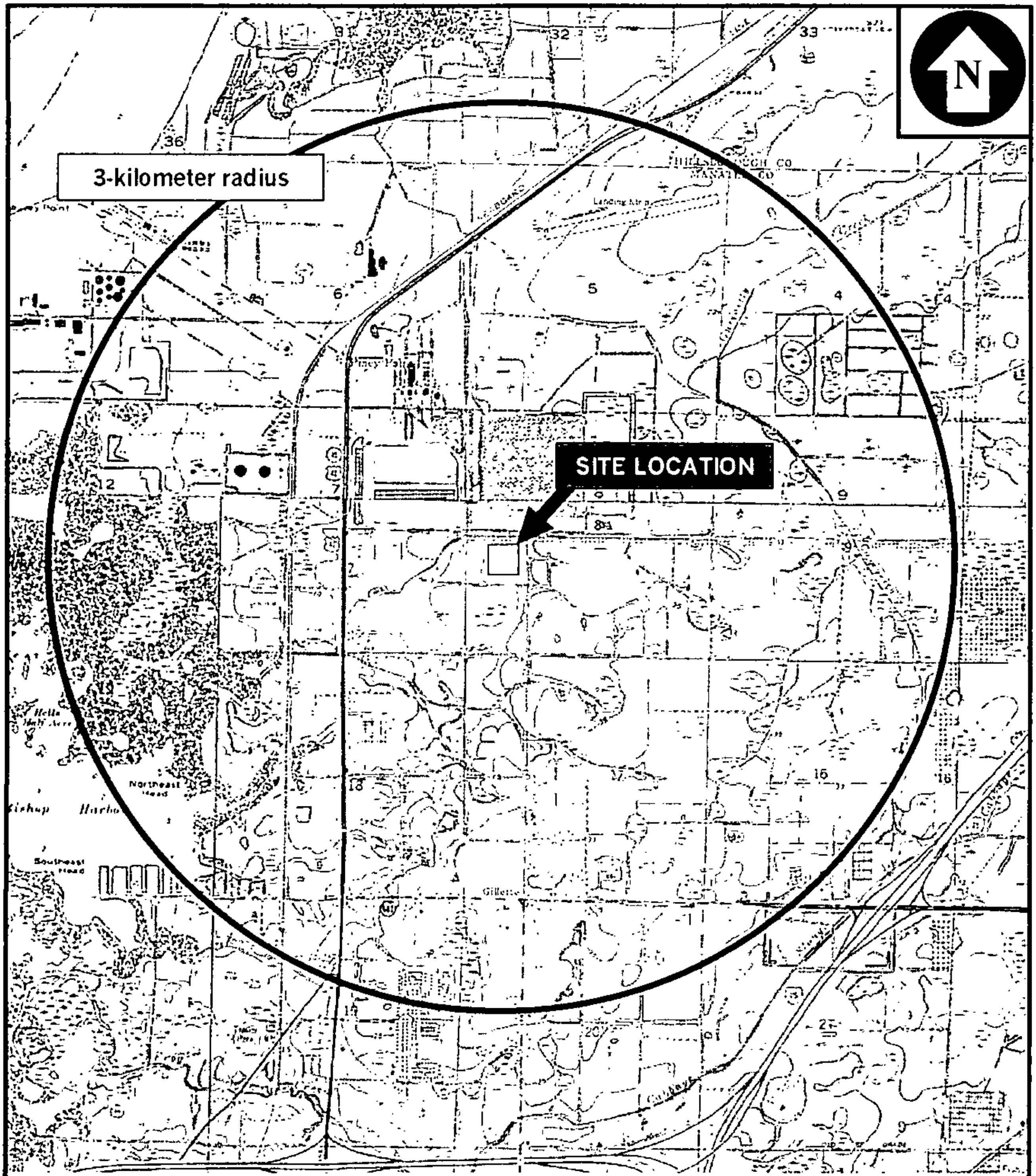
Foot of John Street
Lowell, MA 01852
978-970-5600

3-KILOMETER RADIUS MAP

COMPETITIVE POWER VENTURES
GULF COAST PROJECT
PINEY POINT, FLORIDA

FIGURE 4-1	PROJ. NO. 28366



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TRC
Boott Mills South
Foot of John Street
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978-970-5600

3-KILOMETER RADIUS MAP

COMPETITIVE POWER VENTURES
GULF COAST PROJECT
PINEY POINT, FLORIDA

FIGURE 4-1 | PROJ. NO. 28366

U.S.FISH&WILDLIFE SERVICE
AIR QUALITY BRANCH
P.O. BOX 25287, Denver, CO 80225-0287

Date: September 27, 2000

Telephone: (303) 969-2617
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To: Al Linero
Patty Adams
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From: Ellen Porter

Subject: CPV Gulfcoast, Ltd. PSD-FL-300

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Thank you for giving us the opportunity to comment on this project.