

FT4 Equipment Description

PRATT & WHITNEY

2 X FT4C-1 TWINPAC

108 MW ELECTRIC GENERATING PLANT

GENERAL DESCRIPTION

1. The FT4C-1 TWINPAC Power Island is a completely self-contained, automatic, gas turbine-powered electric generating package nominally rated at 54 MW. The unit contains all the equipment required for local unattended operation and provisions for interconnection to a remote control panel. It has the capability to start up in the event of loss of purchaser-provided A.C. electrical power when the unit is in a stand-by condition. This built-in starting capability, plus the ability of the unit to assume full load in less than four minutes after initiation of the start signal, provides excellent protection in event of “black-out”.

The FT4C-1 TWINPAC consists of a generating module with an Electric Machinery Manufacturing Co. open cycle, air-cooled, 57.3 MVA (Base), 13.8 KV, 0.90 power factor, two-pole, turbine type generator with a brushless exciter driven by two (2) opposed, direct-connected Pratt & Whitney Aircraft FT4C-1 Gas Turbines. The Turbines are coupled through diaphragm couplings to each end of the generator shaft which provide for the total thermal growth of the unit while retaining the ability of the generator to operate at half power with one turbine decoupled for inspection or repair.

The gas turbines are provided with their own lubrication system, including storage tanks. The generator has a separate lubrication system with an A.C. motor-driven lube oil pump with D.C. backup. Both systems are air-cooled.

The generator is top connected via 3000 ampere, 15 KV, 95 KV BIL bus duct to its high voltage metal clad switchgear containing the 1000 MVA, 3000 ampere Air Circuit Breaker.

The turbines, generator and controls are housed in painted steel enclosures with painted steel inlet and exhaust stacks.

The turbines are separated from the generator by two-diaphragm walls to prevent mixing the turbine secondary cooling air and generator primary cooling air and to provide more effective fire protection. An automatic fire protection system is provided for each of the gas turbines. The gas turbine air inlet stacks are acoustically treated and are fitted with sound attenuating baffles. The exhaust stack shells are constructed of stiffened carbon steel plate, externally insulated, and sheathed with ribbed aluminum siding. The interior of the exhaust silencers are lined with stainless steel sheets, and are fitted with sound attenuating baffles constructed of stainless steel face sheets and internal framing.

Two FT4C-1 packages will be provided for a total of 108 MW generating capacity.

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The control enclosure contains the gas turbine control, generator control panel, Motor Control Center, high voltage metal clad switchgear and batteries.

This General Description is typical.

2. **Equipment**

The major equipment included in the TP4-2 TWINPAC consists of:

- a) A steel enclosure with inlet and exhaust stacks fitted with sound attenuating devices.
- b) Gas Turbine Prime Movers, each equipped with the following systems:
 - (1) Operating Controls
 - (2) Lubricating System
 - (3) Fuel Control and Fuel System, including Booster Pump and Filter
 - (4) Starting Turbine
 - (5) Ignition System
 - (6) Automatic Anti-Icing
 - (7) Flexible Coupling
 - (8) Mounts and Base
- c) Open Cycle, Air Cooled Generators with brushless exciters and associated electrical equipment including:
 - (1) Voltage Regulators
 - (2) High and Low Voltage Switchgear
 - (3) Turbine and Generator Control Panels
 - (4) Sequencers
 - (5) Protective Relaying
 - (6) Motor Control Centers
 - (7) Batteries and Chargers
 - (8) Auxiliary Transformers
 - (9) Master Terminal Strips

3. **Operation**

The TP4-2 TWINPAC is designed for either local or remote automatic operation on the distribution or transmission system of an electric utility. In the event of a blackout of a main power station, the unit also may be started and operated as an “isolated” generating station from either the local or remote control station.

The TWINPAC has five (5) modes of operation:

- (1) Parallel – Manual and Automatic (Remote – Local)
- (2) Isolated – Manual and Automatic (Remote – Local)

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- (3) Isolated Precise – Manual and Automatic (Local Only)
- (4) Idle – (Local Only)
- (5) Test – (Local Only)

Mode 1 provides the capability of achieving any desired load level either automatically or manually.

When the “normal” loading-unloading rate is selected, the unit can be brought to full load within five (5) minutes from breaker closure, or similarly from full load to breaker opening within five (5) minutes of initiation of stop signal. When the “fast” loading-unloading rate is chosen, these same actions can be accomplished in fifteen (15) to twenty (20) seconds.

When used to compensate for peak-load periods, the TP4-2 TWINPAC is normally operated unattended from a remote control station in the Automatic-Parallel Mode. In this mode, the load selection – Peak, Base Load, or Minimum Load – is made at the control panel by setting the Power Programming Switch to the desired load level. Upon actuation of the Start Switch, the unit will automatically start up, sequence, and synchronize with the line, and go immediately to one of the selected load levels and remain at this level. While in operation, the unit can be automatically shifted from one load level to another by actuation of the power Programming Switch.

If the unit is first brought on the line in the Automatic Parallel Mode to any one of the above four programmed load levels, it may be placed in the Manual-Parallel Mode and the load level may be manually adjusted to any desired value between any programmed load level (Maximum, Peak, Base Load or Minimum Load) and zero power by actuation of the speed governor switch.

When the service of the TWINPAC is no longer required, actuation of the remote Stop Switch will automatically unload the unit, sequence it to the “Idle” and “Cool-Down” phases to a complete stop. This same sequence of events can also be accomplished locally at the Control Room.

The unit can also be manually brought on the line from the local control room by selecting the Manual-Parallel Mode of operation. In this mode, actuation of the module Start Switch will automatically start-up and sequence the module to its idle speed condition (3550 rpm free turbine speed) from where it can be manually synchronized and loaded. This feature can also be incorporated into the remote control panel at additional cost.

This TWINPAC can also be used for blacked-out station start-up or “isolated” operating condition by selecting “Isolated Mode”. In this mode, the unit can be started and automatically or manually (depending upon selection) close onto the purchaser’s dead bus. On actuation of its Start Switch, the module will automatically sequence to 2950 rpm generator speed at which point the breaker is closed manually or automatically depending on the method chosen. The unit will load within its capability, governing along a 4% droop slope. Frequency may also be controlled by actuation of the governor switch.

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When the unit is the only available source of power, it may be operated in the Isolated Precise Mode from the local control room or remote control panel if this extra equipment is provided. When in this mode, actuation of its Start Switch will automatically sequence the unit to 3600 rpm and maintain the speed. The main breaker can be closed, either automatically or manually, after reaching this speed and governing will be isochronous with load demand. When either the “Isolated” or “Isolated-Precise” modes are selected, “dead-bus” relay will prevent closure of the main breaker on a “live-bus”.

To ensure the FT4’s capability to start and provide power when operating in these isolated modes, should purchaser-provided electrical service to the unit become unavailable, a battery pack and station auxiliary transformer are provided. All electrical equipment involved in starting or tripping is designed for direct-current operation. The station auxiliary transformer is energized as soon as the generator is producing power and the main breaker is closed, thus supplying station power, including D.C. through a rectifier, preventing further drain on the battery.

For testing and “trimming” the unit, Idle and Test Modes are provided. In the Idle Mode, the unit will automatically sequence to idle speed (approximately 6000 rpm N2 speed) on actuation of the Start Switch. The Test Mode, with its associated Test Panel, provides direct individual engine speed control and permits manual breaker closure and loading for test and trim purposes.

The TWINPAC has two basic operating controls: a Speed Governor Switch to adjust speed or load, and a “Voltage Adjust Rheostat” (VAR Switch) to adjust terminal voltage or vars. When the unit is in the Isolated Mode, the VAR Switch controls the terminal voltage and the Speed Governor controls the frequency. However, when the unit is in the Parallel Mode, the Speed Governor Switch will change the load on the machine and the VAR switch will change the reactive power from a preset value. Both switches can be used locally or remotely.

The unit can be restarted, if so desired, after the Stop Switch has been actuated, provided the shutdown sequence has not progressed to the fuel cut-off stage, at which point the engine must be allowed to come to windmilling speed before restarting (this requires approximately one {1} minute). Protective relays will prevent restarting during this phase of shutdown sequencing.

In an emergency, the TWINPAC can quickly be brought to the shutdown condition by actuation of either one of the Emergency Stop Buttons located in the Remote or the Local Control Room. Actuation of these buttons, or any of the shutdown relays, will cause the quick acting fuel shut-off valves to close, thus by-passing the normal shutdown sequence and stopping the unit in the shortest time interval.

In the event that an electrical or mechanical fault should occur in one of the units, protective relays will automatically energize an alarm signal if continued operation is permissible, or take the unit off the line if necessary and bring it directly to the shutdown condition. Annunciators are provided in the Control Room to indicate the location or cause of the fault.

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4. FT4C-1 TWINPAC Control System Description

A. Control System Description

1. Woodward NetCon 5000

This system has a central processing unit (CPU) for unit sequencing and fuel governing. It is a 32 bit CPU with high speed and great accuracy, utilizing conventional analog and digital input/output devices. It also includes a final driver for the fuel control valve. A new liquid fuel control valve and integral shutoff valve are provided. The NetCon 5000 is considered to be the best state-of-the-art control available for this type of generating unit. It represents the maximum system integration available at this time. The NetCon 5000 is powered from the 125 VDC batteries.

An industrial 19-inch color CRT is provided and can be used to start/stop, load the unit, and select power levels. Displays are selected by use of a mouse. The CRT provides the operator with all alarm and trip indications.

Additionally, sensors, transducers, or I/O are provided to digitally display and record all parameters including the following for each engine:

- ❑ Speed: N1, N2, N3
- ❑ Pressure: PS4, PT7, P AMB, Fuel Pressures, Lube Pressures
- ❑ Temperature: TAMB, TT2, TT7 Individual, Average and Spread
- ❑ Megawatt Output, Megavar Output, Generator Voltage
- ❑ Performance: Corrected Values of N1, N2, PS4/PT2 (Compressor Pressure Ratio), PT7/PT2 (Engine Pressure Ratio, Wf (Fuel Flow), Ww (Water Flow), TT7 Avg. and Generator Load

2. Special Design Features and Options

The following is a list of special design features, which are included in the control equipment:

- a) The DCS has logic to improve reliability and availability by using dual speed sensors and switching from a failed sensor to a good one without tripping, but with an alarm. Also, sensor signal arrangement on I/O boards is such that a degree of fault tolerance is achieved. Operation can continue with some boards out of service while an alarm is displayed.
- b) All set points will have digital accuracy to eliminate the drift of analog controls.
- c) The digital set points and accuracy eliminates many of the tedious calibration procedures performed by the technicians during maintenance, startup, and load trimming of analog controls.
- d) The design philosophy is one that eliminates adjustments and is as self- diagnostic as practical.

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- e) All alarms are individually printed out and not ganged into one alarm window which helps pin down the cause of a problem to the specific engine parameter involved and therefore contributes to less down time. The "first out" feature identifies the cause of a shutdown.
- f) Start Ramp with Fuel Limit - Eliminates the need for seasonal winter/summer start ramp trim or adjustment.
- g) Black Start - The DCS is DC powered and the vibration monitor is DC powered. A small inverter powers the MMI CRT and computer but black start is still possible with these out of service.
- h) Metal oxide varistor transient suppressors are installed for auxiliary control relays and fuel solenoid valves to protect DCS and vibration monitor electronics from high speed, high amplitude, inductive spikes.
- i) The water wash sequence is integrated into the DCS.
- j) The fuel shut off valve test logic is integrated into the DCS.
- k) Lite-off flow test logic is built into the DCS.
- l) Standard industrial inlet air temperature sensors and transmitters are provided to improve accuracy. Both engines can continue to run if one sensor fails.
- m) Automatic performance calculations are provided to simplify performance trend monitoring.
- n) Improved load sharing between gas generators is provided with digital accuracy and with no adjustments required.
- o) The system documents operator action automatically as an aid to problem diagnosis.
- p) A remote monitoring modem will be provided so that operating history, alarms, operating parameters and performance can be viewed. This requires a dedicated phone line which is to be provided by the Owner. ESI provides the remote monitoring for the warranty period.
- q) Energy control center remote SCADA operation for remote start/stop and load control is an available option.
- r) Local plant office master monitor is also an available option to permit alarm monitoring and group start mode.
- s) All fuel and lube pressures are automatically monitored by new solid-state pressure transducers with plus or minus 0.25 percent accuracy. All transducers are equipped with three way test valves.

3. Control CRT

The Control CRT is an industrial color CRT which is used by the operator to start/stop load and select power level, is icon driven, and has a 19" color screen. It provides the operator with alarm and event lists and built in trending capability for approximately 30 days of operational data storage. All analog parameters can be displayed in groups in a trend format.

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4. Operator Control Panel

Operator Control Panel has indicating lights and switches for operator control in addition to control functions on the CRT.

5. Vibration Monitor

Vibration Monitor is a rack-mounted digital device for gas generator vibration monitoring. High temperature accelerometers are used. The signals are processed by the separate vibration monitor and sent to the DCS where the alarm and trip functions are processed, and additionally are made available for trend history. Vibration monitoring of the free turbine is accommodated.

6. NetCon 5000 Main Unit has a single Central Processing Unit (CPU) which is programmed for both the sequencing and the fuel governing function of the control system. It is a 32 bit CPU. The Woodward NetCon 5000 uses a single chassis in order to house all of the circuit boards required for both engines. It contains the maximum system integration that is available at this time.

7. The Main Chassis houses some of the input/output circuit boards (I/O) for the main unit and is located in one of the 19" racks. Other I/O cards are locally mounted in the control panel.

8. Power Supply is a 125 VDC powered unit that provides controlled voltage DC to the rest of the DCS system. It provides system logic during a coast-down following a major power loss.

9. Printer is a unit that is used to print all alarms and events and to provide CRT screen copies in color.

10. I/O connections to the NetCon 5000 are made with plug-in connectors at the I/O cabinets in the control room. The I/O cabinets are standard 19" wide equipment rack mounts. These cabinets have interface terminal boards which are used to terminate all field I/O and connector harnesses to the NetCon control panel terminals.

11. Operator Interface Displays: Numerical data is displayed for alarms. Digital displayed data and analog trend displays are used by the operator to determine equipment status, as well as to control the unit, start/stop, load, etc. Trending is stored for thirty days of operation in the MMI System.

12. The AVR is a new digital device that has independent manual backup voltage control.

13. Water Injection System for NOx Control

The water injection skid provides water injection flow to four (4) engines (two (2) TWINPAC units). The skid is located in the turbine auxiliary room which is heated, ventilated and insulated. Maintenance clearances are provided around the skid.

The skid contains all pumps, control valves and shutoff valves for automatic water injection operation. A second pump provides redundancy and both pump motors operate at 480 V supply voltage. The motor starters are located on the skid. Two (2) TEFC 40 HP 480V boost pumps and two (2) TEFC 100 HP 480V main pumps are provided for redundancy. The boost pumps have discharge filters to protect the downstream control valves and engine systems. Either boost pump and either main pump can be valved in to provide full water injection flow to the eight engines. Normally one pump is the main and the other is the backup. Transfer is

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accomplished manually. The design does not require both pump outputs to run in parallel. The backup pump can also be used for future inlet fogging to provide an evaporative cooling effect to the gas generator air inlets to boost power output on hot days if inlet fogging nozzles, controls and piping are installed.

The boost pumps also serve a dual function as they are used to supply water wash to the engine bellmouth wash nozzles.

The logic for the control of the water injection valves and the protection of the engines is built into the Woodward NetCon digital integrated control system. Common pump services are controlled by a MicroNet NetCon subsystem mounted in a panel in the control room. The NetCon control system uses fuel flow for ratio control purposes within the EPA accuracy limits of five percent. Fuel flow totalization and heat rate calculations are included. Water flowmeters are included for each engine and are located on the skid. Water flow is also totalized in the NetCon.

The system automatically air purges the fuel nozzles of water in the engine at each shutdown. An instrument air supply is provided to the skid to operate the control valves and to the engine base for nozzle air purging purposes.

The engine interface consists of an ESI-patented water and fuel mixing block and necessary piping to accept the interface check valve and mixer. The mixer passes water into the liquid fuel manifold when operating on gas fuel.

Water injection is turned on during the start sequence at minimum power, and it is turned off at minimum power during the stop sequence. Megawatt output can be varied from minimum power to full load while maintaining the appropriate water to fuel ratio. The required water to fuel ratio is different for each fuel and it is automatically controlled by the DCS. Flameout detection monitoring, automatic EGT spread detection, and automatic load limiting are also provided in the DCS. The inlet fogging option is automatically sequenced on if provided.

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BILL OF MATERIAL

Two (2) FT4C-1 TWINPAC Generating Units

Each remanufactured Model FT4C-1 TWINPAC Generating Unit includes the following equipment:

1. COMBUSTION TURBINE PACKAGE

- a) Two (2) weatherproof, prime painted steel enclosures, each including:
 - (1) Inlet Air Silencer, Two-Stage Filter
 - (2) New Exhaust Stack with Sound Suppression Treatment
 - (3) Fire Protection system
 - (4) Ventilation System
 - (5) Low Voltage Heaters
 - (6) AC and Emergency DC lighting system
- b) Two (2) P&WA Model FT4C-1 industrial combustion turbines including:
 - (1) Operating Controls
 - (2) Lubricating System
 - (3) Fuel Control and Fuel System, including Booster Pump and Filter
 - (4) Starting Turbine
 - (5) Ignition System
 - (6) Automatic Anti-Icing System
 - (7) Flexible Coupling
 - (8) Mounts and Base
- c) Pratt & Whitney Free (Power) Turbine

2. GENERATOR – EXCITER PACKAGE

- a) Weatherproof, acoustically-insulated, prime painted steel enclosure including:
 - (1) Sound Treated Air Inlet and Exhaust
 - (2) Two (2) Side Mounted Filters
- b) One (1) Synchronous Generator, 57,300 KVA; (base rated at 80 F. and 1,000 feet), 0.9 power factor, 60 Hz, 3 phase, 13,800 volts, 2 pole, 3600 RPM, open, air-cooled, two (2) sleeve bearing, bracket type, complete with the following accessories:
 - (1) A 300 VDC direct-connected brushless exciter.
 - (2) One (1) completely assembled generator lubrication system module; consisting of one (1) AC motor driven oil pump, one (1) DC motor driven oil pump for start up, shut-down and emergency use, three (3) oil pressure switches, one (1) AC motor driven cooling fan, two (2) oil level switches, one (1) 250 gallon oil tank, one (1) vapor extractor fan.
 - (3) One (1) neutral grounding transformer 25 KVA.
 - (4) One (1) Bus Duct, 15 KV, 95 BIL, 3000 amp. Enclosed bus suitable for throat connection at each end, including terminations and support structures.

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3. CONTROL AND SWITCHGEAR PACKAGE

One (1) Pre-fabricated metal control enclosure, NEMA 3 design, prime painted steel, capable of withstanding the following loads: 100 MPH steady, 120 MPH gust wind loads (40 PSF) and 30 PSF snow and/or ice loads.

The enclosure will include electric heating and air conditioning with thermostatic control to maintain an inside ambient temperature of 70 F. The enclosure will also include fluorescent lighting, 125 volt D.C. emergency lighting, and 110 VAC receptacles.

The control enclosure will house the following equipment:

- a) One (1) Generator Control Panel – Panel #1, 46”W x 90”H free standing, NEMA construction, hinged for access to interior components with sufficient strip heaters (480 VAC) to preclude condensation and interior lights with switch. The panel will be primed and finish painted.
- b) One (1) Breaker Panel – Panel #2, 46”W x 90”H free standing NEMA construction, hinged for access to interior components, with sufficient strip heaters (480 VAC) to preclude condensation. Interior lights will be provided with switch. The panel will be primed and finish painted.
- c) One (1) Relay Panel – Panel #3, 46”W x 90”H free standing NEMA construction, hinged for access to interior components, with sufficient strip heaters (480 VAC) to preclude condensation. Interior lights will be provided with switch. Panel is also hinged for back access and provided with suitable structural support for rigidity. The panel is to be primed and finish painted.
- d) One (1) Motor Control Center, 600 V, NEMA 1, Class 11, Type C Construction; primed and finish painted.
- e) Auxiliary components consisting of the following:
 - (1) One (1) Station battery, 60 cell 125 VDC, 100 ampere-hour at eight (8) hour rate, C&D Model DCU-9 lead-calcium or equal with free standing battery rack in heated and ventilated compartment.
 - (2) One (1) set direct-burial, quick-connect cables for interconnections between gas turbine/generators and air start pack enclosure and the local control and switchgear enclosure.
 - (3) One (1) 150.0 KVA auxiliary Power transformer.

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4. ACCESSORY EQUIPMENT

- a) One (1) Air Start Pac with two (2) 15 HP motor driven air compressors and storage capacity for four (4) TWINPAC starts or eight (8) single engine starts housed in a painted steel enclosure for two (2) TWINPACs.
- b) External Winslow liquid fuel filter assembly for two (2) TWINPACs.
- c) One (1) 3" A.O. Scott fuel meter and one (1) 3" fire valve per TWINPAC.
- d) Standard engine water wash and drying systems.
- e) One (1) fiberglass tank (10,000 gallon) for storage of demineralized water for two (2) TWINPACs.
- f) Water injection system for NO_x control for two (2) TWINPACs.
- g) Bus from control house to transformer for two (2) TWINPACs.
- h) Remote panel
- i) Liquid fuel forwarding skid for two (2) TWINPACs.

5. CONSTRUCTION AND TRAINING SERVICES

- a) Erection, checkout, and startup
- b) Paint units.
- c) Operator and maintenance training.

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PERFORMANCE

1. RATING

The FT4C-1 TWINPAC is offered at a Base Load Rating of 108,000 KW output at the generator terminals, with corresponding estimated heat rates of 11,600 BTU/KW-HR (LHV).

These ratings assume a clean condition and operation at the Peak or Base Load levels respectively, with water injection at ambient air conditions of 59 F. temperature and 0 feet elevation (14.4 psia) with 3" H2O inlet and 1" H2O exit duct losses and when burning OF FREE WATER Aviation kerosene (Jet A) or other distillate Fuels, conforming to TPM FR-1 and FR-2 Specifications.

2. OUTPUT AT OFF-STANDARD CONDITIONS

Power outputs at other inlet air temperatures are shown on the enclosed Curve .

3. HEAT RATE

The Heat Rate at outputs and temperatures other than those quoted above will generally conform to the enclosed Curve.

4. AUTOMATIC START CYCLE

The TP4-2 TWINPAC will start on initiation of a starting signal from a local or remote control center, automatically sequence, and synchronize to the line in approximately 180 seconds from initiation of the start signal. It will then go to full load in five (5) minutes if the "normal" loading rate is selected or in approximately fifteen (15) to twenty (20) seconds if the "fast" loading rate is selected.

5. AUTOMATIC SHUTDOWN CYCLE

With the initiation of a stop signal, the governor will be energized and run to its minimum stop, unloading the generator and scheduling minimum fuel flow to the engines. The TWINPAC may be unloaded at the fast or normal rate. Upon reaching the no-load condition, the generator main breaker is automatically opened by a no-load sense relay. The engine is run at the minimum fuel setting for a five (5) minute cool-down period. Upon completion of the cool-down, the fuel is cut off, the engine shaft comes to rest within six (6) minutes, and the free turbine-generator shaft coasts to a stop within twenty (20) minutes. During the five-minute cool-down period, the unit may be either locally or remotely signaled to resynchronize and load by actuation of the start switch. Once the fuel cut-off stage has been reached, the engine must be allowed reach windmilling speed before restarting (this requires approximately one (1) minute).

CHARACTERISTICS AND PERFORMANCE

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1. GAS TURBINE

a) Characteristics (Preliminary)

(1) Engineering Data

Controlling Specification: P&WA No. 6382

Type:

A multi-stage reaction turbine driven by hot gases from an axial-flow generator, consisting of multi-stage compressors driven by multi-stage reaction turbines.

Model: FT4C-1

Number of Stages:

Gas Generator:

Low-Speed Compressor: 9

High-Speed Compressor 7

Low-Speed Turbine 2

High-Speed Turbine 1

Power Turbine 2

Principal Dimensions:

	<u>Gas Generator</u>	<u>Gas Turbine (over-all)</u>
Length, Inches	158	327.4
Width, Inches	42.5	76.3
Height, Inches	50.5	85.2
Weight, (Approx. lbs.)	6550	16,300
Direction of Rotation -	viewed from shaft end	CW/CCW

(2) Service Requirements

Fuel:

(a) Liquid Fuel Specification FR-1

* Delivery Rate – gph (Max. flow rate during acceleration only – Est.)	6930
Delivery Pressure at Gas Turbine, psig	5-50
Delivery Temperature at Gas Turbine Enclosure, F. Minimum	25

*Based on a natural gas fuel containing 950 BTU/SCF (LHV) (HHV/LHV 1.11)

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and delivered to the engine from Purchaser's supply system in a CLEAN and DRY condition (filtered to 30 Microns absolute).

**Cyclic pressure variations can be tolerated so long as total pressure excursion does not exceed ± 5 psi from average pressure supply.

*Based on a distillate fuel with a density of 6.9 lbs/gal. And a LHV of 18,200 BTU/lb. (HHV/LHV = 1.06), delivered to the engine from Purchaser's supply system in a CLEAN and VOID OF FREE WATER condition (below 5 microns solid particles and 0.01% water by volume).

Lube Oil:

(a) Gas Turbine

□ Specification	PWA 521
□ Total required for complete system fill, Gals. Per engine	45.6
□ Consumption gph (Avg.)	0.1

(b) Generator:

□ Specification – turbine oils similar to Mobile DTE-23 having a viscosity between 130 and 180 S.U.S. at 100 F. and a pour point below the expected ambient temperature.	
□ Total required for complete system fill gals., Per generator	250
□ Consumption gph. Negligible	

Electrical:

Purpose:

Lighting, Heating and
Intermittent Power

Quantity:

50 KW per engine, 440 volt,
60 Hz or 380 Volt-50 Hz,
3 phase

b) Performance:

At ambient air conditions of 59 F. Sea Level (14.4 psia) 3" H₂O inlet and 1" H₂O exhaust pressure losses with water injection. (Two TWINPACs)

Utilization: Electric Generator Prime Mover

	<u>Reserve Peak</u>	<u>Peak</u>	<u>Base Load</u>
Net Output: KW			108,000
Estimated heat Rate: BTU/Net KWH. (LHV).			11,600

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2. GENERATOR-EXCITER-REGULATOR

Manufacturer - Electric Machinery Mfg. Co.

a) Generator Data

Type – Synchronous, two-pole, turbogenerator, three-phase 50 Hz, air-cooled.

Nameplate Rating – (At ambient conditions of 80 F. and 1000 ft. elevation)

	<u>BASE</u>	<u>PEAK</u>
KVA	57,300	61,100
KW	51,600	55,000
Power Factor	0.90	0.90
Voltage	13,800	13,800
Current	2,390	2,570
Speed, RPM	3,000	3,000
Short Circuit Ratio	Greater than 0.5	

Characteristics

Total Temperatures (Not to exceed) -

	<u>BASE</u>	<u>PEAK</u>
Stator - by detectors	110	120
Rotor - by resistance	125	135

Total temperatures are based on continuous operation at nameplate rating.

Field Characteristics - (Base Rating)

	<u>Amperes</u>	<u>Volts</u>
No-load and at rate generator terminal voltage	210	85
Rated load and at rated generator terminal voltage	510	300

Reactances In percent values on generator nameplate (rating) approximate.

Synchronous	198%
Transient	26%
Subtransient	14%
Negative Sequence	14%
Zero Sequence	7.2%

Time Constants

Open Circuit	Time Constant	7.0 secs.
Armature	Time Constant	0.3 secs.

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Transient	Time Constant	0.6 secs.
Subtransient	Time Constant	0.035 secs.

Dielectric Test Voltages

Stator	Per ANSI Standards C50-1-14
Rotor	

Physical Data (Approximate)

Length (including base and exciter)	254"
Width (including base and exciter)	108"
Height (including base and exciter)	131"
Stator Weight	114,000 lbs.
Rotor Weight	33,700 lbs.
Overall Weight (including base and exciter)	154,000 lbs.
Rotor inertia (WK2) Lb-Ft ²	26,000
Space required to remove rotor	300"

Insulation System

Class:	Stator B
	Rotor B

Efficiency - (including windage, bearing and exciter losses)

Full load	98.0%
$\frac{3}{4}$ load	97.3%
$\frac{1}{2}$ load	96.6%
$\frac{1}{4}$ load	94.0%

Telephone Interference Factor - (Per ANSI Standard C50-1-16.2)

Balanced	70
Residual	50

Operating Voltage Variation

The generator will be capable of operating at rated KVA, power factor and frequency at any voltage ± 5 percent of the rated voltage although not necessarily with standard temperature rise.

Voltage Regulation -

With constant field current and with generator operating at rated voltage, rated speed and rated KVA load.

0.90 power factor	35%
1.00 power factor	25%

FT4 Equipment Description

Waveform Deviation

Open Circuit Terminal Voltage Wave - 10 percent (max).

Generator Short Circuit Requirements

The generator will be capable of withstanding, without injury, a 30 second, 3 phase short circuit at the terminals when operating at the highest capability KVA, rated power factor, and at 5 percent over-voltage. The generator will also be capable of withstanding, without injury, and other short circuit at its terminals of 30 seconds duration, or less, provided the machine phase currents under fault conditions are such that the negative phase sequence current (I_2), expressed and the duration of the fault in seconds (T), are limited to values which give an integrated product ($I_2/2T$) equal to, or less than, 30. Also, the maximum phase current shall be limited by means of suitable reactance or resistance to a value which does not exceed the maximum phase current obtained from the 3-phase fault.

b) Exciter Data

Type: Brushless

Nameplate Rating

KW	160
Voltage	300
Amps	510
Speed	3000 RPM

Insulation System

Class -	Armature	B
	Field	B

Total Temperatures

Field -	by Thermometer	140 C.
Armature -	by Thermometer	140 C.

Performance

Nominal ceiling voltage: 150 percent

(3) Voltage Regulator Data

Type: Static regulator with reactive current compensation circuit and maximum and minimum excitation limit circuits.

Performance

Regulation or sensitivity	$\pm 2\%$
Voltage adjustment range	$\pm 10\%$

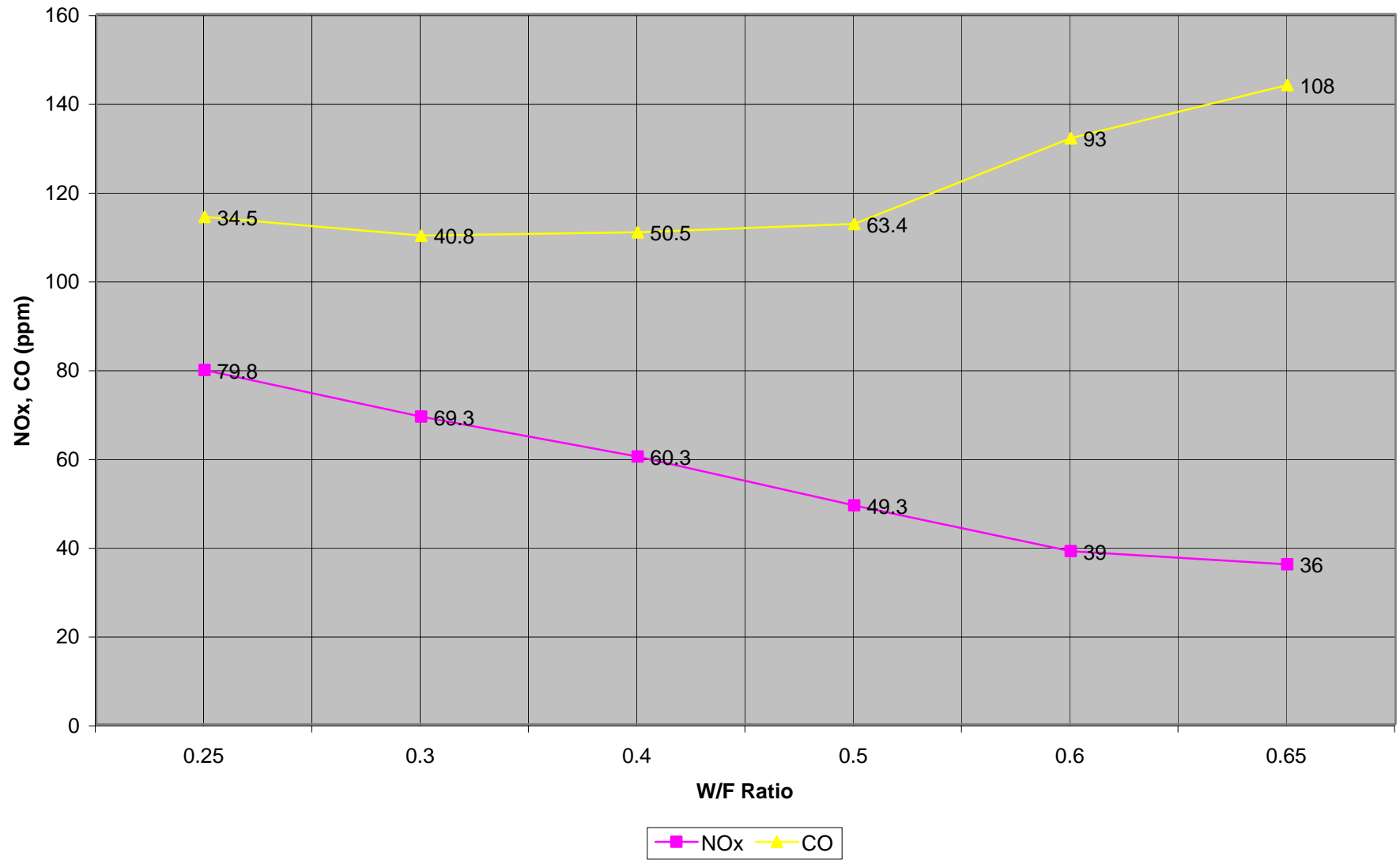
FT4 Equipment Description

d) Exciter-Regulator Performance

Speed of response - Better than 0.5 seconds

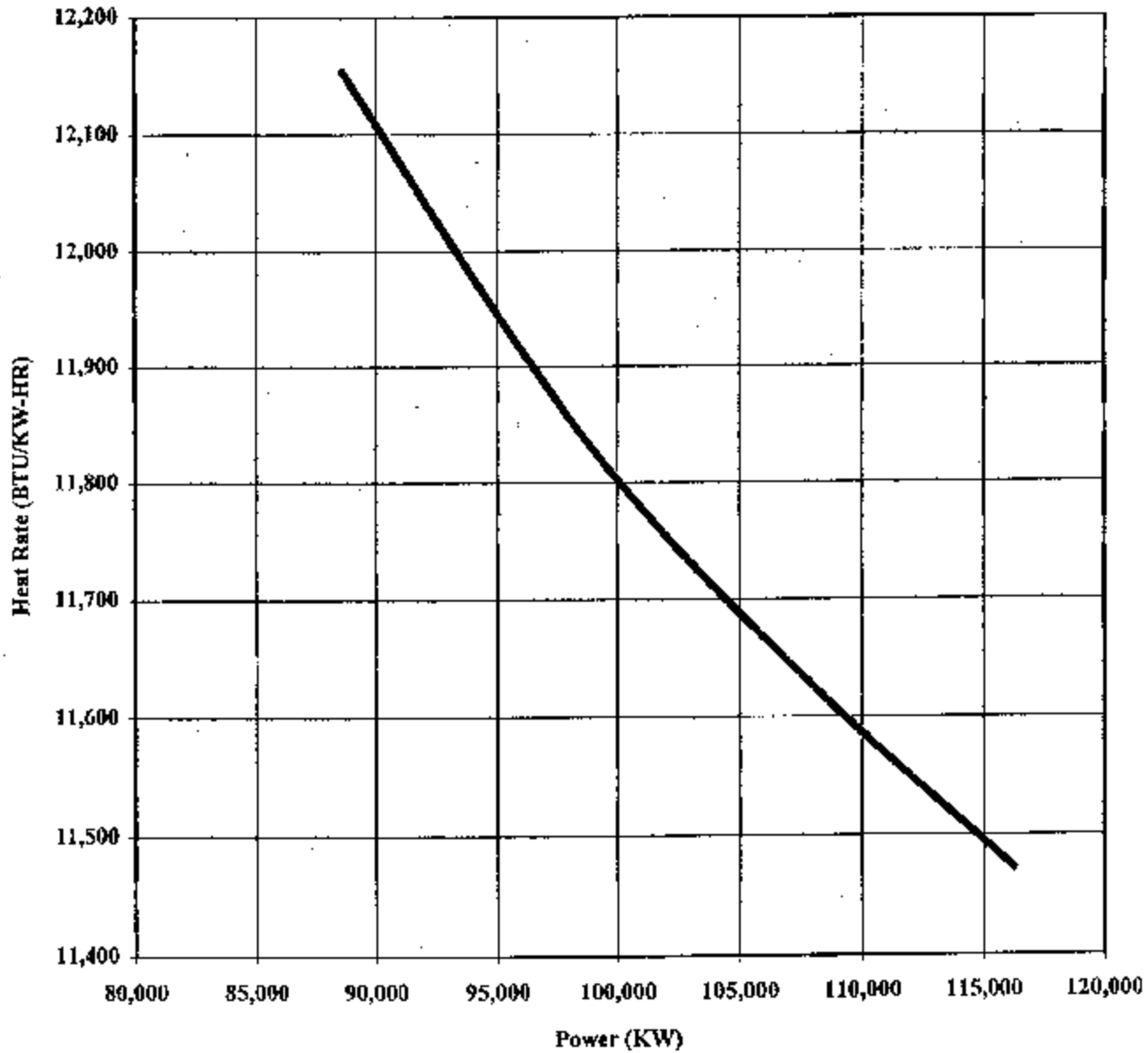
Short Circuit Sustaining Capability on a sustained three-phase fault – Greater than 150%

FT4C-1 Emissions Data





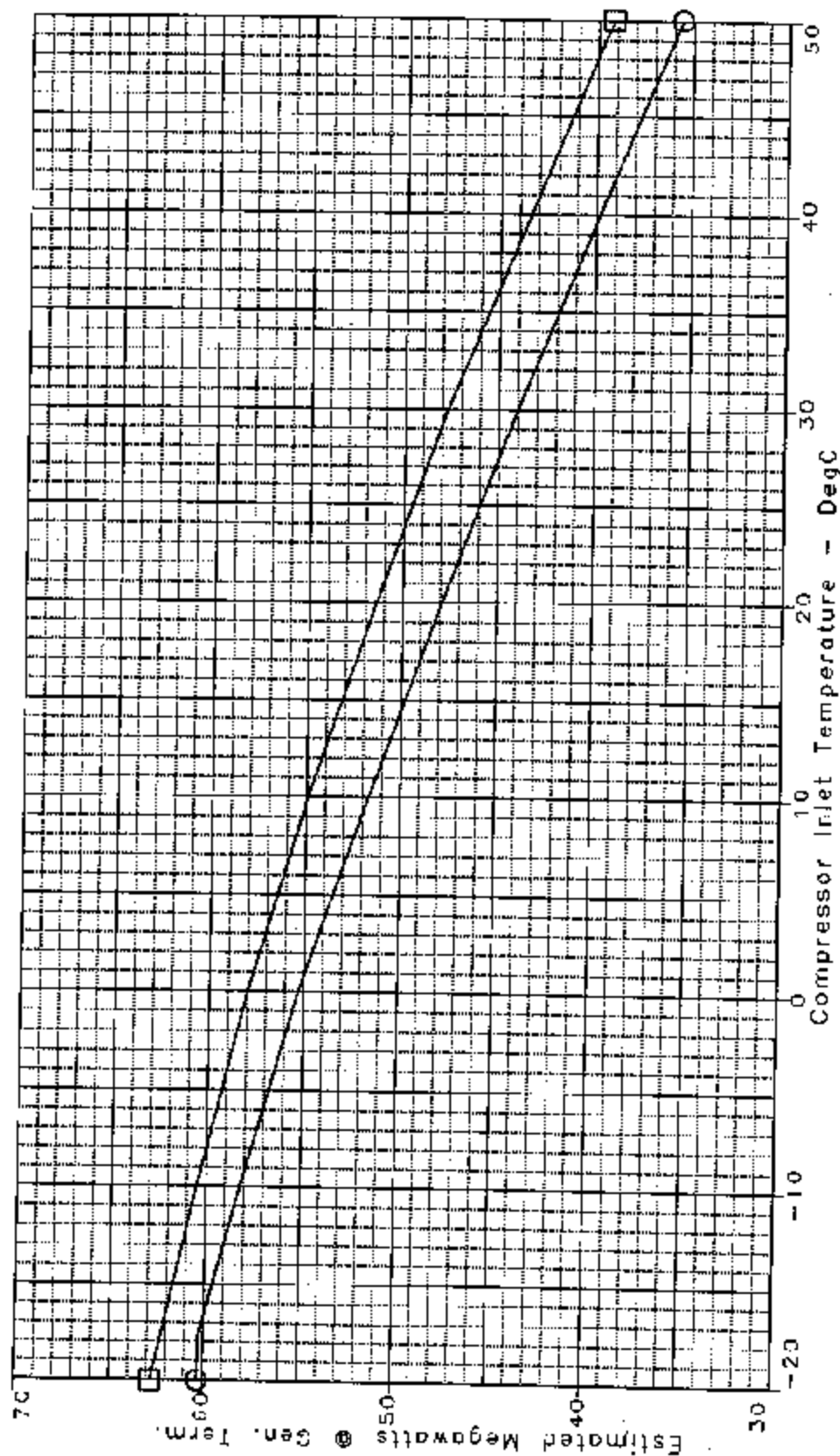
**Two FT4C-1 Twin Pacs
Estimated Performance
Heat Rate Vs. Power**

Altitude: 385' ASL
Relative Humidity: 60%
Installed Losses: 4" w.g. inlet & 1" w.g. exhaust
Water Injection to 75 ppm NOx
60 HZ



Turbo Power and Marine Systems, Inc.
 FT4C-1 Win Pac (New and Clean)
 Gross Megawatt Output vs. Compressor Inlet Temp.
 Sea Level, 50 Hz
 76.2 mm H₂O inlet & 25.4 mm H₂O exh. losses

1  Elect. Base
 2  Peak



08/03/96

Figure 1

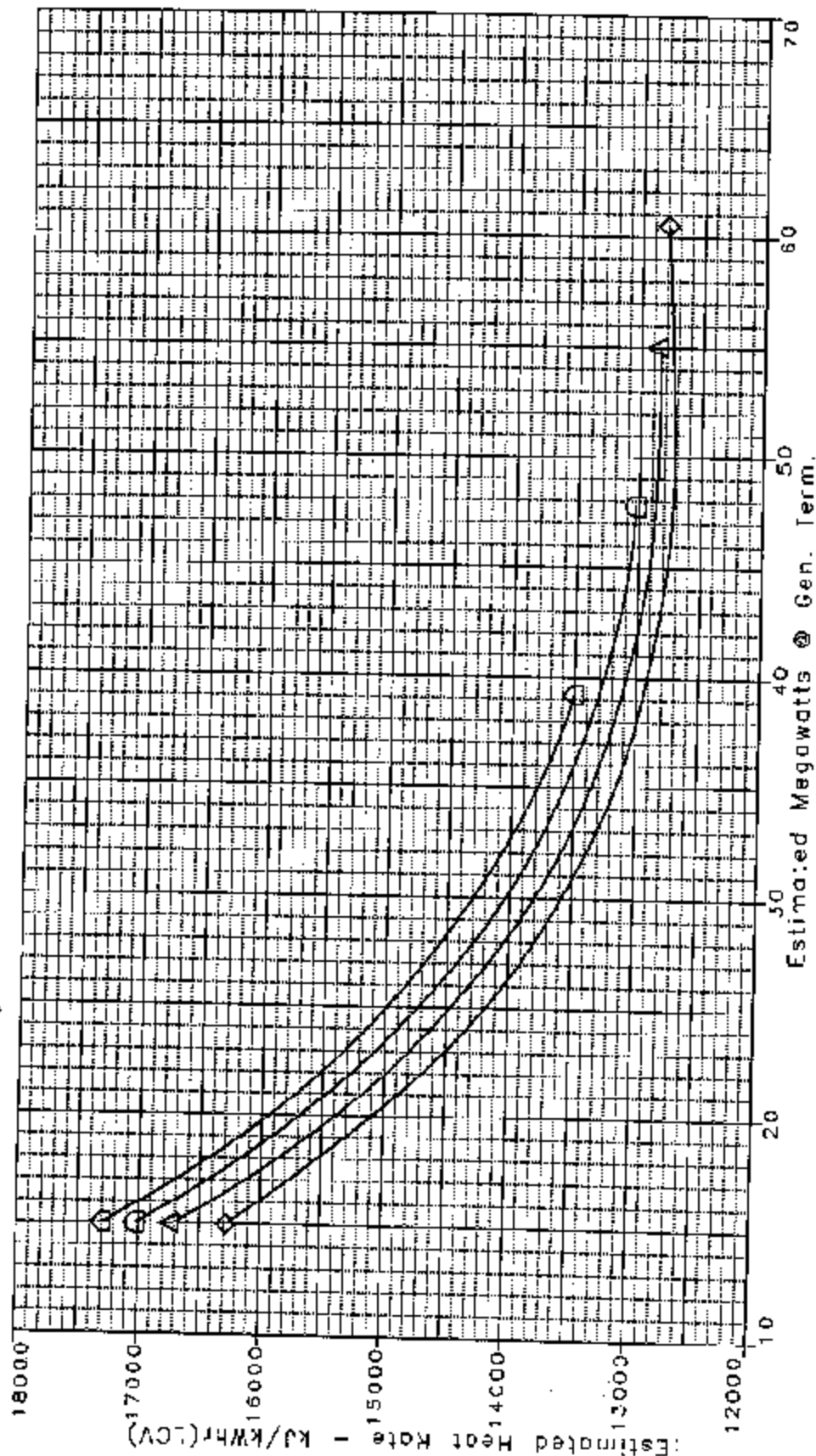
Turbo Power and Marine Systems, Inc.

FT4C-1 Twin Pac (New and Clean)

Est. Heat Rate vs. Megawatt Output

Sea Level, 50 Hz

3 8 8 CIT = 76.2 mm H2O inlet & 25.4 mm H2O exh. losses
 5 5 CIT = 50 Deg C 4 4 CIT = 10 Deg C 5 5 CIT = 30 Deg C



06/03/96

Figure 2