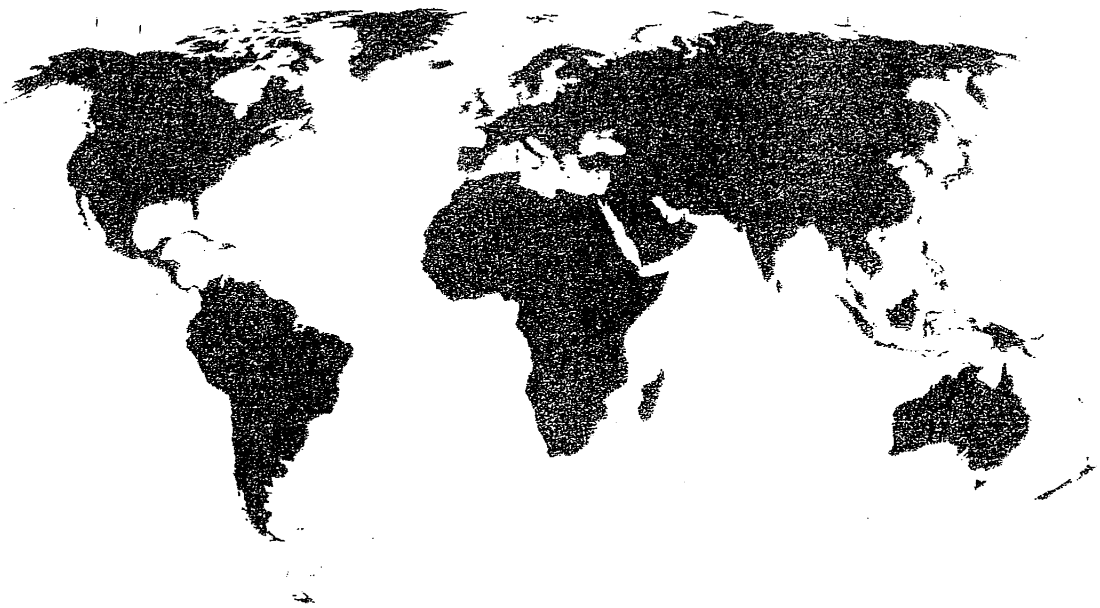
251B11/12 ECONOPAC APPLICATION HANDBOOK



WESTINGHOUSE
Power Generation Projects Division
PGBU 6967

Introduction

The 251B11/12 ECONOPAC™, nominally rated at 50 MW, is a self-contained, electric power generating system. The combustion turbine packaged plant is used in either simple cycle or heat recovery applications. The development of this package stems from the requirements for a low first cost, rapid on-line generation system, to be used in intermittent-peaking operation or continuous service as desired. Heat recovery applications include those for repowering, combined cycle, and cogeneration.

The 251B11/12 ECONOPAC incorporates a main gear between the combustion turbine and generator. The gear ratio varies with 50- and 60-Hz applications, but the combustion turbine itself remains the same. The 251B11 ECONOPAC is for 50-Hz applications, while the 251B12 ECONOPAC is for 60-Hz applications.

The design of the ECONOPAC has evolved from 45 years experience in combustion turbine technology, including hundreds of packaged power plant applications. From this background and from a sensitivity to the changing needs of our users, Westinghouse has developed a responsive design philosophy. Westinghouse can supply all equipment and coordination necessary for an operable power generation plant that will meet your requirements worldwide.

Plant Description

THE ECONOPAC SYSTEM

The 251B11/12 ECONOPAC provided by Westinghouse is designed and engineered to provide the user with a complete generating system. All components and subsystems are carefully selected and optimized to form a compact plant, housed within enclosures, designed to comply with environmental requirements as well as showing Westinghouse's increasing concern for aesthetics.

The 251B11/12 ECONOPAC system features modular construction to facilitate shipment and assembly. The system is pre-assembled to the maximum extent permitted by shipping limitations. Where possible, subsystems are grouped and installed in auxiliary packages to minimize field assembly. These packages are completely assembled and wired at the factory and require only interconnection at the site.

Descriptions in this Handbook primarily refer to the 60-Hz 251B12 ECONOPAC with an open air-cooled generator. However, data is also provided for the 50-Hz 251B11 ECONOPAC, and for totally enclosed water-air cooled (TEWAC) generators. The 251B11 ECONOPAC arrangement is essentially the same as the 251B12 arrangement.

The basic bill of material for each ECONOPAC system contains the following equipment and assemblies:

Combustion Turbine on Bedplate Assembly

- Generator
- Exciter
- Auxiliaries:

  Starting Package

Inlet System

Exhaust System

Electrical/Control Package

Compressor Water Wash System

Gas Fuel System

Cooler Assemblies

Distillate Fuel System - Optional

NOx Injection System (Water or Steam) - Optional

Generator Switchgear

Medium Voltage Motor Starter

Fire Protection System

Non-segregated Phase Bus (Optional)

MAJOR PLANT EQUIPMENT SUMMARY

Combustion Turbine on Bedplate Assembly

The combustion turbine, the main reduction gear, and the integral lubrication system are assembled on a single bedplate.

Recognized as the heart of the ECONOPAC plant, the combustion turbine consists of three basic elements: axial-flow compressor, combustion system and power turbine. Incorporated into the design are such features as a horizontally split sectionalized casing, two-bearing support, turbine air cooling system, compensating alignment system, and axial-flow exhaust.

The combustion turbine drives from the cold compressor-end, with the turbine coupled to the generator through the horizontally offset main reduction gear. The main reduction gear comprises a double-helical gear and pinion.

The integral lubrication system provides lubricating oil to the combustion turbine, generator, and reduction gear. The oil reservoir is an integral part of the turbine bedplate, with many of the system components preassembled on the bedplate assembly.

Generator and Exciter

The air-cooled generator and brushless exciter are equipped with integral lube oil and cooler piping, and necessary instrumentation. A solid coupling connects the generator directly to the main reduction gear. Open air-cooled and totally enclosed water-air cooled (TEWAC) generators are available.

Starting Package

The electric motor starting package is a self-contained assembly, premounted on a bedplate and shipped as a complete module. The package contains all the equipment necessary to provide torque for acceleration to self-sustaining speed, and a disconnect means to allow disengagement of the starting device once the unit reaches self-sustaining speed. During cool-down periods, a turning gear provides for a slow roll of the combined turbine and generator.

Inlet Air Filtration

The inlet air filtration system is a static system comprised of weather hoods, a disposable pre-filter, and a high efficiency final filter. The weather hoods and trash screen offer weather protection and prevent large debris from entering the filter housing. The two stages of filtration remove both large particles and fine particulates from the air stream. Other filter systems, such as self-cleaning, are available as options.

Inlet Air System

A side inlet air duct directs filtered air into the compressor inlet manifold. The manifold is designed to provide an efficient flow pattern into the axial-flow compressor. A parallel baffle silencing configuration is located in the inlet system for sound attenuation.

Exhaust System

After expanding through the combustion turbine, the gases pass through the exhaust manifold and exhaust transition. For simple cycle applications, the exhaust gases enter the atmosphere through the exhaust stack. For heat recovery applications, the gases are directed to the heat recovery steam generator.

Electrical/Control Package

The electrical/control package contains equipment necessary for sequencing, control and monitoring of the turbine and generator. This includes the Powerlogic II control system, motor control centers, generator protective relay panels, voltage regulator, pressure switch and gauge cabinet, fire protection control system, redundant air conditioners, battery and battery charger. The batteries are in an isolated section of the package and are readily accessible from the outside.

Compressor Wash System

The compressor wash system is provided for both on-line and off-line compressor cleaning.

Gas Fuel System

This system includes all equipment, valves, piping, and instrumentation required to control the flow of gas fuel into the combustors. All components of the gas fuel system are located on a skid adjacent to the turbine enclosure.

Distillate Fuel System

This system includes all equipment, valves, piping, and instrumentation required to control the flow of distillate fuel into the combustors. Most components of the system are located on a skid adjacent to the combustion turbine enclosure, with the fuel control valve located inside the turbine enclosure.

Water Injection System

The water injection system is used to introduce water directly into combustors through the fuel nozzles for NOx control. The system includes all equipment, valves, piping, and instrumentation required to control the flow of water into the combustors.

Steam Injection System (Optional)

Steam injection is most often used in combined cycle applications. The steam injection system provides a controlled flow of steam to the combustor to maintain NOx emissions to a predetermined level. The steam is introduced into the fuel gas piping downstream of the fuel gas control valve. All of the system components are located on the fuel gas skid, adjacent to the turbine enclosure.

Cooler Assemblies

The lubricating oil cooler is an air-to-oil type using ambient air for cooling. This cooler is located near the combustion turbine enclosure, on a support structure. Shell-and-tube or plate-type heat exchangers are available as options, in lieu of the air-to-oil cooler.

The turbine rotor cooling air is drawn from the compressor discharge and flows through an external air-to-air cooler. The air-to-air cooler is mounted on top of the electrical/control package.

Generator Switchgear

The 13.8-kV, 60 Hz (11.5-kV, 50 Hz) generator metalclad switchgear is the weatherproof, outdoor, aisleless type with vertical cells, and it contains a vacuum breaker. Included is generator surge protection with potential and current transformers. A 3000-A breaker is available for the 251B12, while a 4000-A breaker is available for the 251B11.

Medium Voltage Motor Starter

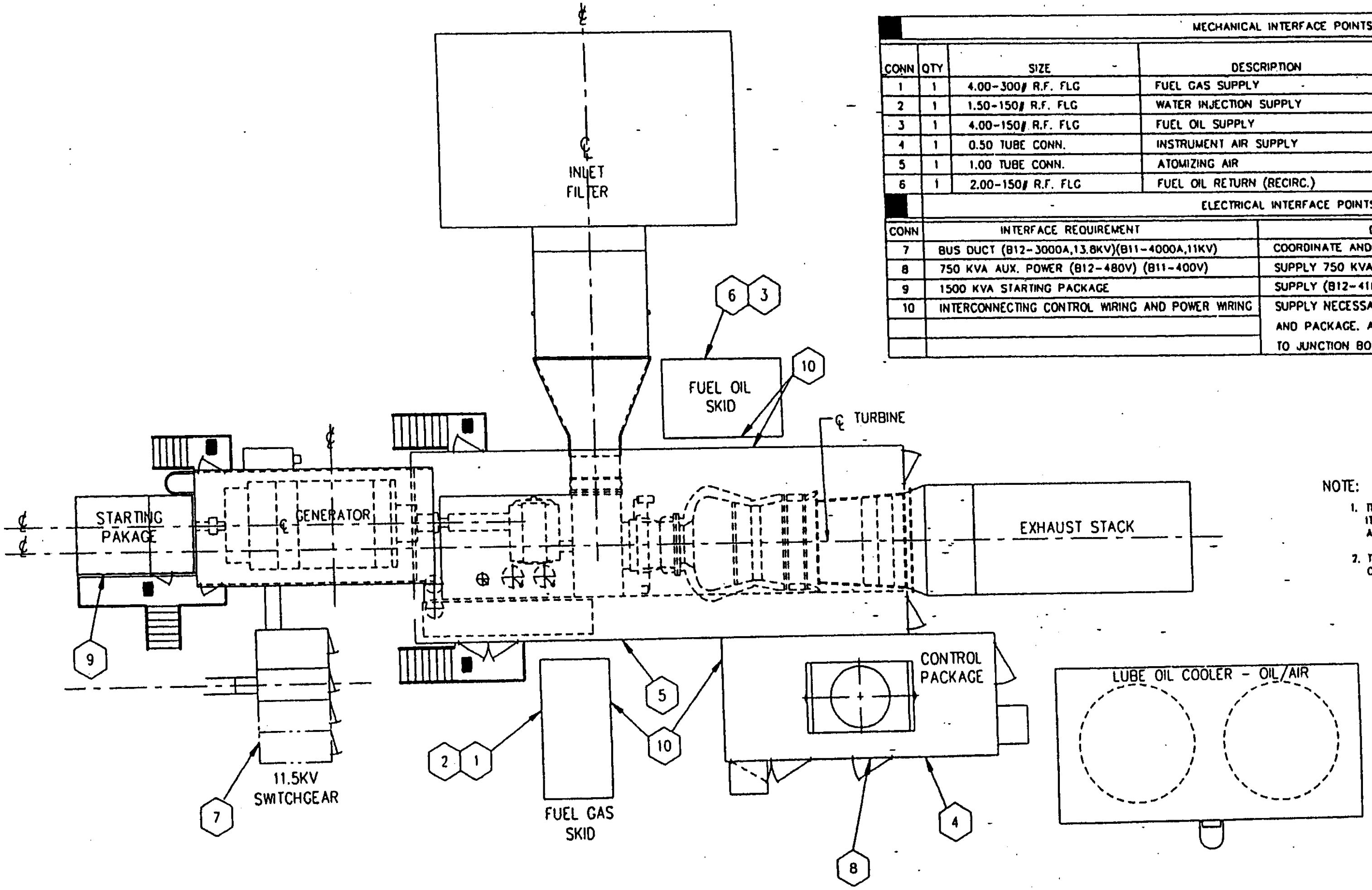
The fused motor-starter controls the power to the single-speed, (4.16 kV, 60 Hz; 3.3 kV, 50 Hz) squirrel-cage induction motor used to start the combustion turbine. The starter is a metal-enclosed unit incorporating 3-pole heavy duty 400-A rated vacuum contactor of drawout construction suitable for continuous operation.

FIRE PROTECTION SYSTEM

The fire protection system gives visual indication of actuation at the local control panel located in the electrical/control package. Two subsystems are used:

1. A low pressure Halon substitute (FM 200) fire protection system for the turbine enclosure and the electrical/control package. Thermal detectors are provided in the enclosures. A fire in any area initiates the fire protection systems in that area only and shuts down the unit.

2. An automatically actuated dry chemical type system for the exhaust bearing area of the turbine, consisting of temperature sensing devices, spray horns, dry chemical tank, and all interconnecting piping.



MECHANICAL INTERFACE POINTS

CONN	QTY	SIZE	DESCRIPTION	TYPICAL FLOW OR QTY	TYPICAL PRESSURE	TYPICAL TEMPERATURE
1	1	4.00-300# R.F. FLG	FUEL GAS SUPPLY	28,000 LB/HR	340 PSIG	40 - 120°F
2	1	1.50-150# R.F. FLG	WATER INJECTION SUPPLY	65 GPM	25-50 PSIG	60 - 100°F
3	1	4.00-150# R.F. FLG	FUEL OIL SUPPLY	100 GPM	25-50 PSIG	150°F (MAX)
4	1	0.50 TUBE CONN.	INSTRUMENT AIR SUPPLY	15 SCFM	100 PSIG	-----
5	1	1.00 TUBE CONN.	ATOMIZING AIR	90 SCFM	250 PSIG	-----
6	1	2.00-150# R.F. FLG	FUEL OIL RETURN (RECIRC.)	10-100 GPM	25 PSIG	150°F

ELECTRICAL INTERFACE POINTS

CONN	INTERFACE REQUIREMENT	DESCRIPTION OF PURCHASER INTERFACE
7	BUS DUCT (B12-3000A,13.8KV)(B11-4000A,11KV)	COORDINATE AND SUPPLY BUS FROM GEN. BRK. TO STEPUP TFX.
8	750 KVA AUX. POWER (B12-480V) (B11-400V)	SUPPLY 750 KVA AT ELECTRICAL CONTROL PACKAGE JUNCTION BOX.
9	1500 KVA STARTING PACKAGE	SUPPLY (B12-4160V, B11-6.6KV) SOURCE AT STARTING PACKAGE
10	INTERCONNECTING CONTROL WIRING AND POWER WIRING	SUPPLY NECESSARY WIREWAYS, CABLES, AND CONDUITS BETWEEN SKIDS AND PACKAGE. ALL AUXILIARY SKIDS AND PACKAGES ARE PREWIRED TO JUNCTION BOXES.

NOTE:

1. THIS DRAWING IS INTENDED TO SHOW MAJOR CONNECTION POINTS. IT DOES NOT INCLUDE MANY MISCELLANEOUS CONNECTIONS, SUCH AS VENTS AND DRAINS.
2. THE INFORMATION SHOWN IS REPRESENTATIVE AND IS SUBJECT TO CHANGE AT WESTINGHOUSE'S DISCRETION.

PRELIMINARY

251B11/12 ECONOPAC APPLICATION HANDBOOK	
PROPRIETARY INFORMATION	Westinghouse Electric Corporation Power Generation Projects Division
DATE 2/24/95 DRAFTER ACG ENGINEER C.BROWN APPROVED BY	TYPICAL PURCHASER INTERFACE POINTS 251B12 ECONOPAC
CUST NO. 94590	Drawing No. G2610101 ISSUE 01 Page of

Equipment Typical Technical Data Sheets

COMBUSTION TURBINE

Compressor

Type	Axial Flow
Number of Stages	19
Transonic Stage	No
Rotor Speed	5427 rpm
Compression Ratio	15:1
Material of Rotor	NiCrMoV
Blade Material	AISI 630/AISI 403
Material of Stator Blading	AISI 403
Disc Materials	Stages 1-11, 4340 Alloy Steel Stages 12-19, Cr-Co Alloy Steel
Coating on Stationary Blades	Sermetel 5380 DP

Compressor Inlet Guide Vanes

Type	Variable Angle
Variable IGV Drivers	Pneumatic
Material	AISI 630/AISI 403

Combustion System

Combustor Type	Can-Annular
Number of Combustors	8
Number of Fuel Nozzle	1 per Combustor
Type of Ignitors	Spark Plug (Capacitive Discharge)
Total Number of Ignitors	2
Combustor Materials	
Liner	Hastelloy X
Transition	INCO 617/Hastelloy X
Nozzle	INCONEL 625/Stainless Steel

	Number and Type of Flame Detectors	2 - UV Detectors
	Description of Nozzle	For Liquid Fuels: Pressure-Atomizing System For Gaseous Fuels: Orifice Jets
Turbine		
	Number of Stages	3
	Bearings Type	
	Radial	Tilting Pad (4 Pads)
	Thrust	Tilting Pad, Double Acting Kingsbury
	Quantity	
	Radial	2
	Thrust	1 (Double Acting)
	Material	
	Casing	Low Carbon Steel
	Discs	NiCrMoV Alloy Steel
	1st Blades	INCO 738 LC Cast
	2nd Blades	INCO 738 LC Cast
	3rd Blades	UDIMET 520 Forged
	Vanes	ECY 768/X-45
	Coatings	
	Vanes	R1 - MCrAly Base with Thermal Barrier Coating R2 - Sermaloy J R3 - None
	Blades	R1 - Sermaloy J R2 - Sermaloy J R3 - Sermaloy J (optional)

Thermal Performance

Thermal Performance

INTRODUCTION

This section provides the user with a systematic method of determining the performance of a 251B11/12 ECONOPAC for specific site conditions. Five basic parameters are used to measure plant performance: power, heat rate, exhaust flow, exhaust temperature, and fuel flow. Conditions that directly affect performance are elevation, compressor inlet temperature, excess inlet and exhaust duct losses, water or steam injection, and part load operation. (Relative humidity has little affect on performance, and therefore, is not used in these performance corrections.)

Table 1 on the following page provides plant performance for a standard 251B11/12 ECONOPAC. Plant performance is presented on the basis of ISO (International Standards Organization) referenced conditions. ISO conditions are defined as 59°F ambient temperature, sea level (14.696 psia) and 60% relative humidity. Inlet and exhaust duct losses of 4.0 in-water and 4.0 in-water respectively have already been included in the ISO performance to compensate for typical inlet and exhaust duct systems[1]. Using correction factors, the effects of site conditions on plant performance can be estimated for a variety of operating configurations. (The Thermal Performance and Emission Tables in Tab 4 provide tabular information for a variety of site conditions.) Should more accurate performance be required please contact Westinghouse Electric Corporation.

Net power is the power at the generator terminals minus turbine auxiliary loads. In Table 1, net power and net heat rate are provided for a 251B11/12 ECONOPAC with an open-air cooled generator, and a totally enclosed water air cooled (TEWAC) generator, (for more detailed performance characteristics of these generators, see the Generator Performance Curves in Tab 6).

[1] 4.0 in-water is a typical loss for an exhaust system. See page 7 for a listing of optional inlet and exhaust system typical losses.

TABLE 1
251B11/12 ECONOPAC SYSTEM PERFORMANCE FOR ISO CONDITIONS

Conditions:

Sea level, 59°F ambient temperature, 60% relative humidity, generator pf=.85, baseload, no water or steam injection, 4.0 in-water inlet loss, 4.0 in-water exhaust loss.

Natural Gas Fuel[2]	
Net Power, kW	
Open-Air Cooled Generator	48,000
TEWAC[3] Generator	48,050
Heat Rate, Btu/kWh LHV (kJ/kWh LHV)	
Open-Air Cooled Generator	10,600 (11,185)
TEWAC Generator	10,590 (11,175)
Exhaust Flow, lb/hr (kg/hr)	1,373,800 (622,170)
Exhaust Temperature, °F (°C)	974 (523)
Fuel Flow, lb/hr (kg/hr)	24,280 (11,000)
No. 2 Distillate Oil[4]	
Net Power, kW	
Open-Air Cooled Generator	46,400
TEWAC Generator	46,450
Heat Rate, Btu/kWh LHV	
Open-Air Cooled Generator	10,750 (11,345)
TEWAC Generator	10,740 (11,335)
Exhaust Flow, lb/hr (kg/hr)	1,376,500 (623,410)
Exhaust Temperature, °F (°C)	975 (524)
Fuel Flow, lb/hr (kg/hr)	26,880 (12,170)

[2] Natural gas - 20,960 Btu/lb LHV.
[3] TEWAC = Totally Enclosed Water-to-Air Cooled.
[4] No. 2 distillate oil - 18,560 Btu/lb LHV.

The 251B11/12 ECONOPAC system performance in simple cycle (conventional combustor[5]) mode for specific site conditions is determined by using the matrix in Table 2a and equations in Table 2b. The correction factors are found in the corresponding curves provided (Figures 1 - 12). Tab "a" curves are in English units, Tab "b" are in Metric units. Likewise, the figure numbers are suffixed with an "a" for the curves using English units and a "b" for the curves in Metric units.

TABLE 2a
Matrix for Obtaining Corrections to ISO Performance
(For Simple Cycle Applications)

	Elevation Figure 1 (a or b)	Compressor Inlet Temp.[6] Figure 2 (a or b)	Excess Inlet Losses[7] Figure 3 (a or b)	Excess Exhaust Losses[7] Figure 4 (a or b)	Water or Steam Injection[8] Figures 6-9 (a or b)	Part Load[9] Figures 10-12 (a or b)
Power	P1	P2	P3	P4	P5	P6
Heat Rate	HR1=1.0	HR2	HR3	HR4	HR5	HR6[10]
Exhaust Flow	EF1	EF2	EF3	EF4=1.0	EF5	EF6
Exhaust Temp.	ET1=1.0	ET2	ET3	ET4	ET5	ET6

TABLE 2b
Correction Equations
(For Simple Cycle Applications)

Net Power =	ISO Power x P1 x P2 x P3 x P4 x P5 x P6
Net Heat Rate =	ISO Heat Rate x HR1 x HR2 x HR3 x HR4 x HR5 x HR6[10]
Exhaust Flow =	ISO Exhaust Flow x EF1 x EF2 x EF3 x EF4 x EF5 x EF6
Exhaust Temperature =	(ISO Exhaust Temp x ET1 x ET2 x ET5 x ET6) + ET3 + ET4
Fuel Flow =	Net Power x Net Heat Rate / LHV of Fuel

5 Refer to Tables 3a and 3b for simple cycle, part load operstion with dry low NOx combustors.

6 Evaporative cooling reduces the compressor inlet temperature and increases the relative humidity into the compressor. Figure 5 shows correction factors for evaporative cooling, and should be used to determine the effective compressor inlet temperature. Evaporative cooling causes an additional inlet loss of 0.5 in-water.

7 An inlet loss of 4.0 in-water and an exhaust loss of 4.0 in-water have already been calculated into the performance. Correct only for additional losses.

8 For Water/Fuel and Steam/Fuel ratios to meet specific NOx emission requirements refer to NOx Emission Control, Tab 3.

9 Part load operation is achieved with fuel reduction and inlet guide vanes fully open. P6 = % base load/100.

10 HR6 = FF6/P6 where FF6 is read from Figure 12.

The following example illustrates the correction and calculation procedure for a sample 251B11/12 ECONOPAC site. This sample calculation is for a simple cycle peaking plant (see part load corrections to ISO performance for heat recovery applications in Table 3 if applicable) and operates under the conditions below:

Example 1

Mode	Simple Cycle
Generator	Open-Air Cooled
Elevation	1000 ft.
Ambient Temperature	70°F
Relative Humidity	60%
Excess Inlet Loss	2.0 in water
Excess Exhaust Loss	4.0 in water
Injection	1.0 lb water/lb fuel
Load level	75%
Fuel	No. 2 Fuel Oil (18560 Btu/lb)
	No Evaporative Cooling

The following matrix shows the correction factors derived from Figures 1-12 for the above sample site conditions. Using these values and the correction equations from Table 2b, the net site performance can be calculated, as shown.

Matrix Showing Correction Factors for Sample Site

	Elevation Figure 1a	Compressor Inlet Temp. Figure 2a	Excess Inlet Losses Figure 3a	Excess Exhaust Losses Figure 4a	Water or Steam Injection Figures 5a-9a	Part Load Figures 10a-12a
Power	0.965	0.950	0.991	0.993	1.093	0.75
Heat Rate	1.0	1.02	1.003	1.006	1.027	1.080
Exhaust Flow	0.965	0.975	0.995	1.0	1.023	0.9965
Exhaust Temp.	1.0	1.005	+1.40°F	+2.80°F	1.003	0.85

Correction Equations for Sample Site

Net Power =	46,400 x 0.965 x 0.950 x 0.991 x 0.993 x 1.093 x 0.75 = 34,310 kW
Net Heat Rate =	10,750 x 1.0 x 1.02 x 1.003 x 1.006 x 1.027 x 1.080 = 12,270 Btu/kWh LHV
Exhaust Flow =	1,376,500 x 0.965 x 0.975 x 0.995 x 1.0 x 1.023 x 0.9965 = 1,313,660 lb/hr
Exhaust Temp. =	(975 x 1.0 x 1.005 x 1.003 x 0.85) + 1.4 + 2.8 = 840°F
Fuel Flow =	34,310 x 12,270/18,560 = 22,680 lb/hr

For heat recovery applications it is normally desirable to maintain a high turbine inlet temperature during part load operation to improve cycle efficiency. To accomplish this, the inlet guide vanes can be modulated during part load operation to limit mass flow through the combustion turbine and maintain constant turbine exhaust temperature. The correction matrix is the same as Table 2, except that part load correction factors are found in Figures 13 (a or b) and 14 (a or b). The correction equations below will yield net plant performance using variable inlet guide vanes for part load operation.

TABLE 3a
Matrix for Obtaining Corrections to ISO Performance
(For Heat Recovery Applications[11])

Performance Parameter	Elevation Figure 1 (a or b)	Compressor Inlet Temp.[12] Figure 2 (a or b)	Excess Inlet Losses[13] Figure 3 (a or b)	Excess Exhaust Losses[13] Figure 4 (a or b)	Water or Steam Injection[14] Figures 6-9 (a or b)	Part Load[15] Figures 13-14 (a or b)
Power	P1	P2	P3	P4	P5	P6
Heat Rate	HR1=1.0	HR2	HR3	HR4	HR5	HR6[16]
Exhaust Flow	EF1	EF2	EF3	EF4	EF5	EF6
Exhaust Temp.	ET1=1.0	ET2	ET3	ET4=1.0	ET5	ET6

TABLE 3b
Correction Equations
(Heat Recovery Applications)

Net Power = ISO Power x P1 x P2 x P3 x P4 x P5 x P6

Net Heat Rate = ISO Heat Rate x HR1 x HR2 x HR3 x HR4 x HR5 x HR6[16]

Exhaust Flow = ISO Exhaust Flow x EF1 x EF2 x EF3 x EF4 x EF5 x EF6

Exhaust Temperature = (ISO Exhaust Temp. x ET1 x ET2 x ET5 x ET6) + ET3 + ET4

Fuel Flow = Net Power x Net Heat Rate / LHV of Fuel

The following example illustrates the correction and calculation procedure for a sample 251B11/12 ECONOPAC site used in a heat recovery process, and operating under the conditions below:

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[11] These tables also apply to simple cycle application with dry low NOx combustors.

[12] Evaporative cooling reduces the compressor inlet temperature and increases the relative humidity into the compressor. Figure 5 shows correction factors for evaporative cooling, and should be used to determine the effective compressor inlet temperature. Evaporative cooling causes an additional inlet loss of 0.5 in-water.

[13] An inlet loss of 4.0 in-water and an exhaust loss of 4.0 in-water have already been calculated into the performance. Correct only for additional losses.

[14] For Water/Fuel and Steam/Fuel ratios to meet specific NOx emission requirements refer to NOx Emission Control, Tab 3.

[15] Part load operation is achieved with modulated inlet guide vanes to maintain constant turbine exhaust temperatue, P6 = % base load/100.

[16] HR6 = FF6/P6 where FF6 is read from Figure 14 (a or b).

Example 2

Mode	Heat Recovery, Base
Generator	Open Air Cooled
Elevation	500 ft.
Ambient Temperature	85°F
Relative Humidity	60%
Excess Inlet Loss	3.0 in-water
Excess Exhaust Loss	12.0 in-water
Injection	1.2 lb steam/lb fuel
Load Level	80%
Fuel	Natural Gas (20,960 Btu/lb LHV)

Evaporative Cooling Used.

The following matrix shows the correction factors derived from Figures 1a-9a and 13a-14a for the above sample site conditions. Using these values and the correction equations from Table 3b, the net site performance can be calculated, as shown. (Note: from Figure 5a, evaporative cooling lowers the effective inlet temperature from 85°F to 75°F).

Matrix Showing Correction Factors for Sample Site

	Elevation Figure 1a	Compressor Inlet Temp. Figure 2a	Excess Inlet Losses Figure 3a	Excess Exhaust Losses Figure 4a	Water or Steam Injection Figs. 6a-9a	Part Load[17] Figs. 13a-14a
Power	0.982	0.935	0.987	0.980	1.097	0.80
Heat Rate	1.0	1.025	1.005	1.020	.965	1.06[18]
Exhaust Flow	0.982	0.960	0.993	1.0	1.024	0.88
Exhaust Temp.	1.0	1.005	+2.1°F	+8.4°F	1.002	1.00

Correction Equations for Sample Site

Net Power =	48,000 x 0.982 x 0.935 x 0.987 x 0.980 x 1.097 x 0.80 = 37,411 kW
Net Heat Rate =	10,600 x 1.0 x 1.025 x 1.005 x 1.02 x .965 x 1.06 = 11,390 Btu/kWhr
Exhaust Flow =	1,373,800 x 0.982 x 0.960 x 0.993 x 1.0 x 1.024 x 0.88 = 1,158,870 lb/hr
Exhaust Temp. =	(974 x 1.0 x 1.005 x 1.002 x 1.00) + 2.1 + 8.4 = 991°F
Fuel Flow =	37,411 x 11,390/20,960 = 20,330 lb/hr

[17] For heat recovery applications, the inlet guide vanes are modulated to maintain constant turbine exhaust temperature.

[18] Part load heat rate is calcualted as FF6/P6, where FF6 is from Figure 14a.

TYPICAL INLET AND EXHAUST DUCT LOSSES

It is sometimes necessary to add additional equipment to the standard ECONOPAC that affects inlet and exhaust losses. Listed below are typical excess losses that can be used in calculating net plant performance. These losses shown are in addition to the base configuration with a 4.0 in-water inlet duct loss (two-stage pad inlet filter and standard silencing) and 4.0 in-water exhaust duct loss (30 ft. exhaust stack with standard silencing).

Optional Inlet Features[19]	Excess Losses (in-water)
Evaporative cooler	0.5
Trash screen and weather louvers	0.15
Inertial filter	0.10
Pulse-type filter	0.40
Demister - coalescer pad	0.15
Upgraded inlet silencer[20]	0.10

Optional Exhaust Features[19]	Excess Losses (in-water)
Upgraded exhaust silencer[20]	0.5
Heat recovery steam generator[21]	9.0

MAXIMUM POWER

The maximum allowable power output of a 251B11/12 ECONOPAC is 58.5 MW. This maximum is reached at low compressor inlet temperatures, and is dependent on NOx control injection rates. In simple cycle applications, the fuel flow is reduced as needed to prevent power output beyond the maximum. In heat recovery applications (or with dry low NOx combustors) the inlet guide vanes are modulated to prevent operation above maximum.

19 Equipment is assumed to be in clean condition; however, values may vary.

20 See Acoustics, Tab 7, for a further explanation of optional sound levels.

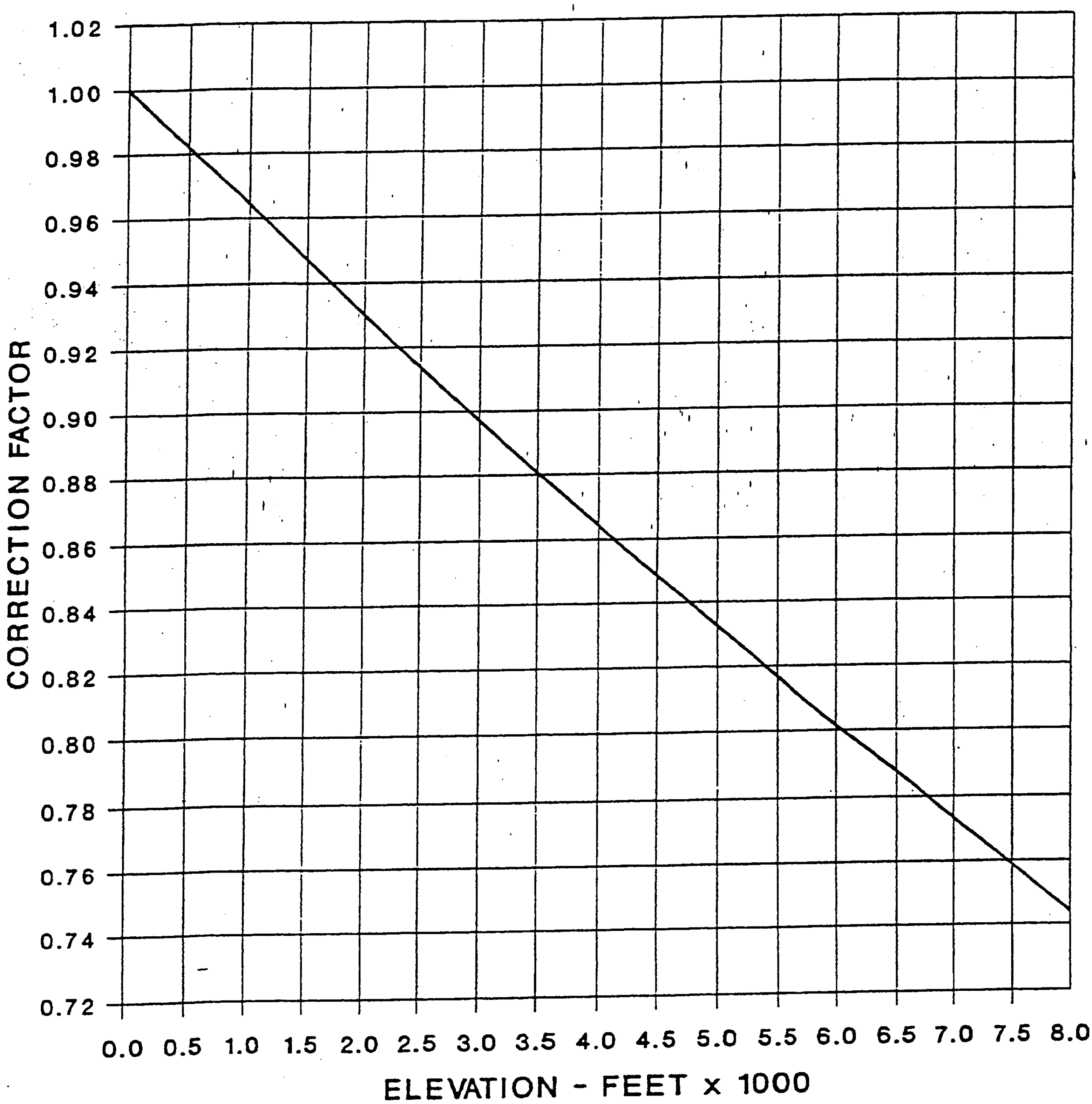
21 9.0 in-water loss for HRSG is a typical example, values may vary.

Correction Curves, English Units

251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR POWER & EXHAUST FLOW vs ELEVATION

FIGURE 1a



NOTE: ELEVATION HAS NO EFFECT ON HEAT RATE OR EXHAUST TEMPERATURE

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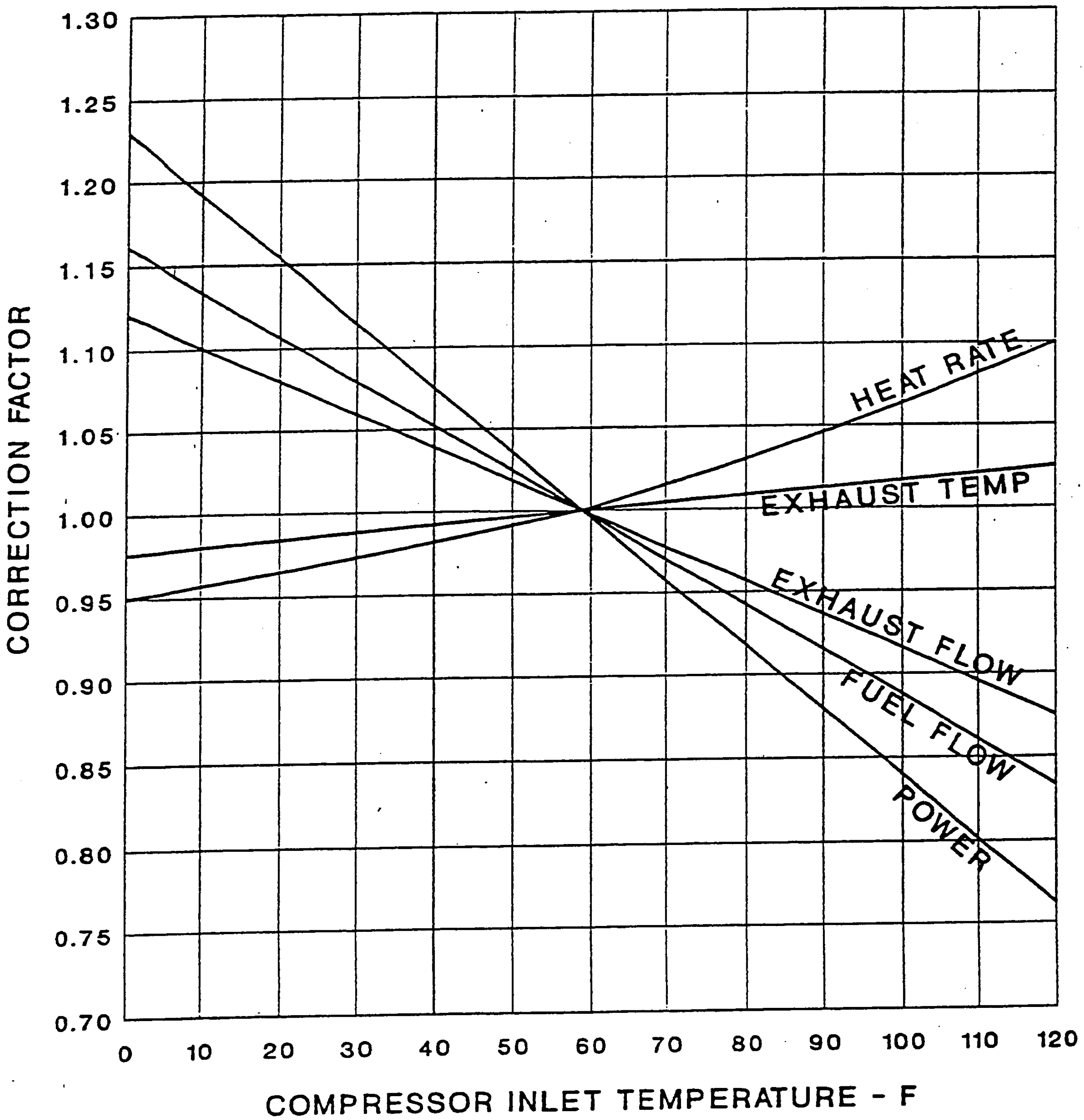
251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR POWER, HEAT RATE, FUEL FLOW, EXHAUST TEMP & FLOW vs COMPRESSOR INLET TEMPERATURE

FIGURE 2a



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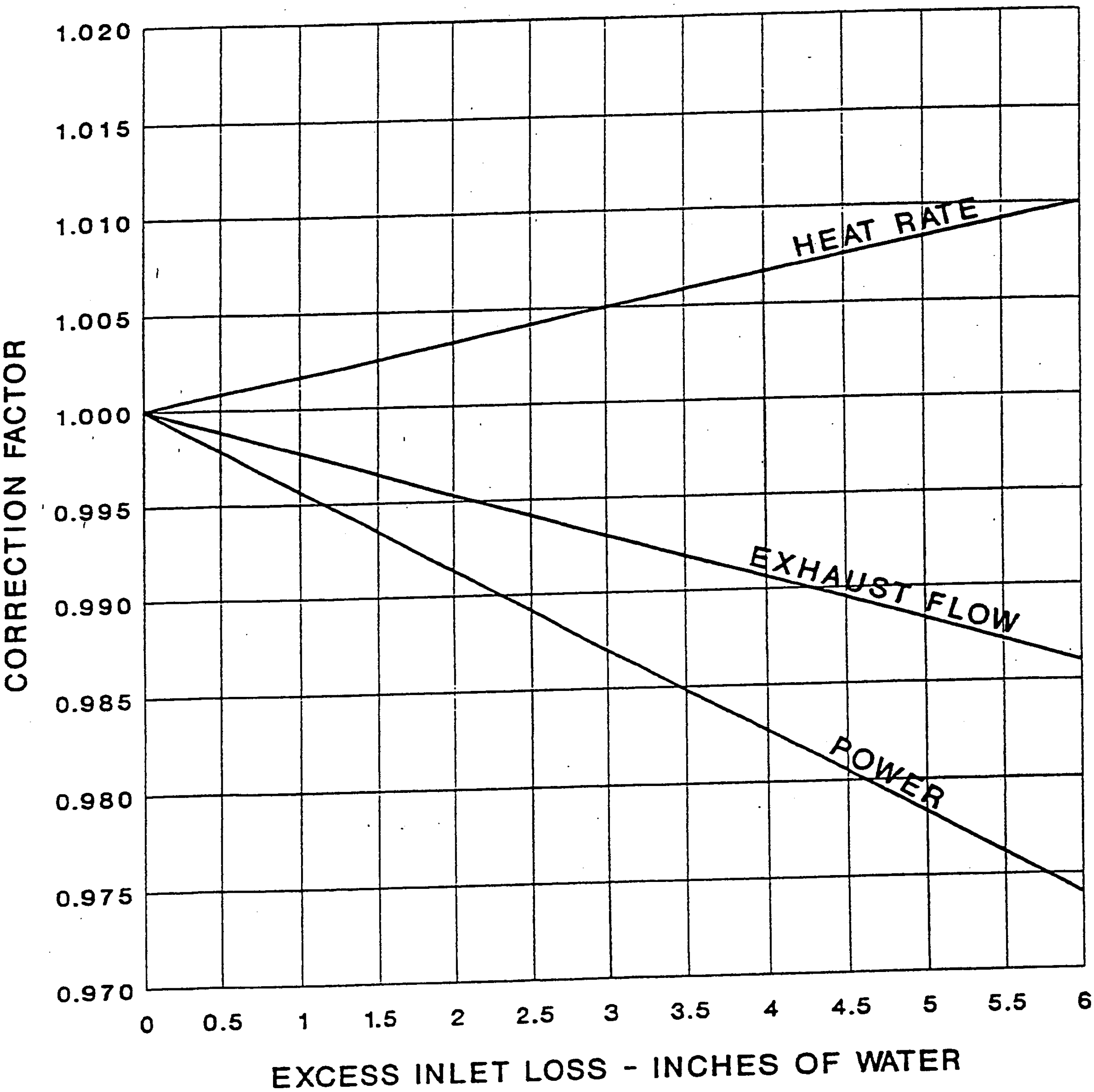
251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR POWER, HEAT RATE & EXHAUST FLOW vs EXCESS INLET LOSS.

FIGURE 3a



NOTE: FOR EVERY 10 INCHES OF WATER OF EXCESS INLET LOSS, ADD 7 deg F TO THE TURBINE EXHAUST TEMPERATURE

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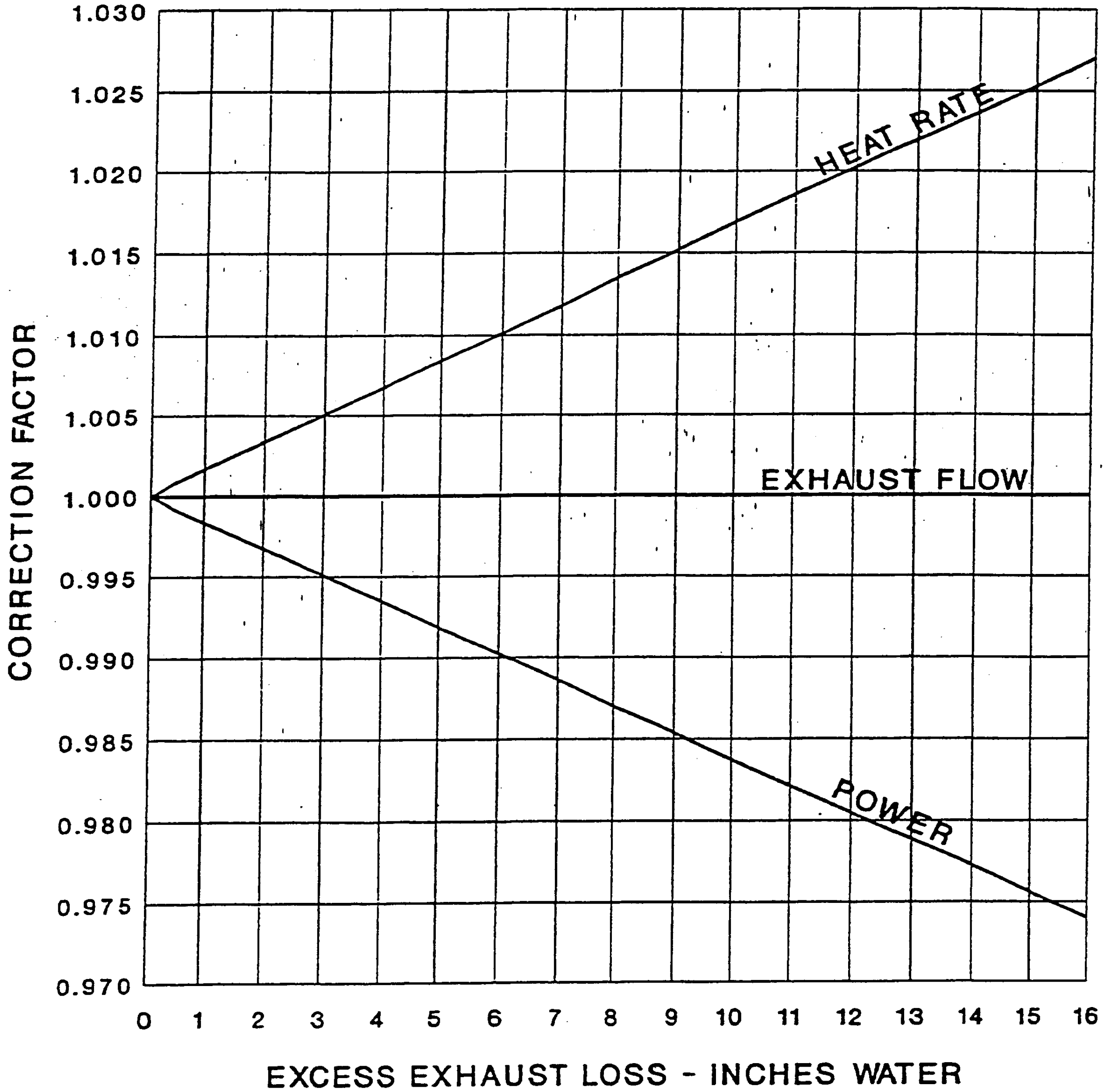
251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR POWER, HEAT RATE & EXHAUST FLOW vs EXCESS EXHAUST LOSS

FIGURE 4a



NOTE: FOR EVERY 10 INCHES OF WATER OF EXCESS EXHAUST LOSS, ADD 7 deg F TO THE TURBINE EXHAUST TEMPERATURE

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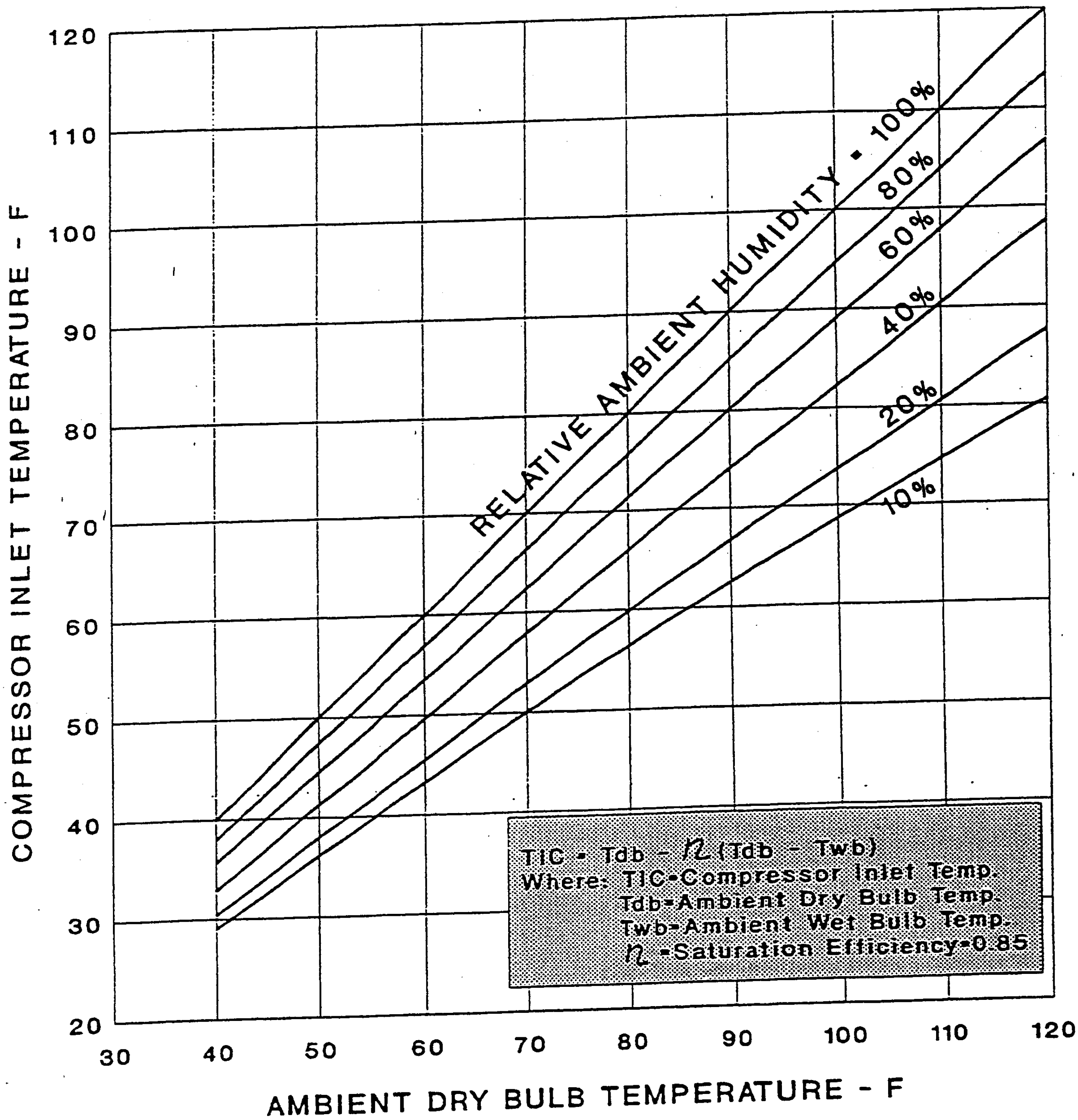
251B11/12 ECONOPAC PERFORMANCE
EVAPORATIVE COOLER EFFECT ON COMPRESSOR INLET TEMPERATURE

FIGURE 5a



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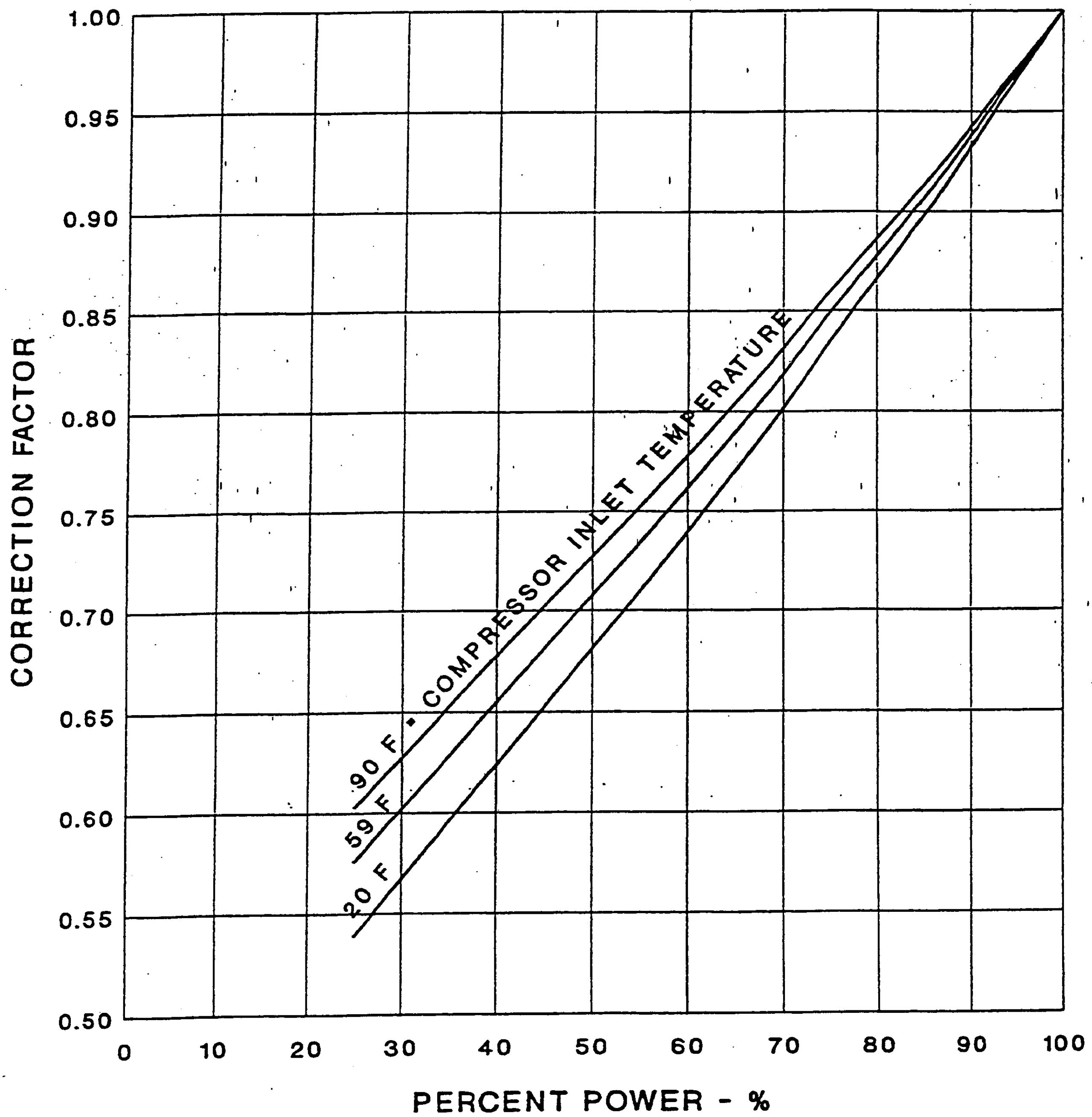
251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR EXHAUST TEMPERATURE (F) AT PART LOAD

FIGURE 10a



NOTE: INLET GUIDE VANES (IGV) WIDE OPEN

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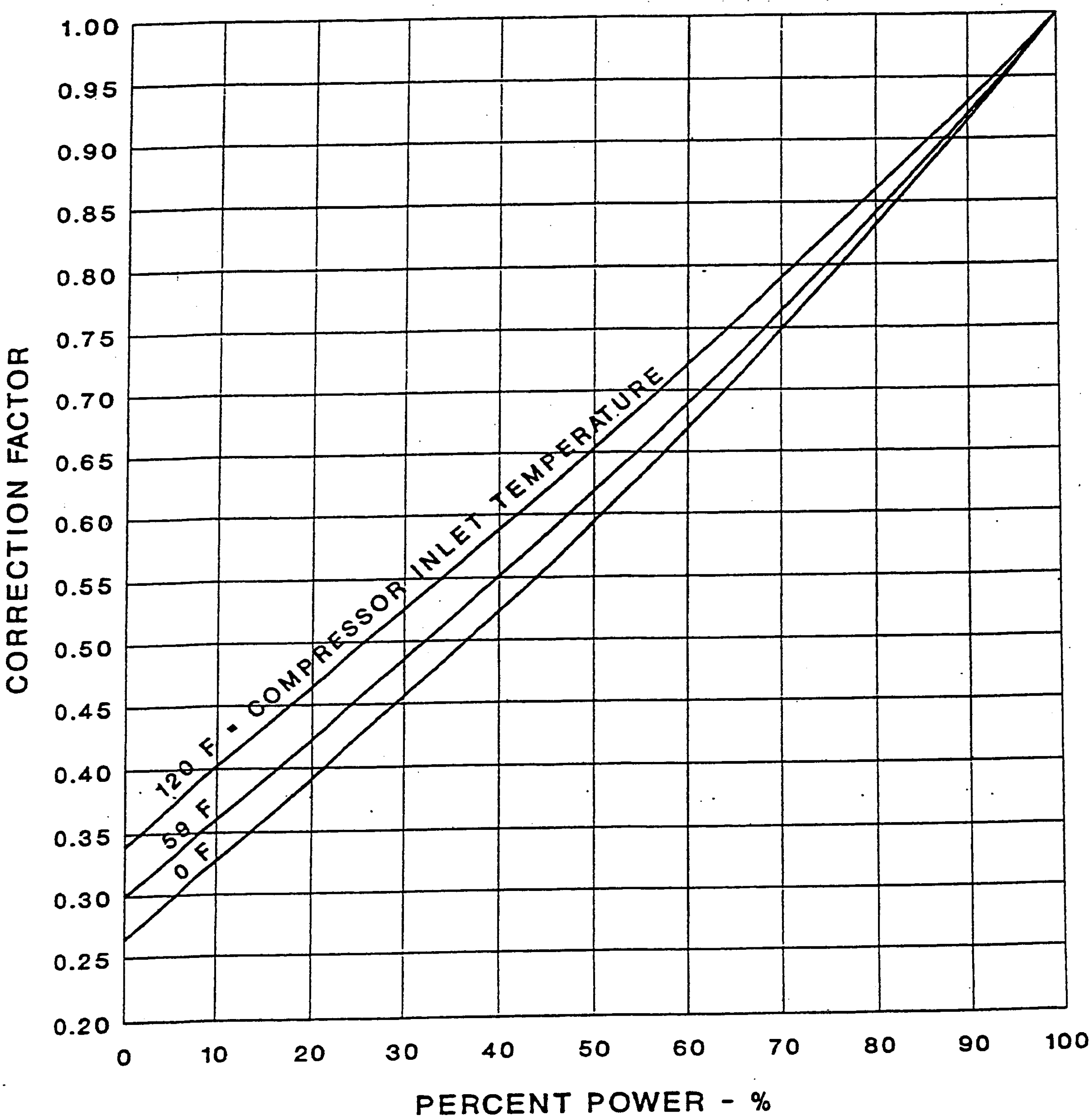
251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR FUEL FLOW (LB/HR) AT PART LOAD

FIGURE 12a



NOTE: INLET GUIDE VANES (IGV) WIDE OPEN

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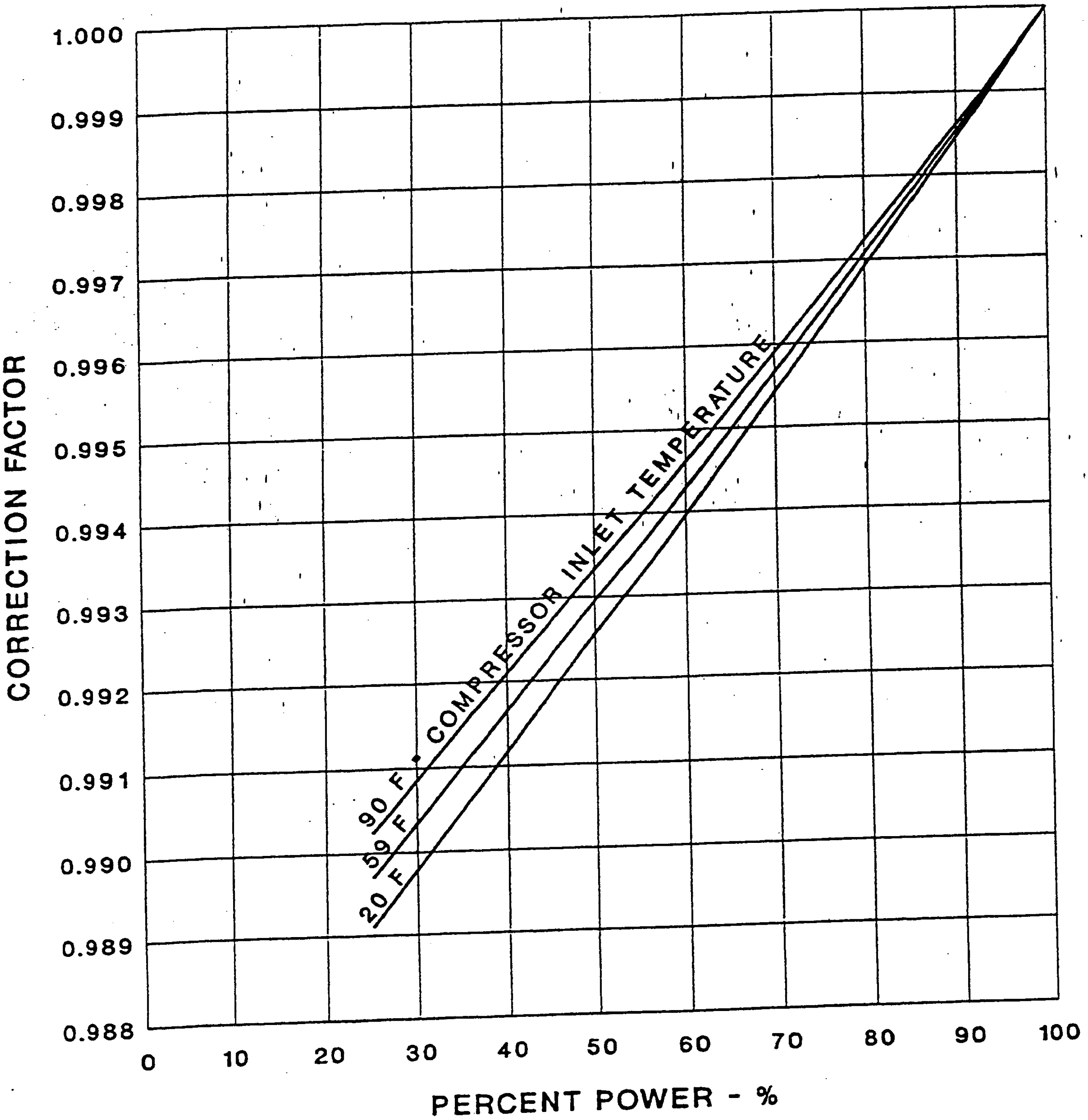
251B11/12 ECONOPAC PERFORMANCE

CORRECTION CURVE FOR EXHAUST FLOW (LB/HR) AT PART LOAD

FIGURE 11a



NOTE: INLET GUIDE VANES (IGV) WIDE OPEN

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NOx Emission Control

CONVENTIONAL COMBUSTOR

With the conventional combustor, Westinghouse offers NOx emission control using either water or steam injection. Water injection is typically used for simple-cycle applications. Steam injection is typically used in heat recovery applications due to its availability and effect on heat rate.

Using water injection, NOx emission rates as low as 25* ppmvd for natural gas and 42* ppmvd for No. 2 oil can be achieved for the 251B11/12. The water injection ratios required to meet these emission rates are 1.3 lb water/lb fuel for natural gas and 1.0 lb water/lb fuel for No. 2 fuel oil.

The same NOx emission rates can be reached using steam injection. A steam injection ratio of 1.85 lb steam/lb fuel is required to achieve 25* ppmvd for natural gas, while 1.84 is required to achieve 42* ppmvd for No. 2 fuel oil.

The effect of water and steam injection on NOx emissions is illustrated in the attached curves:

- Water/Fuel Ratio vs. NOx for Natural Gas
- Water/Fuel Ratio vs. NOx for No. 2 Fuel Oil
- Steam/Fuel Ratio vs. NOx for Natural Gas
- Steam/Fuel Ratio vs. NOx for No. 2 Fuel Oil

The water or steam to fuel ratios for the required NOx levels can then be determined for both natural gas and No. 2 oil fuels (the water or steam ratio can be used to correct the combustion turbine performance--see Thermal Performance in Tab 1).

For a tabulation of typical NOx and other stack emissions, refer to Thermal Performance and Emission Tables in Tab 4.

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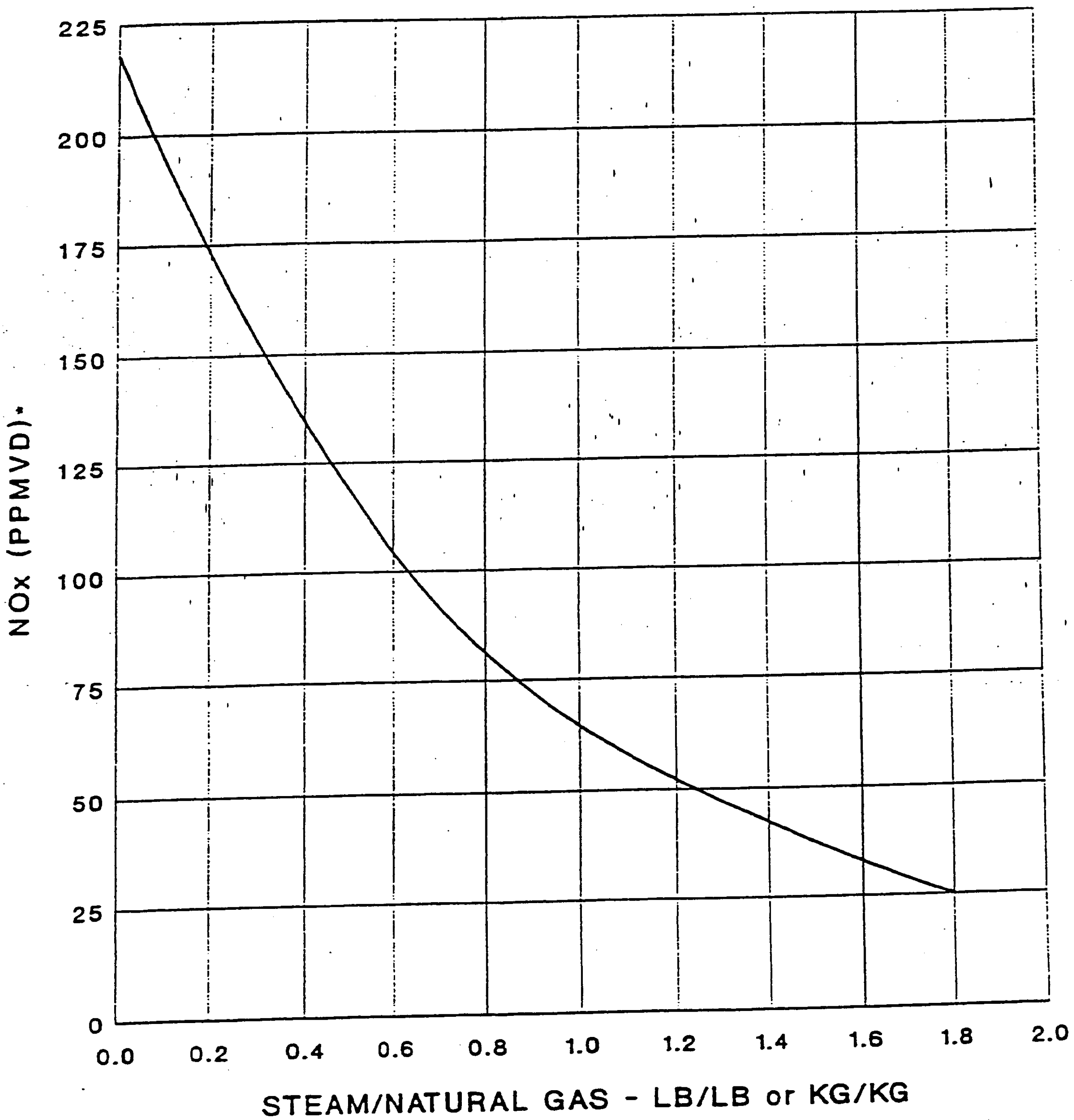
* NOx values are corrected to 15% oxygen and ISO conditions.
Fuel-bound nitrogen in No. 2 oil is assumed to be less than 0.015% by weight.

251B11/12 ECONOPAC PERFORMANCE
STEAM INJECTION/NATURAL GAS FUEL RATIO vs NOx EMISSIONS

FIGURE 3



* NOx values are corrected to 15% oxygen and ISO conditions at base load.

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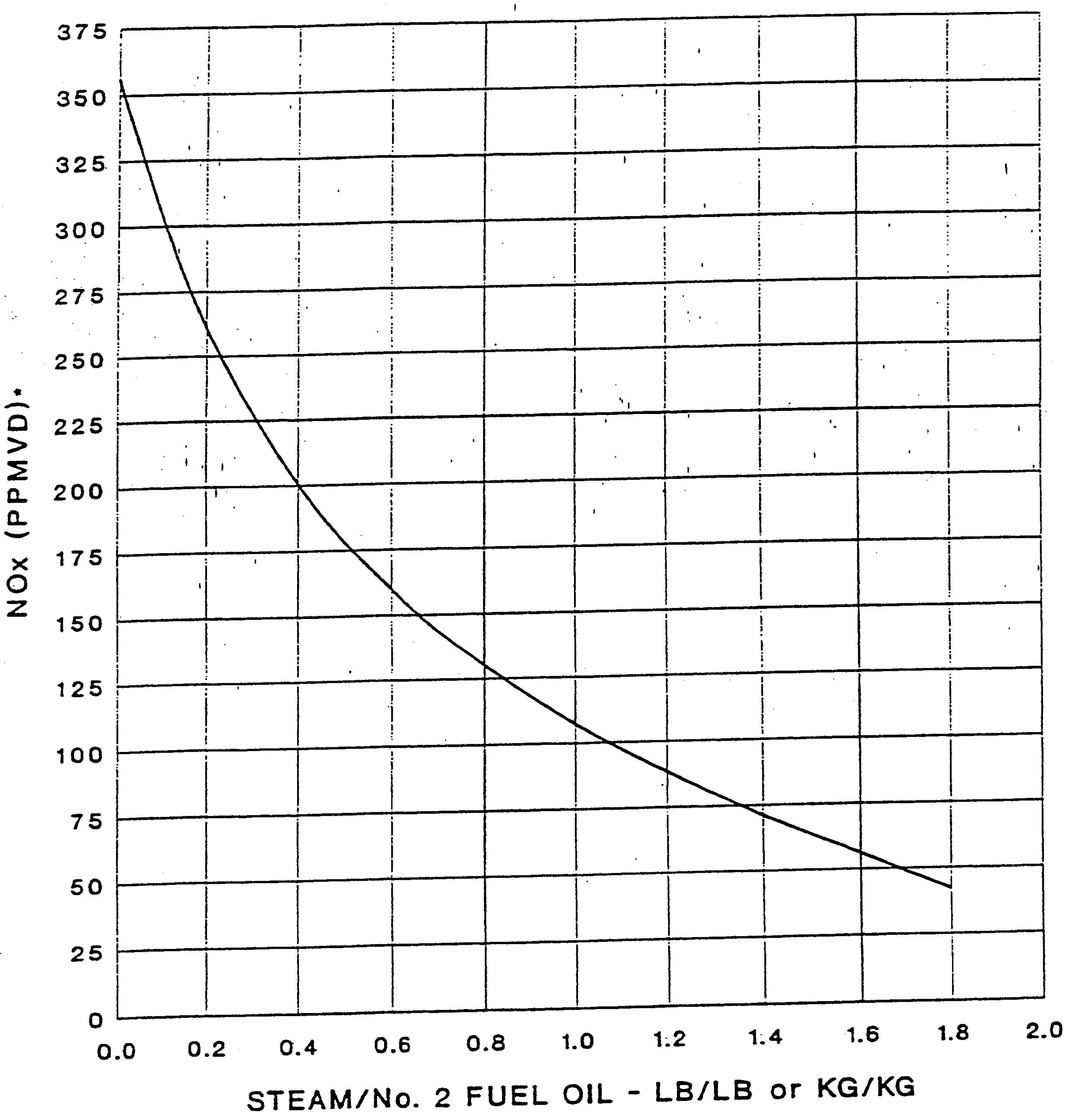
251B11/12 ECONOPAC PERFORMANCE

STEAM INJECTION/OIL FUEL RATIO vs NOx EMISSIONS

FIGURE 4



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* NOx values are corrected to 15% oxygen and ISO conditions at base load. Fuel-bound nitrogen is assumed less than 0.015% by weight.

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