DESCRIPTION OF ORIMULSION™
TEST BURN AT
FPL SANFORD UNIT 4

PREPARED FOR:

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West Palm Beach, Florida

PREPARED BY:

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STATEMENT OF PROFESSIONAL ENGINEER REGISTERED IN FLORIDA

This is to certify that the engineering features of this pollution control project have been examined by me and found to be in conformity with modern engineering principles applicable to the treatment and disposal of pollutants characterized in the permit application. There is reasonable assurance, in my professional judgment, that the pollution control facilities, when properly maintained and operated, will discharge an effluent that complies with the proposed emission limits, all applicable ambient air quality standards and prevention of significant deterioration increments of the State of Florida, and the rules and regulations of the department. It is also agreed that the undersigned will furnish, if authorized by the owner, the applicant a set of instructions for the proper maintenance and operation of the pollution control facilities and, if applicable, pollution sources.

Signed David A. Buff

David A. Buff
Name (please type)

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1.0 INTRODUCTION

Very large deposits of heavy bitumen, from which emulsified fuels can be developed, have been identified in the Orinoco River area of Venezuela. The national petroleum company, Petroleos de Venezuela, South America, has sponsored the development and demonstration of a technology for the preparation of an emulsion of bitumen in water, known as Orimulsion. Orimulsion consists of an emulsion of about 71 percent bitumen in 29 percent water. Small amounts of an emulsifying agent and a water-soluble magnesium complex are added during the preparation process. Orimulsion has a heating value of approximately 13,000 British thermal units per pound (Btu/lb). The fuel contains up to about 2.8 percent sulfur and 0.2 percent ash (see Table 1-1). Orimulsion is stable at temperatures up to 180°F, but becomes unstable at higher temperatures; therefore, the fuel must be stored at temperatures below about 160°F. Good atomization has been achieved at this temperature using steam as the atomizing agent. Orimulsion can be handled and burned in utility boilers for power generation. Tests in pilot-scale furnaces were followed in July 1988 by a successful long-term demonstration program in the 100-megawatt (MW) corner-fired Dalhousie Generating Station Unit 1 in New Brunswick, Canada. At Dalhousie, 137,500 tons of Orimulsion has been burned, generating approximately 335,000 megawatt hours (MWh) of electricity.

FPL is seeking approval from the Florida Department of Environmental Regulation (FDER) to do a full-scale test burn of Orimulsion at its Sanford Unit 4. This approval involves a petition under Chapter 17-103.120 F.A.C. This attachment to the petition presents the test plan, estimated emissions from Orimulsion, and emissions testing protocol for the test burn.

Table 1-1. Characteristics of Residual Oil and Orimulsion

Parameter	Unit	Current No. 6 Fuel Oil	Orimulsion
Heat of Combustion (HHV)	Btu/lb	18,200	13,000
Sulfur Content	Percent weight	1.5 to 2.0	2.6 to 2.8
Nitrogen Content	Percent weight	0.35	0.5
Ash Content	Percent weight	0.03	0.20
Water Content	Percent weight	<2	28.5

2.0 TEST BURN PROGRAM

2.1 OBJECTIVES

To date, the testing of Orimulsion fuel has been conducted in pilot installations and in the 100-MW Dalhousie Unit No. 1 in New Brunswick, Canada. Tests indicate that Orimulsion fuel has the potential to displace No. 6 fuel oil in steam electric power plants.

The main objectives of the test burn at Sanford Unit 4 are to demonstrate the practicality of firing Orimulsion fuel in a large, front wall-fired utility boiler to evaluate the performance of air emissions control equipment, and to generate a technical database for the engineering and design of the potential future conversion to Orimulsion of the Sanford plant and several other large generating units in FPL's system.

Test burning of Orimulsion at Sanford Unit 4 will provide the opportunity to evaluate the technical and operational features under utility operating conditions. Various technical uncertainties will be clarified or resolved during this test burn period. Fuel handling, storage and combustion, properties of the flue gas, removal efficiency of gaseous and particulate pollution control devices, solid waste handling and disposal, and equipment performance and operating characteristics will be tested and evaluated. The knowledge and experience gained during the test burn will assess the feasibility of full conversion to be assessed.

2.2 TEST PLAN

A preliminary test plan has been developed which defines the activities and identifies the resource requirements for the test burn. The test burn will be carried out in four phases:

1. Startup tests,
2. Initial characterization tests,
3. Operational tests, and
4. Structured performance tests.

Startup Tests--Startup tests would be performed to verify that all new or refurbished equipment has been properly installed and operates as required. The work during the startup tests would be similar to that on conventional projects. These tests will identify early potential problems and assure satisfactory operation during the other test phases.

Initial Characterization Tests--Initial characterization tests will be the first series of tests involving the firing of Orimulsion. The purpose of this test is to establish equipment limitations and operating procedures while using this fuel. These tests will also familiarize plant personnel with Orimulsion firing and serve as an operational training program.

Initial characterization tests will focus on boiler performance. The testing will begin by firing Orimulsion in a few burners; additional burners firing Orimulsion will gradually be added. Temperature measurements will be taken to set the maximum and minimum load limits of the unit. Measurements and analyses will be performed to establish optimal levels of operating parameters (e.g., excess air levels, fuel heating requirements, atomizing steam pressure, soot-blowing schedule, etc.) to be used during the test burn program.

Initial characterization tests will also involve further assessments of the fuel storage and handling systems inspected during the startup tests. Key parameters to be evaluated include storage tank settlement and fuel-handling system pressure drops, product stability, and heating system performance. These tests would be initiated with startup testing. Storage tank settlement will be evaluated as soon as the tank is filled with Orimulsion. This testing will provide a basis for establishing the need of mixing and the schedule to be followed throughout the test burn program. Fuel samples will be taken from various locations in the tanks over a period of several weeks and at different locations in the fuel-handling system.

Operational Tests--Operational testing will be performed to determine the effects of continuous firing of Orimulsion. The boiler will be fired continuously on Orimulsion fuel for up to 24 hours each day during the test period except for scheduled shutdowns or when system dispatch dictates switching back to fuel oil. System dispatch requirements will dictate the operating load levels for the unit. The operational tests will be used to evaluate:

1. Ash accumulations and locations,
2. Soot blower effectiveness,
3. Combustion patterns and efficiency,
4. Operating difficulties,
5. Maintenance requirements,
6. Causes of forced outages, and
7. Low-temperature corrosion.

Orimulsion stability and settlement throughout the fuel-handling system will also be determined. Maintenance logs developed during the test burn program will be used to evaluate the effect of Orimulsion firing on plant availability and on operation and maintenance costs. Equipment failure rates reported during the test will be compared to those observed when firing oil.

The flue gas cleanup equipment (desulfurization and particulate matter removal) will contribute the most cost in full conversion to Orimulsion. However, there currently are significant uncertainties in the design of such equipment for Orimulsion applications. The solid waste products and particle size distribution resulting from combustion are expected to differ from those resulting from burning No. 6 fuel oil. The ability to remove sulfur dioxide (SO_2) from Orimulsion flue gases is also not well documented. Therefore, extensive pilot testing will have to be performed. The plan calls for temporary installation of small, self-contained pilot plants for several emissions control technologies, including electrostatic precipitator, a lime spray dryer, and different fabric filter designs. The pilot plants will be connected via a slip-stream duct parallel to the existing flue-gas ductwork (Figure 2-1). Flue gas from the particulate control devices will be further characterized for design of wet scrubber or regenerable process equipment. Emission measurements will be taken to understand and quantify the equipment's operating performance (refer to Section 4.0).

Structured Performance Tests--The structured performance tests are designed to determine the performance of specific systems under controlled conditions. Two structured test series are planned on oil: the first during the startup test period, i.e., before firing any Orimulsion, and the second after completion of the Orimulsion test burn. Four structured performance tests are planned on Orimulsion. Boiler testing will be conducted during each series, and balance of plant (i.e., fuel-handling and storage equipment and air pollution control equipment) testing will be performed twice.

The structured boiler performance tests are designed to establish performance differences between Orimulsion and oil firing and to obtain basic boiler design information for application to a conversion at Sanford and other units. Performing tests on both oil and Orimulsion will also provide an opportunity to gather data regarding slagging and fouling characteristics for firing both fuels.

The structured performance tests on oil will be performed at four distinct plant loads (25-, 50-, 75-, and 100-percent loads). These tests will be used to characterize unit performance with oil firing over the unit's entire load range after modification. The structured performance tests on Orimulsion will be at the same four plant loads.

Performance characterization of the boiler during the structured test series will include boiler gross efficiency, combustion efficiency, stack emission rates, ash and slag characterization, burner and flame documentation, and boiler metal temperatures at strategically selected detection points.

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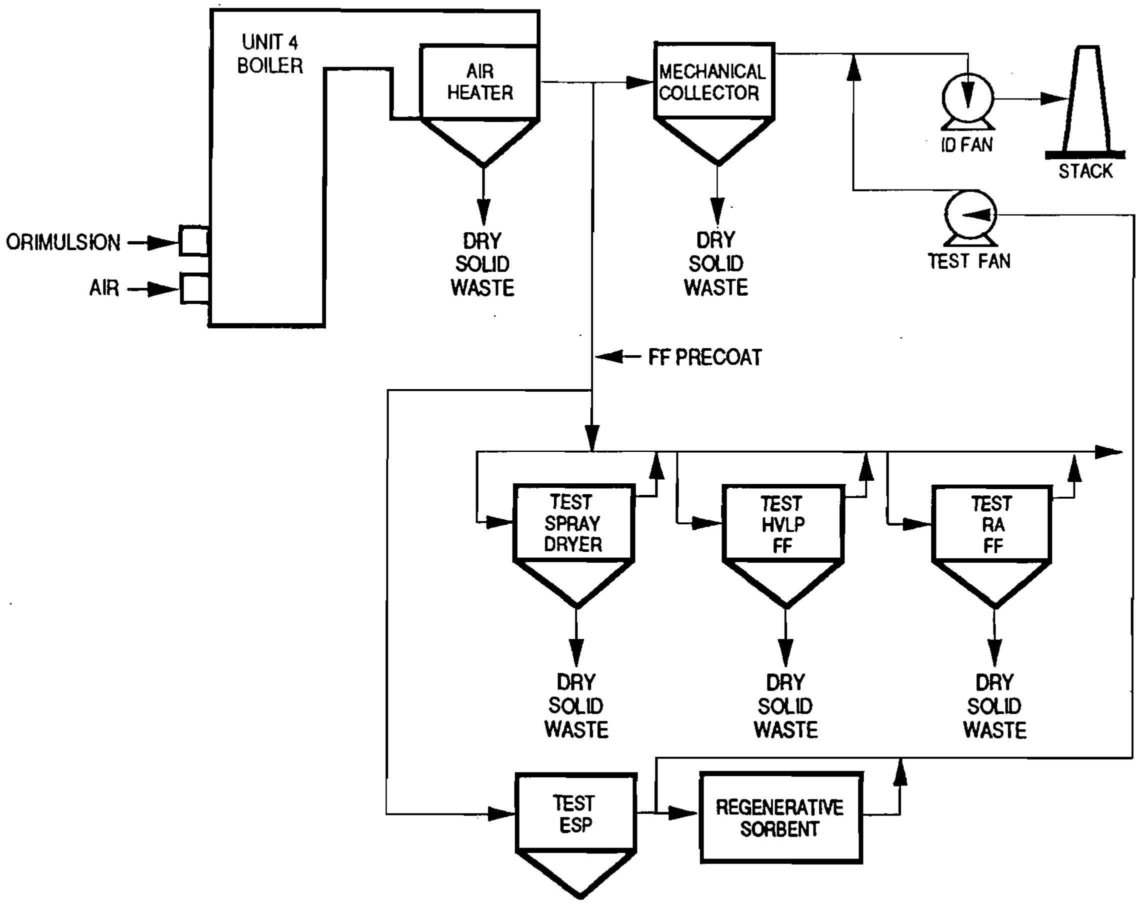

SANFORD PLANT ORIMULSION TEST BURN
Pilot - Scale Emissions Control Equipment Testing

Flue gases diverted to side stream (5,000 acfm) to evaluate:

1. Three particulate control technologies for possible future use *upstream of a wet scrubber or regenerable sorbent FGD system:*
   - (a) Electrostatic Precipitator (ESP)
   - (b) Reverse Air Fabric Filter (RA - FF)
   - (c) High - Volume - Low - Pressure Pulse Jet Fabric Filter (HVLP - FF)
2. Lime Spray Dryer (FGD) in combination with the Reverse - Air or Pulse Jet Fabric Filters.

Figure 2-1 FLUE GAS SCHEMATIC

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Balance of plant areas which will be tested include plant cycle efficiency, mechanical collector performance, pilot precipitator performance, ash properties relevant to ash disposal, and pilot spray dryer and fabric filter performance. These tests will be scheduled simultaneously with boiler performance tests since much data will be common to both. The first set of plant performance tests will be on oil to establish baselines for comparison. Two of the balance of plant test series will be on Orimulsion, one series early in the test burn period and the other near the end.

To evaluate the impact of Orimulsion conversion on overall plant efficiency, the following parameters will be measured: net plant heat rate, turbine cycle efficiency, boiler efficiency, and auxiliary power consumption.

2.3 EMISSION CONTROLS PILOT TESTING

An emissions control system will be proposed for SO_2 and particulate matter emissions for full-scale Orimulsion conversions.

Flue gas desulfurization (FGD) systems with relatively high SO_2 removal efficiencies are currently available. These technologies, which are calcium based and use wet or dry scrubbing, are characterized by high investment costs. Lower cost technologies are being developed for applications that require less stringent SO_2 removal. These emerging controls involve dry injection processes which introduce sorbent into either the furnace or post-furnace regions (i.e., in-duct injection).

Particulate control technologies considered feasible for Orimulsion are fabric filters and electrostatic precipitators (ESP). The ash and gases produced by Orimulsion firing are expected to be similar to oil firing in many respects. However, there is limited utility experience with fabric filters used on oil-fired units and virtually no experience on fabric filters with Orimulsion fuel.

Pilot scale testing of fabric filters will be performed during the Orimulsion test burn at Sanford 4 to collect design operating data. Two types of fabric filters will be investigated for Sanford, the reverse-air type and the pulse-jet type (low, intermediate, and high pressure).

Several desulfurization methods are feasible for Orimulsion firing, including spray dryer, in-duct injection and wet scrubbing. Each has different particulate removal requirements. Spray drying will produce higher solids loading and will require greater capacity for particulate removal. The wet-scrubbing alternative could require the highest particulate removal efficiency.

The dust loading produced by dry scrubbers will require a high removal efficiency. Fabric filters are the preferred method of particulate control for this alternative. There is good fabric filter operating experience collecting sulfur containing solids and unreacted reagent from fluid-bed boilers and from coal-fired dry-scrubbing applications. The particulates form a cake on the fabric surface that is fairly easy to remove. A fabric filter improves SO_2 removal by extending the contact between reagent and gas. Gases leaving a dry scrubber will be relatively cool so it will be possible to use less expensive fabric as the filtering medium.

For the wet-scrubbing alternative, the particulate collector will be located upstream of the FGD system. ESPs have been used in these applications due to the higher particulate removal requirements and higher temperatures. However, ESP experience in an Orimulsion application is limited, and a pilot ESP facility will therefore be included in the test burn. Characterization of the gas stream from the pilot-scale ESP will furnish the necessary design data for a wet scrubber system, as well as for a possible regenerable sorbent system.

2.4 PILOT TESTING SOLID WASTE MANAGEMENT

The Sanford Unit 4 Orimulsion test burn will also provide the raw data necessary to meet the following important objectives relating to solid waste handling:

1. Characterization of the chemical and physical properties of the solid wastes for use as input in the design of full-scale waste handling systems.
2. Evaluation of the methods and equipment used to manage the solid wastes during the test burn.

Two types of solid waste will be generated during the test burn--Orimulsion fly ash and lime spray dryer solid waste. The spray dryer waste will be composed of the fly ash mixed together with calcium sulfite, calcium sulfate, and unreacted lime.

A vacuum, dilute pneumatic system will be utilized during the test burn to transfer solid waste from the particulate collectors (pilot-scale fabric filters and electrostatic precipitator) and the spray dryer to a temporary storage silo. Samples of the ash from the particulate collectors will be analyzed to determine metals content for possible sale of recovered metals. Samples of the spray dryer waste will be studied for stability as part of an ongoing laboratory analysis program sponsored by FPL in cooperation with the Florida Institute of Technology.

Due to the small volume of solid waste generated during the test, wastes may be transported off-site for ultimate disposal at a facility acceptable to FDER. The quantity of fly ash that will be generated is estimated at approximately 3,600 lb. Total waste generated from the spray dryer will be about 16,000 lb.

A second alternative for management of test burn solid wastes is disposal on-site utilizing a landfill with an impermeable liner. This approach would involve a relatively small area, approximately 10 feet (ft) x 10 ft x 5 ft high. Provision would be made for groundwater monitoring and leachate control, with routing of runoff to the existing plant ash settling basins. The on-site disposal alternative would be equivalent to a "test-cell" and could be used to evaluate landfill design prior to planning for a permanent conversion.

Neither of these alternatives for the test burn would necessitate a change to the power plant's existing state and federal wastewater permit discharge limits.

2.5 SCHEDULE

Figure 2-2 presents a conceptual testing schedule. The actual schedule of testing will probably be affected by early test results, unit reliability, system power requirements, etc. The test program is assumed to start in November or December 1990. Startup tests will proceed parallel with the final phases of construction. Initial startup after the modifications will be on oil. Boiler and balance of plant performance will be tested to develop baseline operations.

The period of oil-fired testing will be followed by initial firing of Orimulsion fuel and initial characterization tests. During this period, optimum settings will be determined, and the plant staff will become familiar with Orimulsion operation. The minimum and maximum limits of Orimulsion firing as a function of unit output and load change rates will be investigated.

After stable operation on Orimulsion has been achieved, boiler and balance of plant structured testing will be performed. This test series will measure Orimulsion performance in a relatively clean boiler. An outage will be scheduled after this test series on Orimulsion to allow inspection, adjustment, or repair of plant components, test equipment, and instruments.

Periods of sustained low load and high load operation will be scheduled early in the test program to identify operating problems before the unit has to be restored to commercial operation. Outages after each period will

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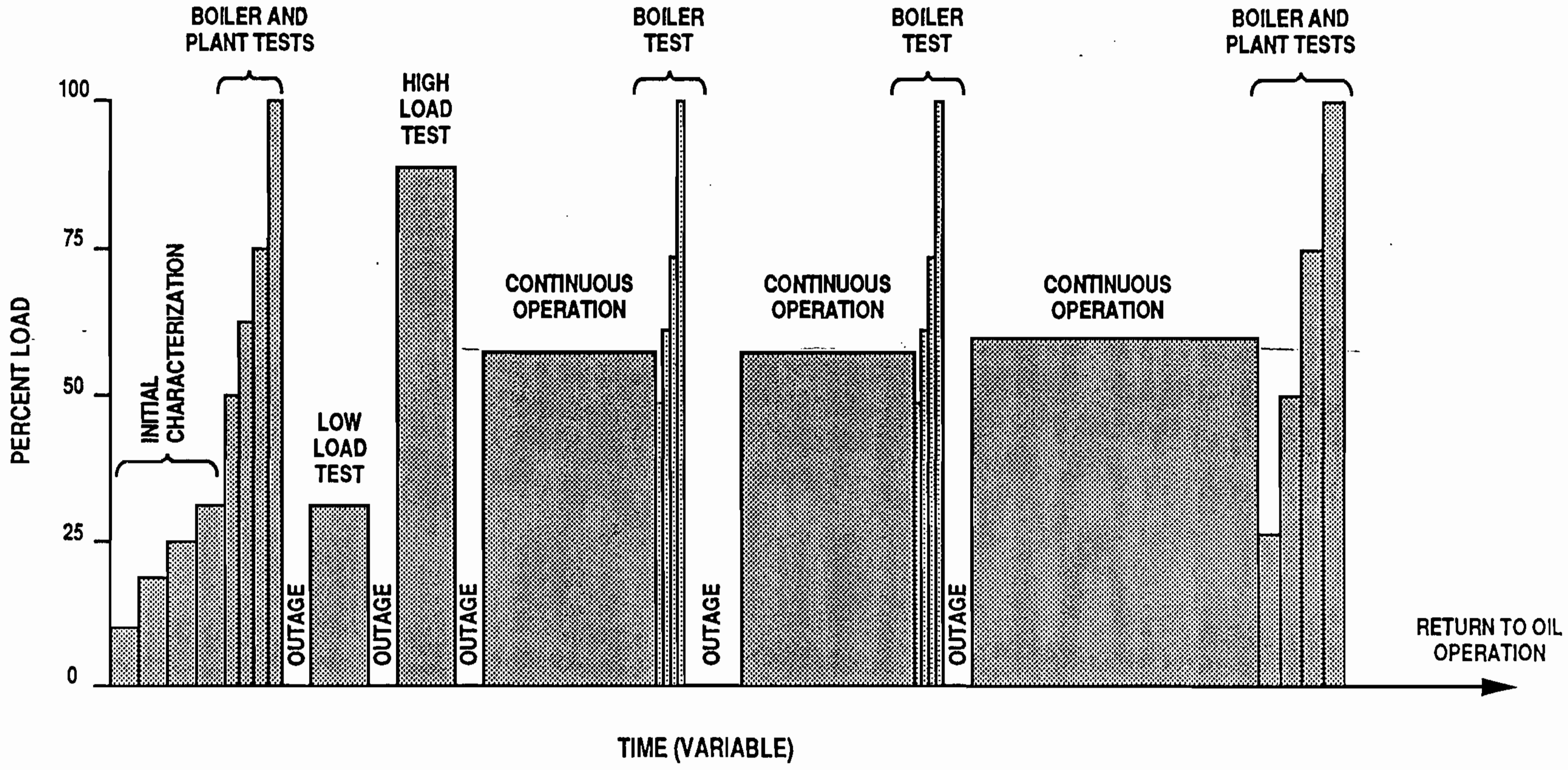

NOTE: TOTAL TEST WOULD TAKE FROM 1 TO 1.5 YEARS TO ACHIEVE 120 FULL-POWER DAYS.

Figure 2-2 TEST BURN SCHEDULE

permit inspection of the boiler for fouling, plugging or slag buildup, and for adjustments or repairs if required.

For three longer periods of the test program, the unit will operate under the normal dispatch mode. Each period will be followed by a boiler performance test and an outage. This will permit detection of changes in unit performance with time, as well as allow equipment adjustments or repairs.

Operation of pilot-scale flue gas desulfurization and particulate control equipment will be scheduled after stable and reliable plant operation has been established.

A series of complete plant tests are scheduled after the final period of Orimulsion firing. These tests will provide data on Orimulsion performance after continuous use under normal operating conditions. These tests will also incorporate all adjustments to plant operations as well as modifications to the equipment and fuel composition.

The final outage will be longer than the other scheduled outages to allow dismantling of test equipment and restoration of the unit to the pretest conditions.

After all Orimulsion data is taken, oil firing will resume. Plant performance on oil will be measured shortly after resumption of oil firing to determine any changes caused by continuous Orimulsion firing.

The test plan will provide over 2,000 hours (up to 120 days) of full-power equivalent of Orimulsion-fired operation. (A full power hour is defined as the maximum heat input to Unit 4 for one hour, which is 4,050 x 10^6 Btu; 120 full power days is the equivalent of 11.66 x 10^{12} Btu heat input.) This is believed to be adequate for collection of needed design data.

2.6 EQUIPMENT MODIFICATIONS AND OPERATION

Due to the temporary nature of the test burn program, equipment modifications will be kept to a minimum, but will be consistent with the need to gather performance and operating data for the design of a full conversion to Orimulsion firing. New equipment and existing equipment that will be provided or refurbished for use with Orimulsion during the test burn is listed in Table 2-1 and discussed in the following sections.

2.6.1 FUEL HANDLING

No. 6 fuel oil currently is heated with steam for both bulk storage and burner feed heating. To assure that Orimulsion is kept below its maximum storage temperature of 180°F, some heat exchange equipment will be added. A fuel flow meter will be added to assure accurate recording of Orimulsion use.

The hot water heat exchanger and associated equipment is being added to the existing tanks instead of submerged direct heaters to assure a uniform temperature of 100°F for the Orimulsion. These heaters also will serve as the primary heaters for Orimulsion firing.

For Orimulsion storage, two existing tanks (C and D) will be used. These tanks will be inspected and insulation will be added to assure that a temperature of 100°F is maintained. Vertical mixers in Storage Tank C will be inspected to assure operation. Tank D does not have mixers. Having one tank with and one tank without mixers will allow an evaluation of long-term storage on Orimulsion properties, e.g., settling and separation.

The existing burner feed pumps will be fitted with variable speed drives to accurately match pump flow rates to burner requirements.

2.6.2 BOILER AUXILIARIES

Burner guns and tips will be added to allow steam atomizing during Orimulsion firing. The steam atomization system will use the existing

Table 2-1. Equipment Requirements for Orimulsion Test Burn

System	New	Inspect/Adjust/ Refurbish
Fuel Handling	Hot water heat exchangers (heat tracing and burner supply heating), circulating hot water pumps, hot water surge tank Orimulsion fuel flow meter	Storage tanks C & D (condition assessment, insulation) Burner feed pumps Tank C vertical mixers (axial flow blades)
Boiler Auxiliaries	Burner guns and tips (steam atomization)	Furnace wall blowers
Balance of Plant	Emission testing related flue-gas ductwork (sidestream--air emission testing) Pilot plants for rotary atomized lime spray dryer, regenerable absorber, reverse air fabric filter, pulse jet fabric filter (low, intermediate, and high pressure), and electrostatic precipitator Test fan	

plant auxiliary steam system and the existing fuel oil return piping. No. 6 fuel oil will be fired using steam atomization.

Furnace wall blowers, which were used during the coal-oil mixture (COM) testing, will be used during the test burn.

2.6.3 BALANCE OF PLANT

Duct work related to the flue gas testing will be added to provide a side stream for the pilot plants. The pilot plants (see Figure 2-1) will use about 5,000 acfm for testing removal efficiencies of particulate matter and SO_2.

3.0 ESTIMATED EMISSIONS

3.1 REGULATED POLLUTANTS

The characteristics of Orimulsion compared with other fuels burned (either alone or in combination with other fuels) at the Sanford Plant are presented in Table 3-1. Currently, a medium sulfur (i.e., between 1.0 and 2.0 percent) residual fuel oil is burned at the plant, which results in maximum PM and SO_2 emissions of 0.1 and 1.65 to 2.25 lb/million Btu heat input, respectively. Higher sulfur (i.e., 2.5 percent) residual fuel oil and COM have been previously burned; the highest PM and SO_2 emissions using these fuels were 0.7 and 2.75 lb/million Btu heat input, respectively. The 2.5 percent sulfur residual oil represents the maximum permitted SO_2 emission rate.

It is anticipated that test burning of Orimulsion will result in temporarily increased PM and SO_2 emissions for the Sanford Unit 4 over currently occurring or permitted levels . Table 3-2 presents the maximum expected emissions for all regulated pollutants during the test burn and those requiring approval by the FDER. Annual emissions are based on 120 days of operation at full power, i.e., the maximum heat input of 4,050 x 10^6 Btu/hr.

Maximum SO_2 emissions would be 4.3 lb/million Btu heat input based on the worst-case Orimulsion fuel quality. Total SO_2 emissions from the plant will be minimized by using low sulfur (i.e., 1 percent) fuel oil in Units 3 and 5. Emissions of sulfuric acid mist may increase with the increase in SO_2 emissions, although the magnesium present in the fuel could act to prevent or limit any such an increase.

PM and PM10 emissions are expected to be no greater than 0.3 lb/million Btu heat input during normal Orimulsion firing and 0.6 lb/million Btu heat input during load changes, soot blowing, and variable testing conditions. This would result in a maximum 24 hour average PM/PM10 emission rate of 0.34 lb/million Btu heat input. The proposed emission

Table 3-1. Comparison of Orimulsion With Other Fuels Burned At The FPL Sanford Plant

Fuel	Medium-S Residual[a]	High-S Residual[b]	Coal[c]	COM[d]	Orimulsion[e]
Sulfur, percent	1.5 - 2.0	2.5	1.5	2.0	2.68
Btu/lb	18,300 typical	18,300 typical	12,500	15,000	13,000
lb $SO_2/10^6$ Btu	1.64 - 2.2	2.75 maximum	2.75 maximum	2.75 maximum	4.14[f]
Ash, percent	0.10 maximum	0.10 maximum	10.0 maximum	5.0 maximum	0.21[g]
Vanadium, ppm	200 maximum	500 maximum	NA	NA	322
Particulate, lb/10^6 Btu	0.10 maximum	0.10 maximum	1.43[h]	0.70[h]	0.22[h]

Note: NA = not available.

[a] Fuel oil currently burned at Sanford Plant.
[b] Fuel oil characteristics representative of maximum permitted limits.
[c] Based on 1981 Sanford coal test burn estimates.
[d] Based on 1980 Sanford COM variance estimates or tests for 40 percent coal and 60 percent oil.
[e] Average of four shipments received at Dalhousie, N.B.
[f] Calculated uncontrolled emission rate (per fuel sulfur content).
[g] Includes magnesium-based additive.
[h] Determined uncontrolled particulate emission rate.

Table 3-2. Maximum Estimated Emissions for Existing and Orimulsion Test Burn at FPL's Sanford Plant (Page 1 of 2)

Data	Existing				Orimulsion Testing				Potential Increase
	Unit 3	Unit 4	Unit 5	Total	Unit 3	Unit 4	Unit 5	Total	
Heat Input (10^6 Btu/hr)	1,650	4,050	4,050		1,650	4,050	4,050		
Sulfur Dioxide									
Emissions Basis	Actual[a]	Actual[a]	Actual[a]		Actual[a]	Actual[b]	Actual[a]		
Emissions Basis (lb/10^6 Btu)	1.65	1.65	1.65		1.1	4.3	1.1		
Emissions (lb/hour)	2,723	6,683	6,683	16,088	1,815	17,415	4,455	23,685	7,598
Emissions (tons/year)[c]	3,920	9,623	9,623	23,166	2,614	25,078	6,415	34,106	10,940
Particulate Matter									
Emissions Basis	Actual[d]	Actual[d]	Actual[d]		Actual[d]	Actual[e]	Actual[d]		
Emissions Basis (lb/10^6 Btu)	0.125	0.125	0.125		0.125	0.338	0.125		
Emissions (lb/hour)	206	506	506	1,219	206	1,369	506	2,081	863
Emissions (tons/year)[c]	297	729	729	1,755	297	1,971	729	2,997	1,242
Particulate Matter (PM10)									
Emissions Basis	AP-42[f]	AP-42[f]	AP-42[f]		AP-42[f]	PM=PM10	AP-42[f]		
Emissions Basis (lb/10^6 Btu)	0.09	0.09	0.09		0.09	0.338	0.09		
Emissions (lb/hour)	146	359	359	865	146	1,369	359	1,875	1,009
Emissions (tons/year)[c]	211	518	518	1,246	211	1,971	518	2,700	1,454
Nitrogen Oxides									
Emissions Basis	AP-42[g]	AP-42[g]	AP-42[g]		AP-42[g]	AP-42[g]	AP-42[g]		
Emissions Basis (lb/10^6 Btu)	0.70	0.70	0.70	0.81	0.70	0.70	0.70		
Emissions (lb/hour)	1,155	2,834	2,834	6,822	1,155	2,834	2,834	6,822	0
Emissions (tons/year)[c]	1,663	4,081	4,081	9,824	1,663	4,081	4,081	9,824	0
Carbon Monoxide									
Emissions Basis	AP-42	AP-42	AP-42		AP-42	AP-42	AP-42		
Emissions Basis (lb/10^6 Btu)	0.03	0.03	0.03		0.03	0.03	0.03		
Emissions (lb/hour)	55	135	135	325	55	135	135	325	0
Emissions (tons/year)[c]	79	194	194	468	79	194	194	468	0
Volatile Organic Compounds									
Emissions Basis	AP-42	AP-42	AP-42		AP-42	AP-42	AP-42		
Emissions Basis (lb/10^6 Btu)	0.002	0.002	0.002		0.002	0.002	0.002		
Emissions (lb/hour)	3	8	8	18	3	8	8	18	0
Emissions (tons/year)[c]	4	11	11	26	4	11	11	26	0
Lead									
Emissions Basis	AP-42	AP-42	AP-42		AP-42	AP-42	AP-42		
Emissions Basis (lb/10^6 Btu)	2.80X10^{-5}	2.80X10^{-5}	2.80X10^{-5}		2.80X10^{-5}	2.80X10^{-5}	2.80X10^{-5}		
Emissions (lb/hour)	0.05	0.11	0.11	0.27	0.05	0.11	0.11	0.27	0
Emissions (tons/year)[c]	0.07	0.16	0.16	0.39	0.07	0.16	0.16	0.39	0
Sulfuric Acid Mist									
Emissions Basis	AP-42	AP-42	AP-42		AP-42	AP-42	AP-42		
Emissions Basis (lb/10^6 Btu)	2.90X10^{-2}	2.90X10^{-2}	2.90X10^{-2}		1.93X10^{-2}	5.41X10^{-2}	1.93X10^{-2}		
Emissions (lb/hour)	48	117	117	283	32	219	78	329	47
Emissions (tons/year)[c]	69	169	169	407	46	316	113	474	67

Table 3-2. Maximum Estimated Emissions for Existing and Orimulsion Test Burn at FPL's Sanford Plant (Page 2 of 2)

Data	Existing				Orimulsion Testing				Potential Increase
	Unit 3	Unit 4	Unit 5	Total	Unit 3	Unit 4	Unit 5	Total	
Total Fluorides									
Emissions Basis	EPA (198?)	EPA (198?)	EPA (198?)		EPA (1981)	EPA (1981)	EPA (1981)		
Emissions Basis (lb/10^6 Btu)	$3.47X10^{-4}$	$3.47X10^{-4}$	$3.47X10^{-4}$		$3.47X10^{-4}$	$3.47X10^{-4}$	$3.47X10^{-4}$		
Emissions (lb/hour)	0.57	1.40	1.40	3.38	0.57	1.40	1.40	3.38	0.00
Emissions (tons/year)[c]	0.82	2.02	2.02	4.87	0.82	2.02	2.02	4.87	0.00
Mercury									
Emissions Basis	EPA (1989)	EPA (1989)	EPA (1989)		EPA (1989)	EPA (1989)	EPA (1989)		
Emissions Basis (lb/10^6 Btu)	$3.28X10^{-6}$	$3.28X10^{-6}$	$3.28X10^{-6}$		$3.28X10^{-6}$	$1.54X10^{-5}$	$3.28X10^{-6}$		
Emissions (lb/hour)	$5.41X10^{-3}$	$1.33X10^{-2}$	$1.33X10^{-2}$	0.03	$5.41X10^{-3}$	$6.24X10^{-2}$	$1.33X10^{-2}$	0.08	0.05[h]
Emissions (tons/year)[c]	0.01	0.02	0.02	0.05	0.01	0.09	0.02	0.12	0.07
Beryllium									
Emissions Basis	EPA (1989)	EPA (1989)	EPA (1989)		EPA (1989)	EPA (1989)	EPA (1989)		
Emissions Basis (lb/10^6 Btu)	$4.37X10^{-6}$	$4.37X10^{-6}$	$4.37X10^{-6}$		$4.37X10^{-6}$	$1.54X10^{-5}$	$4.37X10^{-6}$		
Emissions (lb/hour)	$7.21X10^{-3}$	$1.77X10^{-2}$	$1.77X10^{-2}$	0.04	$7.21X10^{-3}$	$6.24X10^{-2}$	$1.77X10^{-2}$	0.09	0.04[h]
Emissions (tons/year)[c]	0.01	0.03	0.03	0.06	0.01	0.09	0.03	0.13	0.06
Arsenic									
Emissions Basis	EPA (1989)	EPA (1989)	EPA (1989)		EPA (1989)	EPA (1989)	EPA (1989)		
Emissions Basis (lb/10^6 Btu)	$4.37X10^{-5}$	$4.375X10^{-5}$	$4.37X10^{-5}$		$4.37X10^{-5}$	$3.85X10^{-5}$	$4.37X10^{-5}$		
Emissions (lb/hour)	$7.21X10^{-2}$	$1.77X10^{-1}$	$1.77X10^{-1}$	0.43	$7.21X10^{-2}$	$1.56X10^{-1}$	$1.77X10^{-1}$	0.41	-0.02
Emissions (tons/year)[c]	0.10	0.25	0.25	0.61	0.10	0.22	0.25	0.58	-0.03

Notes:
a. 1.5 percent sulfur and 18,200 Btu/lb;
b. 2.8 percent sulfur and 13,000 Btu/lb;
c. calculated based on 120 full power days;
d. based on an average emission of 0.1 lb/10^6 Btu for 21 hours and excess emissions of 0.3 lb/10^6 Btu for 3 hours;
e. based on an average emission of 0.3 lb/10^6 Btu for 21 hours and excess emissions of 0.6 lb/10^6 Btu for 3 hours;
f. PM10 emissions is 71 percent of PM emissions (from AP-42);
g. based on vertical fired boilers, could be as high as 1 lb/10^6 Btu due to low excess air burners; emissions on Orimulsion equivalent to oil firing.
h. artifact of detection limit; increases not expected;

Emissions of total reduced sulfur, reduced sulfur compounds, hydrogen sulfide, asbestos, vinyl chloride, benzene, and radionuclides are negligble for oil firing.

limit is slightly greater than the uncontrolled emissions observed at the Orimulsion demonstration project at the New Brunswick Power Commission Dalhousie Plant. The uncontrolled steady-state PM emission rate at the 100-MW Dalhousie Unit 1 was 0.22 lb/million Btu heat input. The proposed emission limit reflects potentially higher emissions to account for differences between the Dalhousie unit and the larger 400-MW Sanford Unit 4. The proposed particulate emission limit for the Orimulsion test burn was previously approved by FDER for high sulfur residual oil during the energy emergency of the late 1970s.

PM10 emissions for Orimulsion firing are conservatively assumed to be equivalent to PM emissions. Due to the higher particulate rate and testing uncertainties, the maximum opacity is projected to be 60 percent during steady-state operation, and up to 100 percent is requested during load changes, soot blowing and unsteady/changing conditions caused by testing.

Nitrogen oxide (NO_x) emissions when firing Orimulsion are expected to be similar to firing residual oil. NO_x emissions during combustion originate from the oxidation of fuel-bound nitrogen and combustion air nitrogen. The amount of NO_x from the oxidation of combustion air nitrogen, so-called thermal NO_x, is dependent on flame temperature, excess air level, and flame dynamics. The fuel nitrogen content of Orimulsion is 0.5 percent, which is about 40 percent higher than the residual fuel oil currently being burned. Therefore, NO_x emissions from the fuel-bound nitrogen emissions when firing Orimulsion are expected to increase over that of residual fuel oil, all other factors remaining constant. However, experience in firing Orimulsion has indicated that the high moisture content, i.e., about 30 percent, reduces the peak flame temperature and, concomitantly, thermal NO_x formation. Results from Dalhousie also indicate lower excess air requirements for Orimulsion combustion. While sufficient data are not currently available to precisely predict NO_x emissions when firing Orimulsion, data from the demonstration testing at Dalhousie suggest that total NO_x

emissions would be about the same for Orimulsion as for fuel oil. As a result, the NO_x emissions estimates in Table 3-2 are based on similar AP-42 emission factors for both fuels.

Emissions of carbon monoxide (CO) and volatile organic compounds (VOC) were estimated using AP-42 emission factors for residual oil firing for both current residual oil firing and that during the Orimulsion test burn. Combustion characteristics are sufficiently similar for both fuels to conclude that CO emissions will not be significantly different.

For other regulated pollutants, EPA emission factors for residual oil were also used. Emissions data for these pollutants are not available for Orimulsion firing. Laboratory analysis of an Orimulsion fuel sample found that concentrations of arsenic, beryllium, and mercury were below detectable limits (BDL). The reported BDL concentrations are similar to that reported by EPA (see Table 3-3) but suggest increases in mercury and beryllium. However, this result is an artifact of the detection limit and actual increases of these pollutants are not expected.

3.2 NON-REGULATED POLLUTANTS

Estimated emissions of nonregulated pollutants during the Orimulsion test burn are presented in Table 3-4. These emissions are based on concentrations of these parameters found from analyzing a sample of Orimulsion fuel. Since all reported values were below the detection limits of the analytical procedure, the emission estimates are conservative. Table 3-4 also presents estimated emissions for residual oil firing that were calculated using EPA emission factors.

Table 3-3. Orimulsion and Residual Oil Emission Factors and Estimates for Lead, Arsenic, Beryllium and Mercury

Pollutant	Orimulsion Sample[a]	Residual Oil				Emissions Increase[c]	
		EPA 1980	EPA 1988	EPA 1989	Maximum[b]	(lb/hr)	(tons/yr)
Lead							
Concentration (ppm)	0.02	3.5	NO	NO	3.5	NO	NO
Emission Factor (lb/10^6 Btu)	$1.54x10^{-6}$	$1.91x10^{-4}$	Emission	Emission	$1.91x10^{-4}$	Emission	Emission
Unit 4 Emissions (lb/hr)[d]	$6.23x10^{-3}$	$7.75x10^{-1}$	Factor	Factor	$7.75x10^{-1}$	Increase[e]	Increase[e]
Arsenic							
Concentration (ppm)	0.5 DL	0.8	0.36			NO Increase	NO Increase
Emission Factor (lb/10^6 Btu)	$3.85x10^{-5}$	$4.37x10^{-5}$	$1.90x10^{-5}$	$1.97x10^{-5}$	$4.37x10^{-5}$	Expected	Expected
Unit 4 Emissions (lb/hr)[d]	$1.56x10^{-1}$	$1.77x10^{-1}$	$7.70x10^{-2}$	$7.97x10^{-2}$	$1.77x10^{-1}$	$-2.13x10^{-2}$	-0.03
Beryllium							
Concentration (ppm)	0.2 DL	0.08	0.08				
Emission Factor (lb/10^6 Btu)	$1.54x10^{-5}$	$4.37x10^{-6}$	$4.20x10^{-6}$	$4.37x10^{-6}$	$4.37x10^{-6}$		
Unit 4 Emissions (lb/hr)[d]	$6.23x10^{-2}$	$1.77x10^{-2}$	$1.70x10^{-2}$	$1.77x10^{-2}$	$1.77x10^{-2}$	$4.46x10^{-2}$	0.06
Mercury							
Concentration (ppm)	0.2 DL	0.04	0.06				
Emission Factor (lb/10^6 Btu)	$1.54x10^{-5}$	$2.19x10^{-6}$	$3.20x10^{-6}$	$3.28x10^{-6}$	$3.28x10^{-6}$		
Unit 4 Emissions (lb/hr)[d]	$6.23x10^{-2}$	$8.85x10^{-3}$	$1.30x10^{-2}$	$1.33x10^{-2}$	$1.33x10^{-2}$	$4.90x10^{-2}$	0.07

Note: DL = detection limit.

[a] From Orimulsion samples analyzed by FPL's Power Resources Central Laboratory and Clark Engineers Laboratory.

[b] Maximum of Residual Oil Emission Factors.

[c] Orimulsion emissions minus maximum on residual oil.

[d] Based on a maximum heat input for Unit 4 of 4050 10^6 Btu/hr.

[e] AP-42 emission factor for lead higher than Orimulsion; AP-42 was used for all emission calculations.

Table 3-4. Orimulsion and Residual Oil Emission Factors and Estimates for Selected Non-Regulated Pollutants

Pollutant	Orimulsion Sample[a]	Residual Oil				Emissions Increase[c]	
		EPA 1980	EPA 1988	EPA 1989	Maximum[b]	(lb/hr)	(tons/yr)
Cadmium							
Concentration (ppm)	0.05 DL	2.27		0.3		NO Increase	NO Increase
Emission Factor (lb/10^6 Btu)	$3.85x10^{-6}$	$1.24x10^{-4}$	$1.57x10^{-5}$	$1.64x10^{-5}$	$1.24x10^{-4}$	Expected	Expected
Unit 4 Emissions (lb/hr)[d]	$1.56x10^{-2}$	$5.02x10^{-1}$	$6.36x10^{-2}$	$6.64x10^{-2}$	$5.02x10^{-1}$	$-4.87x10^{-1}$	-0.70
Chromium							
Concentration (ppm)	0.02 DL	1.3		0.4		NO	NO
Emission Factor (lb/10^6 Btu)	$1.54x10^{-6}$	$7.10x10^{-5}$	$2.10x10^{-5}$	$2.19x10^{-5}$	$7.10x10^{-5}$	Increase	Increase
Unit 4 Emissions (lb/hr)[d]	$6.23x10^{-3}$	$2.88x10^{-1}$	$8.51x10^{-2}$	$8.85x10^{-2}$	$2.88x10^{-1}$	$-2.81x10^{-1}$	-0.41
Copper							
Concentration (ppm)	0.8	2.8		5.3		NO	NO
Emission Factor (lb/10^6 Btu)	$6.15x10^{-5}$	$1.53x10^{-4}$	$2.78x10^{-4}$	$2.90x10^{-4}$	$2.90x10^{-4}$	Increase	Increase
Unit 4 Emissions (lb/hr)[d]	$2.49x10^{-1}$	$6.20x10^{-1}$	1.13	1.17	1.17	$-9.24x10^{-1}$	-1.33
Manganese							
Concentration (ppm)	0.5	1.33		No		NO	NO
Emission Factor (lb/10^6 Btu)	$3.85x10^{-5}$	$7.27x10^{-5}$	$2.60x10^{-5}$	Emission	$7.27x10^{-5}$	Increase	Increase
Unit 4 Emissions (lb/hr)[d]	$1.56x10^{-1}$	$2.94x10^{-1}$	$1.05x10^{-1}$	Factor	$2.94x10^{-1}$	$-1.39x10^{-1}$	-0.20
Nickel							
Concentration (ppm)	59	42.2		24			
Emission Factor (lb/10^6 Btu)	$4.54x10^{-3}$	$2.31x10^{-3}$	$1.26x10^{-3}$	$1.31x10^{-3}$	$2.31x10^{-3}$		
Unit 4 Emissions (lb/hr)[d]	$1.84x10^{1}$	9.34	5.10	5.31	9.34	9.04	13.02
Selenium							
Concentration (ppm)	0.5 DL	0.7		No			
Emission Factor (lb/10^6 Btu)	$3.85x10^{-5}$	$3.83x10^{-5}$	$2.35x10^{-5}$	Emission	$3.83x10^{-5}$		
Unit 4 Emissions (lb/hr)[d]	$1.56x10^{-1}$	$1.55x10^{-1}$	$9.51x10^{-2}$	Factor	$1.55x10^{-1}$	$8.51x10^{-4}$	0.0012
Vanadium							
Concentration (ppm)	360	160		200			
Emission Factor (lb/10^6 Btu)	$2.77x10^{-2}$	$8.74x10^{-3}$	$3.52x10^{-3}$	$1.09x10^{-2}$	$1.09x10^{-2}$	see "e"	see "e"
Unit 4 Emissions (lb/hr)[d]	$1.12x10^{2}$	$3.54x10^{1}$	$1.43x10^{1}$	$4.43x10^{1}$	$4.43x10^{1}$	$6.79x10^{1}$	97.7638

Note: DL = detection limit.

[a] From Orimulsion samples analyzed by FPL's Power Resources Central Laboratory and Clark Engineers Laboratory.

[b] Maximum of Residual Oil Emission Factors.

[c] Orimulsion emissions minus maximum on residual oil.

[d] Based on a maximum heat input for Unit 4 of 4050 10^6 Btu/hr.

[e] Maximum vanadium concentration for current fuel oil is 200 ppm; maximum emissions increase shown is for current conditions.

4.0 EMISSIONS TESTING PROTOCOL

The test burn will require emissions testing to assure compliance with the proposed temporary emission limits and to obtain valid data for full-scale Orimulsion conversion. For both objectives, EPA and FDER approved methods will be used. Table 4-1 presents the testing protocol that will be used during the test burn. This table presents the pollutants to be monitored, test methods, test phase, boiler conditions during emission sampling, frequency of sampling, location of sampling, and the purpose of sampling.

Results obtained from the test burn will be reported monthly to FDER. The monthly reports will include but not be limited to:

1. Orimulsion and No. 6 fuel oil usage (recorded in barrels, 10^6 Btu, and number of day burned),
2. Number of full power test days during the month,
3. Characteristics of Orimulsion and No. 6 fuel oil used during the month (percent sulfur, heating value, and percent ash),
4. Copies of emission test results,
5. Opacity records, and
6. Frequency of excess emission.

Monthly reports will be submitted to FDER within 21 days following the end of a month.

Table 4-1. Emissions Testing Protocol for Orimulsion Test Burn at FPL Sanford Unit 4

Pollutant	Test Method[a]	Test Phase	Boiler Conditions During Sampling	Frequency[b]	Sampling Location	Purpose of Emission Sampling
Particulate Matter	EPA Method 5	Initial Characterization	High and lows Loads	Once per Load	Stack	Determine initial Orimulsion emissions
		Operational	Steady-State Operation	Twice (O&SB)	Stack	Assure compliance during operation
		Performance	As a Function of Load	Four	Stack	Determine effects of load on emissions
		Pilot Plant	Steady-State Operation	As Needed	(IN&OUT)	Evaluate control equipment
Visible Emissions	EPA Method 9 and Continuous Opacity with Transmissometer Appendix B PS 1	Initial Characterization	High and lows Loads	Continuous	Stack	Determine initial Orimulsion emissions
		Operational	Steady-State Operation	Continuous	Stack	Assure compliance during operation
		Performance	As a Function of Load	Continuous	Stack	Determine effects of load on emissions
		Pilot Plant	Steady-State Operation	Continuous	(IN&OUT)	Evaluate control equipment
Sulfur Dioxide	Fuel Analysis using ASTM Methods	Initial Characterization	High and lows Loads	As Needed	As Burned	Determine initial Orimulsion emissions
		Operational	Steady-State Operation	As Needed	As Burned	Assure compliance during operation
		Performance	As a Function of Load	As Needed	As Burned	Determine effects of load on emissions
	EPA Method 6C	Pilot Plant	Steady-State Operation	Continuous	(IN&OUT)	Evaluate control equipment
Nitrogen Oxides	EPA Method 7E	Initial Characterization	High and lows Loads	Once per Load	Stack	Determine initial Orimulsion emissions
		Operational	Steady-State Operation	Twice (O&SB)	Stack	Assure compliance during operation
		Performance	As a Function of Load	Four	Stack	Determine effects of load on emissions
Carbon Monoxide	EPA Method 10	Initial Characterization	High and lows Loads	Once per Load	Stack	Determine initial Orimulsion emissions
		Operational	Steady-State Operation	Twice (O&SB)	Stack	Assure compliance during operation
		Performance	As a Function of Load	Four	Stack	Determine effects of load on emissions
Volatile Organic Compounds	EPA Method 25a Corrected for Methane and Ethane	Initial Characterization	High and lows Loads	Once per Load	Stack	Determine initial Orimulsion emissions
		Operational	Steady-State Operation	Twice (O&SB)	Stack	Assure compliance during operation
		Performance	As a Function of Load	Four	Stack	Determine effects of load on emissions
Lead, Arsenic, Beryllium, Mercury, and Sulfuric Acid Mist	Modified EPA Methods 5 & 8 Method 103/104	Operational	Steady-State Operation	Once	Stack	Determine uncontrolled emissions
		Pilot Plant	Steady-State Operation	Once	(IN&OUT)	Evaluate control equipment
Metals: Cr, Cd, Cu, Ni, Mn, Se, and V	Modified EPA Method 5	Operational	Steady-State Operation	Once	As Burned	Determine uncontrolled emissions

[a] See 40 Code of Federal Regulations (CFR) Part 60 Appendix A and Appendix B, Part 61 Appendix B.

[b] O = operation, SB = soot blowing.

IN = inlet to pilot control equipment; OUT = outlet from pilot control equipment.

REFERENCES

U.S. Environmental Protection Agency (EPA). 1988. Toxic Air Pollutant Emission Factors--A Compilation for Selected Air Toxic Compounds and Sources. Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA-450/2-88-006a.