Golder Associates Inc.

6241 NW 23rd Street, Suite 500
Gainesville, FL 32653-1500
Telephone (352) 336-5600
Fax (352) 336-6603

Golder Associates

May 6, 1999

9737572-0100

Mr. C.H. Fancy, P.E., Chief
Bureau of Air Regulation
Florida Department of Environmental Protection
111 South Magnolia Drive, Suite 4
Tallahassee, Florida 32301



Attention: Ms. Teresa Heron

RE: Inlet Foggers – Combustion Turbines 1-12
Florida Power & Light Company (FPL) Fort Myers Plant

Dear Teresa:

0710002-005-AC

This correspondence is submitted to address the Department's information request related to the installation of direct water spray fogging system to the inlet of the Fort Myers gas turbines. The information requested is presented below and in attachments to this correspondence.

1. Information Requested: Please submit additional data to support the statement that the emission rate does not change as a result of inlet fogging.

   Information Submitted: As discussed in the application, the use of the direct water spray fogging systems will increase the relative humidity of the gas stream while concomitantly reducing the temperature due to adiabatic cooling of the inlet air. This effect is no different than when the turbine is operated under the same ambient conditions that occurs during the normal course of operation in any year. However, it allows the turbine to operate under such ambient conditions more frequently and thus can effect annual emissions. The influence on the emission rate of increasing the relative humidity and temperature is explained in EPA's Alternative Control Techniques Document – $NO_x$ Emissions from Stationary Gas Turbines (EPA-453/R-93-007, January 1993). In Section 4.2.1.3 the report provides information that indicates emissions of $NO_x$ decrease with increasing relative humidity. Also, the mass emission of $NO_x$ decreases per mass of fuel input. This is also the same as lower emissions per amount electric power generated (since power and fuel input are directly related).

   The lower $NO_x$ emissions with increasing relative humidity and lower temperature can be shown using the equation in Section 4.2.1.3; the adjustment equation in 40 C.F.R. Part 60 Subpart GG, Section 60.335(c)(1). Table 1 presents calculation of relative $NO_x$ concentrations for various temperatures and relative humidity. As can be seen from the table the relative $NO_x$ concentration decreases with increasing humidity and decreasing temperature. The combined effect can be seen in the last column. Please find attached relevant pages from the EPA cited document. This EPA information is supported by the results of the testing performed at the Putnam Plant that indicated no change in emission rate (concentration) when the fogging system was used. These data also demonstrated no statistical change in CO concentrations as well.

The potential applicability of New Source Performance Standards (NSPS) Subpart GG would be dependant on whether the installation of a fogging system is considered a modification under Section 60.14 of 40 C.F.R. 60. The determination is based on whether a physical change resulted in an increase in the emission rate that is expressed in kilograms per hour. The emission rate can be determined using AP-42, materials balance, CEMs or manual stack tests [see paragraphs (1) and (2) of Section 60.14]. The tests must conducted under representative performance of the facility and that all operating which can effect emissions must be held constant to the maximum degree feasible. As described above, the inlet foggers only changes the ambient conditions that do occur during the normal operation of the turbine. Testing under the requirement to maintain all operating which may effect emissions (i.e., in this case temperature and relative humidity) constant would produce the same result. Thus, the short-term emission rates do not change. Nonetheless, the fogging system does increase the long-term emissions for which a limit on the operation of the fogging system has been requested to keep the increase below the PSD significant emission rate.

2. Information Requested: In reference to Table 1. Emission Estimates of the Ft. Myers Simple Cycle Combustion Turbines indicate the nominal values for power out, heat rate and heat input.

   Information Submitted: The information presented in Table 1 presents the *rate of change* of power, heat rate and heat input for the turbine. The basis of the information is the attached performance curves. As noted from the curves the performance (fuel input and power) is a linear function of inlet temperature. The primary purpose of using the performance curves is to determine the increase in heat rate as a function of temperature. This was determined from the performance curves as 2 mmBtu per °F shown in Table 1. This was then used with the hours of operation to calculate the tons per year. As an example: 2 mmBtu / °F x 0.038 lb/mmBtu x 8 °F/hour x 500 hours x 1 ton/2,000 lb = 0.15 tons/year for particulate matter. The 2 mmBtu / °F was determined as follows: At 59 °F the relative fuel consumption is 1 as shown in the performance curve. The heat input is 717.8 mmBtu/hr based on low heating value (LHV). This is multiplied by 1.06 to convert to high heating value (HHV) which gives 717.8 mmBtu/hr x 1.06 = 760.9 mmBtu/hr at 59 °F. At 80 °F, the fuel consumption is 95% of the 59 °F inlet rating or 0.95 x 760.9 mmBtu/hr = 722.8 mmBtu/hr. The difference is 38.1 mmBtu/hr (760.9 – 722.8) over 21 °F (80 – 59) or 1.81 mmBtu / °F; this value was rounded up to 2 mmBtu / °F.

3. Information Requested: Submit the heat input curves for these units.

Information Submitted: The heat input curve for the unit is attached.

Your prompt review of the application is appreciated. If there are any further questions, please call.

Sincerely,

GOLDER ASSOCIATES INC.

Kennard F. Kosky, P.E.
Principal
Professional Engineer No. 14996

SEAL

KFK/jkk

Enclosures

cc: Rich Piper, Repowering Licensing Manager
William Reichel, Fort Myers Plant General Manager

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Table 1. Relative $NO_x$ Concentrations as a Function of Turbine Inlet Temperature and Realtive Humidity using NSPS Equation[a]

| Temperature (°F) | Relative Humidity (RH) (percent) | Water (grains) per pound of dry Air | Water (grams) per gram of dry Air | Relative $NO_x$ Emission of RH | Temperature (°K) | Relative $NO_x$ Emission of Temp. | Relative $NO_x$ Emission of RH & Temp. |
|---|---|---|---|---|---|---|---|
| 95 | 40 | 100 | 0.0143 | 0.8597 | 308 | 1.1082 | 0.9527 |
| 95 | 60 | 150 | 0.0214 | 0.7506 | 308 | 1.1082 | 0.8318 |
| 95 | 80 | 200 | 0.0286 | 0.6553 | 308 | 1.1082 | 0.7262 |
| 95 | 100 | 250 | 0.0357 | 0.5722 | 308 | 1.1082 | 0.6341 |
| 75 | 40 | 64 | 0.0091 | 0.9480 | 297 | 1.0476 | 0.9931 |
| 75 | 60 | 78 | 0.0111 | 0.9126 | 297 | 1.0476 | 0.9561 |
| 75 | 80 | 119 | 0.0170 | 0.8165 | 297 | 1.0476 | 0.8554 |
| 75 | 100 | 130 | 0.0186 | 0.7925 | 297 | 1.0476 | 0.8302 |
| 59 | 40 | 30 | 0.0043 | 1.0396 | 288 | 1.0000 | 1.0396 |
| 59 | 60 | 44 | 0.0063 | 1.0008 | 288 | 1.0000 | 1.0008 |
| 59 | 80 | 60 | 0.0086 | 0.9583 | 288 | 1.0000 | 0.9583 |
| 59 | 100 | 72 | 0.0103 | 0.9276 | 288 | 1.0000 | 0.9276 |
| 40 | 40 | 15 | 0.0021 | 1.0828 | 277 | 0.9445 | 1.0227 |
| 40 | 60 | 23 | 0.0033 | 1.0595 | 277 | 0.9445 | 1.0007 |
| 40 | 80 | 30 | 0.0043 | 1.0396 | 277 | 0.9445 | 0.9819 |
| 40 | 100 | 36 | 0.0051 | 1.0228 | 277 | 0.9445 | 0.9660 |

[a] As provided in 40 C.F.R Part 60, Section 60.335(c)(1)
Note: water content (mass) per mass of dry air obtained from standard psychrometric chart.

PB93-156586

EPA-453/R-93-007

# Alternative Control Techniques Document--$NO_x$ Emissions from Stationary Gas Turbines

**Emission Standards Division**

**U. S. ENVIRONMENTAL PROTECTION AGENCY**
**Office of Air and Radiation**
**Office of Air Quality Planning and Standards**
**Research Triangle Park, North Carolina 27711**
**January 1993**

substantially lower thermal $NO_x$ emissions than natural gas or DF-2.[18] For fuels containing FBN, the fuel $NO_x$ production increases with increasing levels of FBN.

4.2.1.3 Ambient Conditions. Ambient conditions that affect $NO_x$ formation are humidity, temperature, and pressure. Of these ambient conditions, humidity has the greatest effect on $NO_x$ formation.[19] The energy required to heat the airborne water vapor has a quenching effect on combustion temperatures, which reduces thermal $NO_x$ formation. At low humidity levels, $NO_x$ emissions increase with increases in ambient temperature. At high humidity levels, the effect of changes in ambient temperature on $NO_x$ formation varies. At high humidity levels and low ambient temperatures, $NO_x$ emissions increase with increasing temperature. Conversely, at high humidity levels and ambient temperatures above 10°C (50°F), $NO_x$ emissions decrease with increasing temperature. This effect of humidity and temperature on $NO_x$ formation is shown in Figure 4-4. A rise in ambient pressure results in higher pressure and temperature levels entering the combustor and so $No_x$ production levels increase with increases in ambient pressure.[19]

The influence of ambient conditions on measured $NO_x$ emission levels can be corrected using the following equation:[20]

$$NO_x = (NO_{xo})(P_r/P_o)^{0.5}e^{19(Ho-0.00633)}(288°K/T_a)^{1.53}$$

where:

$NO_x$ = emission rate of $NO_x$ at 15 percent $O_2$ and International Standards Organization (ISO) ambient conditions, volume percent;

$NO_{xo}$ = observed $NO_x$ concentration, parts per million by volume (ppmv) referenced to 15 percent $O_2$;

$P_r$ = reference compressor inlet absolute pressure at 101.3 kilopascals ambient pressure, millimeters mercury (mm Hg);

$P_o$ = observed compressor inlet absolute pressure at test, mm Hg;

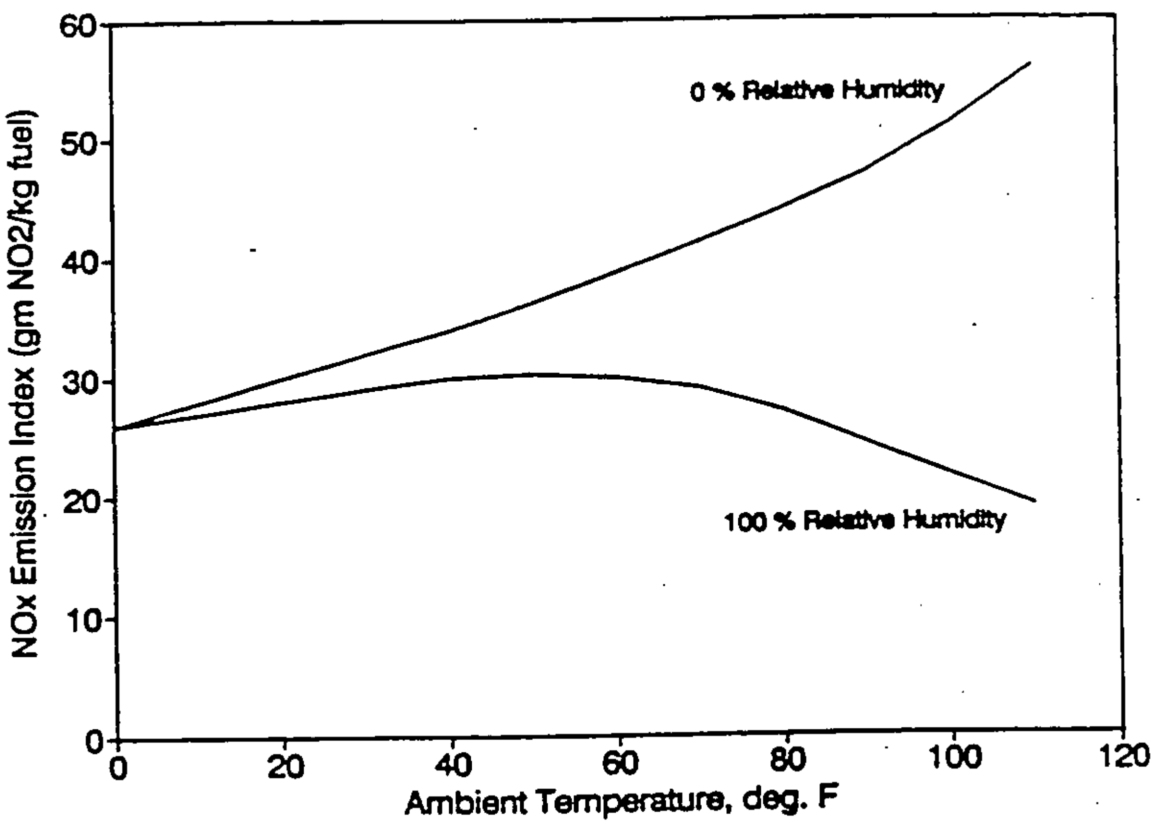



Figure 4-4. Influence of relative humidity and ambient temperature on $NO_x$ formation.[19]

$H_o$ = observed humidity of ambient air, g $H_2O$/g air;

e = transcendental constant, 2.718; and

$T_a$ = ambient temperature, K.

At least two manufacturers state that this equation does not accurately correct $NO_x$ emissions for their turbine models.[8,12] It is expected that these turbine manufacturers could provide corrections to this equation that would more accurately correct $NO_x$ emissions for the effects of ambient conditions based on test data for their turbine models.

4.2.1.4 Operating Cycles. Emissions from identical turbines used in simple and cogeneration cycles have similar $NO_x$ emissions levels, provided no duct burner is used in heat recovery applications. The $NO_x$ emissions are similar because, as stated in Section 4.2, $NO_x$ is formed only in the turbine combustor and remains at this level regardless of downstream temperature reductions. A turbine operated in a regenerative cycle produces higher $NO_x$ levels, however, due to increased combustor inlet temperatures present in regenerative cycle applications.[21]

4.2.1.5 Power Output Level. The power output level of a gas turbine is directly related to the firing temperature, which is directly related to flame temperature. Each gas turbine has a base-rated power level and corresponding $NO_x$ level. At power outputs below this base-rated level, the flame temperature is lower, so $NO_x$ emissions are lower. Conversely, at peak power outputs above the base rating, $NO_x$ emissions are higher due to higher flame temperature. The $NO_x$ emissions for a range of firing temperatures are shown in Figure 4-3 for one manufacturer's gas turbine.[17]

### 4.2.2 $NO_x$ Emissions From Duct Burners

In some cogeneration and combined cycle applications, the exhaust heat from the gas turbine is not sufficient to produce the desired quantity of steam from the HRSG, and a supplemental burner, or duct burner, is placed in the exhaust duct between the

GENERAL ELECTRIC MODEL PG7821: 65,600 KW GAS TURBINE PACKAGE POWER PLANT

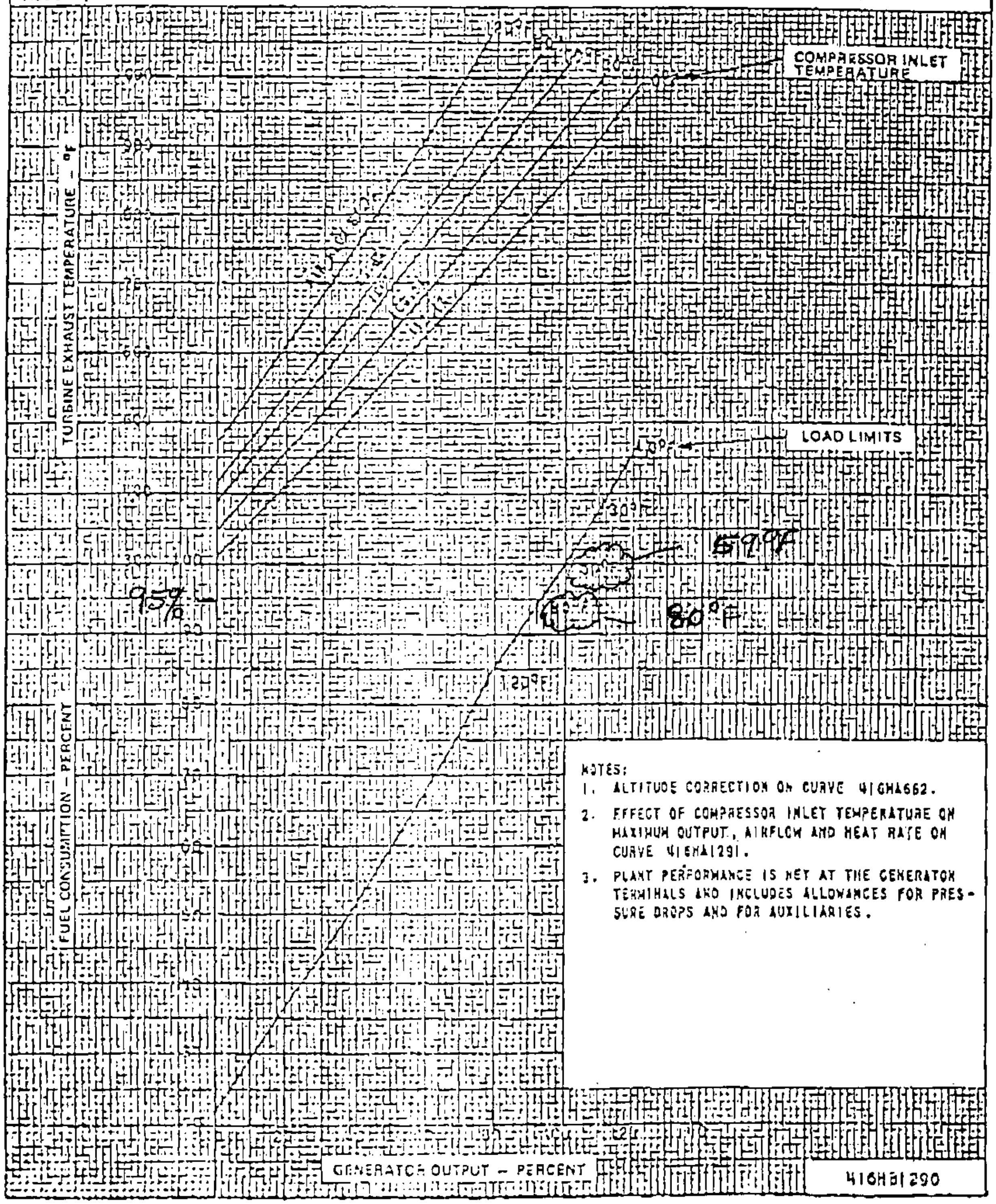
ESTIMATED PERFORMANCE

COMPRESSOR INLET TEMPERATURE 69°F BAROMETRIC PRESSURE 14.7 PSIA

| FUEL | | | NATURAL GAS | DISTILLATE OIL |
|---|---|---|---|---|
| DESIGN OUTPUT | | KW | 65,600 | 65,200 |
| DESIGN HEAT RATE (LHV) | | BTU/KW-HR | 10,900 | 11,010 |
| DESIGN FUEL CONSUMPTION (LHV) | | BTU/HR | $726.8 \times 10^6$ | $717.8 \times 10^6$ |
| HEATING VALUE RATIO | | HHV/LHV | 1.11 | 1.065 |
| DESIGN AIR FLOW | 1,896,000 | LBS/HR | | |
| DESIGN SHAFT SPEED | 3,600 | RPM | | |

BY: R. ROENBECK
DATE: 5/15/72
REV:

MODE: PEAK




NOTES:

1. ALTITUDE CORRECTION ON CURVE 416HA662.
2. EFFECT OF COMPRESSOR INLET TEMPERATURE ON MAXIMUM OUTPUT, AIRFLOW AND HEAT RATE ON CURVE 416HA1291.
3. PLANT PERFORMANCE IS NET AT THE GENERATOR TERMINALS AND INCLUDES ALLOWANCES FOR PRESSURE DROPS AND FOR AUXILIARIES.

416HB1290

# Department of Environmental Protection

Jeb Bush
Governor

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

David B. Struhs
Secretary


April 16, 1999

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. Richard Piper
Repowering Licensing Manager
Florida Power & Light Company
Post Office Box 14000
Juno Beach, Florida 33408

Re: Inlet Foggers – Ft. Myers Plant Combustion Turbines 1-12

Dear Mr. Piper:

The Department received your application for the installation of the direct water spray fogging system at the Ft. Myers Plant. Based on a technical review, the application is incomplete. Pursuant to Rules 62-4, 62-204, 62-210, 62-212, 62-296 and 62-297, F.A.C., please submit the following information, including all relevant reference materials and calculations:

1. Please submit additional data to support the statement that the emission rate does not change as a result of inlet fogging.
2. In reference to Table 1. Emissions Estimates of the Ft. Myers Simple Cycle Combustion Turbines, indicate the nominal values for power output, heat rate and heat input increase.
3. Submit the heat input curves for these units.

Please contact Teresa Heron at 850/921-9529 if you have any questions.

Sincerely,

for C. H. Fancy, P.E., Chief
Bureau of Air Regulation.

cc: Ken Kosky, P.E
Phil Barbaccia, SWD

Is your RETURN ADDRESS completed on the reverse side?

**SENDER:**
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- Complete items 3, 4a, and 4b.
- Print your name and address on the reverse of this form so that we can return this card to you.
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- The Return Receipt will show to whom the article was delivered and the date delivered.

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1. ☐ Addressee's Address
2. ☐ Restricted Delivery

Consult postmaster for fee.

3. Article Addressed to:
Richard Piper
Repowering Licensing Mgr
FP+L
PO BOX 14000
Juno Bch, Fl 33408

4a. Article Number
Z 333 618 097

4b. Service Type
☐ Registered ☑ Certified
☐ Express Mail ☐ Insured
☐ Return Receipt for Merchandise ☐ COD

7. Date of Delivery

5. Received By: *(Print Name)*
K. Naypal

6. Signature: *(Addressee or Agent)*
X

8. Addressee's Address *(Only if requested and fee is paid)*

PS Form **3811**, December 1994 102595-97-B-0179 Domestic Return Receipt

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|---|---|
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| Post Office, State, & ZIP Code Juno Bch Fl | |
| Postage | $ |
| Certified Fee | |
| Special Delivery Fee | |
| Restricted Delivery Fee | |
| Return Receipt Showing to Whom & Date Delivered | |
| Return Receipt Showing to Whom, Date, & Addressee's Address | |
| TOTAL Postage & Fees | $ |
| Postmark or Date 4-15-99 Ft. Myers Plant | |

PS Form **3800**, April 1995