INTERNATIONAL PAPER PROJECT XL
PEMS TEST PLAN

PREDICTIVE EMISSION MONITORING SYSTEM (PEMS)
DEVELOPMENT STUDY FOR THE
WASTE FUEL INCINERATOR (WFI)

at the
International Paper Corporation
Androscoggin Mill
Jay, Maine

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1.0 PROJECT DESCRIPTION

1.1 Project XL

This project is being carried out under Project XL, which is a national pilot program that tests innovative ways of achieving better and more cost-effective public health and environmental protection. Under Project XL, sponsors implement innovative strategies that produce superior environmental performance, provide flexibility, cost savings, paperwork reduction or other benefits to sponsors. The projects are of limited scope and extend for a specified time period. Successful XL proposals must produce superior environmental results beyond those that would have been achieved under current and reasonably anticipated future regulations or policies; produce benefits such as cost savings, paperwork that serve as an incentive to both project sponsors and regulators and are supported by stakeholders. The participants (including EPA, the facility, the state and stakeholders) define in the Final Project Agreement (FPA) the innovation to be tested, what superior environmental performance must be achieved, what flexibility EPA and other co-regulators will need to provide, what conditions will be met, and how results will be monitored and reported. The agreement among the participants is set forth in the FPA which is being signed by EPA, International Paper, ME DEP, and the Town of Jay. Once signed, the project is then implemented according to the FPA and any implementing mechanism. The purpose of this Test Plan is to describe the technical issues and sampling protocol for this XL Project.

1.2 Project Summary

International Paper's Androscoggin Mill, located in Jay, Maine, is proposing to develop, test and implement a highly sophisticated computer model that can estimate pollutant emissions on a continuous basis. Currently, International Paper is required to measure Particulate Matter (PM) [1] and Carbon Monoxide (CO) only once every year and SO_2 and NO_x on a continuous basis. The computer model which IP proposes to develop is called a **Predictive Emissions Monitoring System** (PEMS). This project would develop and then install a PEMS on the waste fuel incinerator (WFI -- a type of boiler that burns paper mill waste products such as wood bark to generate steam). Pollutants to be modeled would include particulate matter (PM), SO_2, NO_x, CO_2 and CO. The PEMS would model the relationship between WFI operating conditions and emission rates to continuously predict pollutant emissions. The PEMS system would facilitate efficient operation of the WFI which could aid in minimizing emissions without impacting production. In addition, a successful model could have broad applicability to other sources of air pollution especially stacks with high moisture content.

The WFI is a significantly more complex type of boiler than those where PEMS have been developed and installed previously. The complex nature of the boiler leads to the incorporation of a larger number of variables into the model. Appendix A provides a detailed list of the variables that will be monitored

[1] International Paper's air license sets forth emission limits for PM10 and PM, but the monitoring method required applies only to PM. For purposes of this test plan, reference to PM includes PM10.

and potentially incorporated into the PEMS (these variables will be discussed further in Section 3 of this Test Plan.) The number of variables (different fuels, burn rates, etc.) likely needed for use in a PEMS for the WFI would result in a rigorous test of PEMS capabilities. PEMS for less complex types of boilers generally use fewer than 20 variables. If successfully developed and implemented, this computer model would provide IP and the surrounding community with continuous information on emissions. A successful model could also provide information to other facilities on how to operate more efficiently while emitting the least amount of emissions possible.

The primary objective of this project is to develop a PEMS neural model of the stack PM that can be used to forecast PM and stay within emission limits. Secondary objectives are to develop a PEMS for the stack SO_2 and NO_X emissions as well as Steaming Rate (SR). The PEMS for the steaming rate (steaming rate is used by IP to measure production of the WFI) will simplify maintaining the maximum stable steaming rate at optimum bark, sludge and oil consumption rates. By developing PEMS for both emissions and production (steaming rate), IP will develop a link between emissions and production so they can then optimize production while minimizing emissions. Additional goals include testing an experimental PM CEM during the mill trial, developing an alternative Relative Accuracy for verifying the performance of PEMS that is affordable, improving ease of operation, and improving visibility of process responses.

As set forth more specifically in Section 4, International Paper plans to closely monitor and evaluate this project, and to conduct Model Specification tests to confirm accuracy of the PEMS. Model Specification tests (see Sections 4.0 for discussion of this and Appendix C for the actual Specifications) would be used in conjunction with other factors such a comparison the CEMs results (and other criteria identified by the Technical Review Team) to evaluate the success of the PEMS.

1.3 Regulatory Flexibility

International Paper is seeking regulatory flexibility in two areas. First, IP requests site-specific, time-limited flexibility to exceed emissions license limits for the WFI, in order to fully develop, test and calibrate the PEMS technology so that the State, IP and EPA can confirm the PEM's accuracy. Second, if the PEMS is demonstrated to be successful, IP requests revision of its monitoring requirements to reduce the sampling frequency of monitoring systems that the PEMS will replace. This request includes reducing PM stack test frequency, as well as removing the requirement for CEMs for NO_x and SO_2, after the PEMS is verified for these constituents. The exact reduction will be developed through Final Project Agreement (FPA) negotiations with EPA, the state, the Town of Jay and interested stakeholders and the appropriate implementing mechanism.

1.3.1 Potential Emission Exceedances

International Paper's Project XL application requests allowance of very short term exceedances of their WFI license limits (not more than several hours at a time). Because of the detailed process testing of the WFI required to develop sufficient data for the WFI PEMS, two types of potential exceedances may occur:

- Exceedances occurring during PEMS Development - in testing the full range of operating conditions, some combinations of parameters may lead to unforseen conditions that would cause an exceedance of the license limit. These would not and cannot be planned in advance but would only occur during the PEMS development phase as described in the "Testing Description and Estimated Timeline" table which is currently predicted to span approximately two weeks;
- Temporary exceedances during calibration - during Model Specification tests (see Section 4.5) to assure that the PEMS has the ability to predict emissions above the license limit. This type of exceedance could be planned ahead of time.

As shown in Table 3 "Testing Description and Tentative Schedule," in Section 3.5, IP will strictly control testing conditions over a finite period of days. The table shows the schedule for the various tests and the parameter ranges scheduled for testing. Also as set forth in Section 3.4, IP has agreed to impose certain controls on facility operations so that violations of National Ambient Air Quality Standards (NAAQS) will not occur. Based on facility production information available to International Paper, ME DEP and using previous stack test information the likelihood of NAAQS exceedances would be highly unlikely since IP agrees to operate at production levels consistent with their previous stack tests. The stack tests show that all of IP's stacks emit at levels below their license limits and this would reduce the likelihood of IP's WFI emissions impacting NAAQS. (Section 2.5 discusses this further and provides a comparison of IP's license limits and their actual emissions).

1.3.2 Monitoring Reductions, Use of PEMS

The second area of regulatory flexibility requested is for replacement of current monitoring methods (annual stack testing and CEMs) with the PEMS, if it is demonstrated to be successful. As discussed in Section 4, IP is committing to a testing schedule to analyze and ensure the accuracy of the PEMS.

1.4 Technical Review Team

A Technical Review Team comprising, at a minimum, representation from active stakeholders, IP, EPA, ME DEP, and the Town of Jay will implement and evaluate the terms of this Test Plan. This Technical Review Team agrees to follow the terms of this Test Plan, the Testing Agreement (to which this Test Plan is appended) as well as the terms of the Final Project Agreement.

1.5 Project Timeline

An approximate project task description and timeline are provided below to show the individual tasks associated with developing and testing a PEMS for the Waste Fuel Incinerator (WFI) for International Paper Androscoggin Mill. The goal is to show the general tasks and their estimated duration. The schedule may change due to weather or operational conditions and the Technical Review Team will be notified of any changes.

Task	**Description**	**Estimated Completion from Project Start Date**	**SO_2 and NO_x CEMs in use**
Sampling and testing for PEMS development	IP runs the WFI under a number of different operating conditions. As an example, all parameters would be set at "normal" conditions and then fuel oil flow would be adjusted to "low" and after reaching steady state, emissions would be measured. Then the fuel oil flow would be set to "average" and after reaching steady state, emissions would be measured, and finally fuel oil flow would be set to "high" and emissions would be measured (see Section 3.)	1 month	yes
Data workup	All the data sources are collected, made compatible, and entered into the computer. This process is resource intensive because some data is manually collected, some is collected on one type of computer and other data is collected on another type of computer. Also, some data represents a daily or weekly value (e.g., sulfur content in the fuel) and other data is provided in one minute increments (e.g., incinerator temperature).	months 2 through 7	yes
Site Specific PEMS model development	The neural network (the portion of the PEMS that develops the mathematical relationship between operating parameters emissions and production) is run to develop the relationship among all the operational parameters and emission rates. Once the model is developed, internal (to the computer) tests are run to assure the model is operating as anticipated.		yes
PEMS Installation and testing	Once the model is completed, it is installed at the facility and many of the operating sensors may be "hardwired" to the computer. The model, wiring, sensors and gauges will be tested by IP to assure everything is working properly.		yes
PEMS adjustment/ calibration	Based on the internal QA/QC, IP will further program and adjust the model. IP may perform an informal relative accuracy test to confirm operation of the pieces of the PEMS	(month 2 to 7)	yes

Task	Description	Estimated Completion from Project Start Date	SO_2 and NO_x CEMs in use
PEMS Formal Validation #1	The formal PEMS validation is performed. This will be a detailed Model Specification test using OAQPS's Model Specifications, testing the PEMS at high, medium and low emission rates or high, medium and low operation rates. If the PEMS accurately predicts emissions, the PEMS will continue to be evaluated. If the PEMS does not accurately predict emission rates for a pollutant (e.g., SO_2 or PM) at this stage then IP may choose to do more PEMS development work and then redo this formal validation test for that pollutant at a later time, or may choose to exclude that pollutant from further evaluation.	7 months	yes
Formal Validation #2	A Model Specification Test will be performed 3 months after the formal validation test #1. CEMs data will be used to further evaluate PEMS performance	10 months	yes
Formal Validation #3	A Model Specification Test will be performed 6 months after the formal validation test #1. CEMs data will be used to further evaluate PEMS performance.	13 months	yes
Annual Model Specification Test	This will be an additional Model Specification Test one year after the formal validation.	25 months	yes
Project Completion	Technical Review Team determines if PEMS are successful. If successful, ME DEP submits SIP revision, which EPA intends to approve.	26 months	no
	<u>OR</u> Technical Review Team determines PEMS are a failure - project terminates or Technical Review Team analyses problems and IP attempts to resolve.	26 months	yes

2.0. Facility Description

2.1 Plant Description

The Androscoggin Mill is a large, integrated kraft pulp and paper mill producing finished coated and uncoated paper at a combined rate of 1,600 tons per day. Approximately 1,300 tons of kraft pulp and 300 tons of groundwood pulp are produced per day from a combination of hardwoods and softwoods.

Wood is brought into the mill in the form of logs and wood chips. Logs are unloaded in the woodyard onto piles that are sorted by species with soft wood and hardwood in different piles. Logs are fed to a water flume where they are transported to one of three wood rooms where bark is removed. Most logs are then chipped and transported to chip silos or chip piles for further storage. Chips in the chip silo are screened to remove both oversized and fine chips for reprocessing or incineration in the WFI. A small percentage of logs are made into groundwood pulp through a grinding process and this is used directly in the paper making process and bypasses the chemical digestion and pulping operations.

Chips are fed to one of two continuous digesters where the lignin is dissolved with a highly caustic solution containing caustic (NaOH) and sodium sulfide (NaS_2) known as white liquor. The continuous digesters include several steps including chip metering, chip presteaming (the chips are impregnated with steam to increase the absorption of white liquor), mixing with white liquor, digestion (performed at high temperature and pressure), and finally the blow tank where the pulp from the digester is released to atmospheric pressure.

Once the chips have been digested and most of the lignin has been removed, the remaining pulp is bleached where further lignin is removed and the pulp is brightened. Process steps include chlorine dioxide "bleaching" in an acidic medium, alkaline extraction (washing), and peroxide delignification. These steps bring the pulp to the desired "brightness" while maintaining optimal strength.

Pulp is pumped to stock storage chests and then pass through refiners which prepare the pulp fibers for paper making. The pulp is then mixed with additives including clay, titanium dioxide, and calcium carbonate which are used for various purposes including coating, whitening, and bulking the pulp mixture when making the paper. The pulp is pumped to the headbox which evenly distributes the pulp mixture onto the fourdrinier, the fine mesh screen which drains the water from the pulp mixture and lays the fibers in line further draining to make the initial sheet of paper. The solids content goes from 0.5% when sprayed onto the fourdrinier to 20% as the sheet moves onto the next step.

Once the "paper" goes through the fourdrinier the sheet passes through a number of compression rollers, vacuums, and drum dryers to flatten dry and smooth the paper. Some of the paper sheets are also coated with clays, sized with starch and calendared to fine tune the thickness of the paper as well as smoothen it out and make the paper glossier.

Kraft mills (such as Androscoggin) employ a chemical recovery cycle to minimize the purchase of chemicals. The digestion process discussed earlier produces black liquor containing the digestion chemicals and partially oxidized lignin removed from the wood chips. This black liquor is burned in the recovery boilers to produce heat for steam production, and recover sodium carbonate and sodium sulfide. These chemicals are then causticized to convert sodium carbonate to calcium carbonate. This is then passed through the lime kiln which converts calcium carbonate to lime and this is slaked to produce quick lime which is used in the digestion process discussed previously.

Wood chips are cooked in 1 of 2 continuous digesters with a cooking chemical, called white liquor. As chips are continuously fed into a digester, cooked pulp (brown stock) is removed and separated from the spent (used) cooking liquor by washers. The separated pulp fibers are moved to the bleach plant, and the spent cooking liquor goes through a recovery process described below. In the bleach plant, the pulp is allowed to react with a chlorine dioxide (ClO_2) mixture to further aid in the bleaching process. Washers then filter the fibers out of this solution and the fibers pass on to a caustic (NaOH) and peroxide (H_2O_2) solution and back to a chlorine dioxide solution that extracts the remaining lignin. Washers then filter the fibers, called bleached stock, out of this solution. The fibers are now essentially ready for use.

The kraft process recovers the cooking liquor chemicals after they are spent. After the spent cooking liquor, called black liquor, is separated from the cooked pulp, it is concentrated by evaporating much of its water content. This concentrates the organic lignin cooked out of the wood chips as well as the inorganic chemicals. This concentrated black liquor is then burned in one of two recovery boilers where the organics provide the fuel to produce steam and the inorganic chemicals form smelt which flows out the bottom of the boiler into the smelt dissolving tank to form green liquor, the beginnings of the new cooking liquor. The lime from the two on-site lime kilns is then reacted with a green liquor solution to form white liquor, which is the new cooking liquor used in the digesters. The spent lime (lime mud) is washed to remove the remaining alkaline material. The filtrate is called weak wash and is used as make-up.

The lime kilns are used to reburn lime mud ($CaCO_3$) and convert it to lime (CaO). The lime is then slaked and causticized with green liquor from the recovery boilers to form white liquor. The white liquor is reintroduced to the kraft cycle.

All sludges to be burned in the WFI are generated from the wastewater treatment system which is an activated sludge treatment system and includes primary clarification, activated sludge lagoon and secondary clarifiers. The primary clarifiers treat wastewaters from the paper machines where paper solids and fibers are gravity settled. Wastewaters from the rest of the mill (such as bleaching and pulping), and the treated water from the primary clarifiers flow directly to the lagoon for biological treatment, and then onto the secondary clarifier where solids are separated. Solids collected from both the primary and secondary clarifiers are passed through filter presses to reduce moisture content and then trucked to the WFI for incineration.

The mill generates power to run the facility using two on-site power boilers, a waste fuel incinerator (WFI), and two recovery boilers. The power boilers burn No. 6 fuel oil and the WFI burns No. 6 fuel oil (waste oil), bark, paper, and sludge. The recovery boilers, which have been discussed previously also produce steam for the facility. A portion of IP's electricity needs is purchased from Central Maine Power Company.

2.2 Summary of Emission Sources

2.2.1 IP's Emission Sources

There are five major stacks located at the Androscoggin Mill which are discussed in detail in the following sections. A summary is provided below. The sources include the:

- Waste Fuel Incinerator (WFI) which is vented to Stack #2,
- Power Boilers #1 and #2 (both boilers exhaust through common Stack #1),
- Lime Kilns #1 and #2 (emissions from Lime Kiln #1 are vented to Stack #3 and emissions from Lime Kiln #2 are vented to Stack #4),
- Recovery Boilers #1 and #2 which exhaust through common stack #5,
- Smelt Tanks #1 and #2, and the
- Regenerative Thermal Oxidizer (RTO) System.

All are described in further detail below. Table 1 provides a list of the major emission sources and their license limits for the IP mill.

Table 1 Summary of Major Emission Sources and their Limits[6]

Emission Sources	PM (lb/hr)	PM_{10} (lb/hr)	SO_2 (lb/hr)	NO_X (lb/hr)	CO (lb/hr)	VOC (lb/hr)	TRS* (ppmv)[1]
Power Boilers #1 and #2	232	232	2185.4	518.5	38	11.6	—[2]
Recovery Boilers #1 and #2	133.3	133.3	806.6	213.3	266.6	22.3	5
Waste Fuel Incinerator	**48**	**48**	**196.8**	**179.2**	**1200**	**140.2**	**---**
Lime Kiln #1	25.5	25.5	6.7	33.3	333.3	1.4	20
Lime Kiln #2	25	25	6.7	33.3	333.3	1.4	20
Smelt Tank #1	13.7	13.7	2.7				.066 (lb/ton BLS) [3]

Smelt Tank #2	11.7	11.2	3.9	---	---	---	.066 (lb/ton BLS) [3]
Regenerative Thermal Oxidizer (RTO) System	1.0	1.0	2.02	0.8	1.2	3.0	0.2 (lb/hr)
IP Actual Licensed Emissions for These Stacks[5]	490	490	3211	978.4	2172	179.9	NA[4]
Androscoggin Energy LLC[6]	*19.2*	*19.2*	*12.5*	*82.7*	*202*	*11.2*	---

* - TRS = Total Reduced Sulfur
1 - Units are in ppmv unless otherwise noted
2 - "—" means no limit
3 - lb/ton BLS is lbs TRS per ton Black Liquor Solids
4 - limits are expressed in different units Total emissions for this pollutant not totaled
5 - See license for actual totals
6 - Approximate limits shown for comparison purposes, see license for actual limit values and any additional limitations.

2.2.2 Potential Replacement of Power Boilers

Androscoggin Energy LLC has constructed a natural gas cogeneration facility producing electricity and waste steam next to the IP facility. It is expected to come on line in the beginning of the year 2000. If the cogeneration facility operates as intended, IP will purchase their waste steam and use it in place of the steam generated by Power Boilers #1 and #2 which will be either shut off and only used as back up steam sources, or operated at a low firing rate. This will further reduce air impacts from the mill (air emissions from the Androscoggin Energy LLC are significantly less than that of the Power Boilers.)

2.3 Description of Waste Fuel Incinerator

The waste fuel incinerator (WFI) is used to produce steam from the combustion of low sulfur (1.8% sulfur) #6 fuel oil, wood residue (bark), wastewater treatment plant sludge, waste paper, and waste oil. Like the lime kiln, particulate matter (PM) emissions from the WFI are only measured during annual stack tests. An opacity monitor cannot be used as a surrogate because of the high moisture content caused by the scrubber. Other emissions (SO_2 and NO_x) are presently being measured using CEMS. Carbon monoxide is being monitored through stack tests.

The WFI was manufactured by Babcock and Wilcox and constructed in 1975. The boiler is rated at design capacity 240MMBtu/hr heat input from the firing of oil and 480 MMBtu/hr heat input and 317,000 lb steam per hour at 900 psig, firing a combination of fuels including biomass and oil. Biomass includes sludge, wood waste (including bark, knots, and screenings, etc.), residue, sawdust absorbed with oil, and waste papers. Oil includes #6 fuel oil, specification waste oil, and oily rags, each with a maximum sulfur content not exceeding 1.8% by weight.

The WFI is not subject to the EPA NSPS Subpart D applicability date of 1971 for Fossil- Fuel-Fired Steam generating units greater than 250 MMBtu/hr. Pollutants emitted from the WFI and regulated by the state are PM, PM10, SO_2, NO_X, CO, and VOC. Emissions are vented to Stack #2. The WFI is controlled by a variable venturi scrubber and demister arrangement, installed with a water spray into the demister. The scrubber media is pH controlled by a caustic solution. In addition, the WFI is equipped with a combustion system designed to ensure the optimal balance between control of NOx and limitation of CO and VOCs.

2.4 Description of Other Air Emission Sources

2.4.1 Power Boilers #1 and #2

Power Boilers #1 and #2 were both manufactured by Babcock and Wilcox with a design heat input capacity of 680 MMBtu/hr each. Power boiler #1 was installed in 1965 and Power boiler #2 was installed in 1967, both prior to the new Source performance Specifications (NSPS) Subpart D applicability date of August 17, 1971 for fossil Fuel-Fired Steam generating units greater than 250 MMBtu/hr.

Power Boiler #1 was converted in 1977 from an oil and bark burning design to fire #6 fuel oil only. This conversion did not result in any design capacity increase and since it was originally installed with oil burning capacity it is therefore not subject to the NSPS applicability date for Subpart D. Both boilers exhaust through a common stack (Stack #1). Regulated pollutants emitted from Power Boilers #1 and #2 are particulate matter (PM), PM10, SO_2, NO_x, CO, and VOCs.

2.4.2 Lime Kilns #1 and #2

Lime Kiln #1 was constructed in 1965, and Lime Kiln #2 was constructed in 1975. Neither of the Lime Kilns are subject to EPA NSPS requirements of 40 CFR 60 Subpart BB, for kraft Lime kilns manufactured after September 24, 1976. The design parameters for the two lime kilns are identical. Each lime kiln is fueled with #6 fuel oil with a design capacity of 8 gal/min (72MMBtu/hr). Design capacity is 248 tons CaO/day each. Lime kiln #1 underwent repair in the fall of 1988. No pulp production increase was realized, not did the cost of repairs exceed 50% of the construction cost of a similar unit and, thus NSPS does not apply.

The #6 fuel oil is fired to aid in the recalcination of the lime, which is then returned to the slackers. In addition, Lime Kilns #1 and #2 are used to incinerate Non Condensible Gases (NCGs) generated by the pulping process at the International Paper facility. Each lime kiln is capable of subjecting NCG gases to 1200°F for at least 0.5 seconds. Both lime kilns serve as the primary and backup and TRS control devices as required on Chapter 124 of the Maine State Regulations.

In 1995, International Paper made minor adjustments to each lime kiln to allow for the combustion of these gases without the presence of lime mud within the preferred (referred to as the tertiary backup system). As part of that project, IP installed an NCG scrubber to scrub the sulfur gases by using a white liquor shower through a packing medium. Particulate emissions from Lime Kiln #1 are controlled by a Peabody variable throat venturi scrubber, and Lime Kiln #2 by an Airpol fixed throat venturi scrubber. The lime mud is also an effective media to scrub SO_2 emissions generated from incineration of TRS gases. Regulated pollutants emitted from the lime kilns are PM, PM10, SO_2, NO_x, CO, VOC and TRS. Emissions from Lime Kiln #1 are vented to Stack #3 and emissions from Lime Kiln #2 are vented to Stack #4.

2.4.3 Recovery Boilers #1 and #2

International Paper installed Recovery Boiler #1 in 1965, and is a Combustion Engineering boiler, with a rated capacity 2.50 MMlb/day of dry black liquor solids. Recovery Boiler #1 is not subject to EPA NSPS 40 CFR part 60 Subpart BB, for Kraft Recovery Boilers manufactured after September 24, 1976. The boiler was converted to a low odor design in 1985. None of the capital expenditure on the conversion resulted in an increase in capacity of the boiler, thus NSPS does not apply.

International Paper installed recovery Boiler #2 in 1975, and is a Babcock and Wilcox low odor boiler, with a rated capacity 3.44 MMlb/day of dry black liquor solids. Recovery boiler #2 is not subject to EPA NSPS 40 CFR part 60 Subpart BB, for Kraft Recovery Boilers manufactured after September 24, 1976. A new furnace and generating section were installed in a major repair project in the fall of 1988. No increase in capacity resulted, and cost was less that 50% of the capital expenditure of a comparable unit, thus NSPS does not apply. Number 6 fuel oil at 0.5% sulfur content in fired in the recovery boilers for start up, smelt burn out, and under process upset conditions.

The flue gas emissions from the two recovery boilers are combined and controlled by the operation of an Electrostatic Precipitator (ESP). Regulated pollutants emitted from Recovery boilers #1 and 32 are PM, PM10, SO_2, NO_x, CO, VOC and TRS. Both boilers exhaust through a common stack (Stack #5) which was constructed in 1977 as part of the Recovery Boiler #2 construction.

2.4.4 Smelt Tanks #1 and #2

Smelt Tank #1 was installed in 1975 and has a design capacity of 2.50MMlb dry BLS/day (BLS-Black Liquor Solids), it is equipped with a wet scrubber which was installed in 1983. There is no gas pretreatment and no demister. Smelt tank #1 is not subject to EPA NSPS 40 CFR part 60 Subpart BB, for kraft Smelt tanks manufactured after September 24, 1976.

Smelt Tank #2 was installed in 1975 and has a design capacity of 3.44MMlb dry BLS/day, it is equipped with a wet scrubber which was installed in 1976. Again, there is no gas pretreatment and no demister. Smelt tank #1 is not subject to EPA NSPS 40 CFR part 60 Subpart BB, for kraft Smelt tanks manufactured after September 24, 1976. Regulated pollutants emitted from Smelt Tanks #1 and #2 are PM, PM10, SO_2, and TRS. VOC RACT was determined to be the control of emissions by the wet scrubber systems which complies with Chapter 124 for the control of TRS. The smelt tanks are meeting BPT.

2.4.5 Regenerative Thermal Oxidizer (RTO) System

The RTO was installed at the IP facility during the fall of 1995 primarily to collect and control TRS emissions from the brown stack washer systems in order to comply with Chapter 124 and to collect and control VOC emissions from the oxygen delignification system.

The RTO is supplementally fired with #2 fuel oil or propane in order to maintain a 1500^{o}F combustion temperature for 0.5 seconds. As a result of combusting TRS gases SO_2 emissions are created. Therefore, the RTO is equipped with a packed tower type wet scrubber. The RTO system comprises the collection system and associated fans, the RTO and the wet scrubber.

2.5 License Limits versus Actual Emissions

Table 2 below lists the various International Paper point sources (stacks), their license limits, and their 1998 stack test emissions data for SO_2 and PM_{10} that represent output at maximum production. They are presented to show that average emissions are less than license limits (the emission levels that are generally modeled for NAAQS impacts). Other pollutants (NO_x, CO and CO_2) were shown through modeling performed by the ME DEP to have a very limited potential to impact NAAQS.

Average emissions for SO_2 are 35% less than license emissions, and average emissions for PM_{10} are 50% less than license limits. Except for the Power Boilers, SO_2 and PM_{10} emissions for the entire facility are much less than allowed in IP's license limits. International Paper has stated that during summer months the power boilers operate at approximately 70% of maximum production and since there is no pollution control device other than the requirement to use low sulfur fuel, emissions are directly proportional to production, and therefore actual emissions during the summer months should be approximately 70% of those presented in Table 2. If as mentioned in Section 2.2, Androscoggin Energy LLC comes on line, the Power Boilers may operate at a significantly reduced load or be shut off completely. This will further reduce actual emissions; an approximate reduction of 80% for SO_2 and 35% for PM would be realized.

TABLE 2 International Paper's stacks, license limits*, and their actual emissions

	Licensed Allowable SO_2 (lb/hr)	Actual Emissions SO_2 (lb/hr)	Licensed Allowable PM_{10} (lb/hr)	Actual Emissions PM_{10} (lb/hr)
Power Boilers	2,185	2020[1] (1414)	267	145[3]

Recovery Boilers #1 and #2	806	48.8	133	37.5
Lime Kiln #1	7	0.09	25.5	9.8
Lime Kiln #2	7	0.09	25	12
Smelt Tanks #1 and #2	6.6	----	25.4	----
Regenerative Thermal Oxidizer System	2.02	----	1.0	----
Waste Fuel Incinerator	197	10.5	48.8	45.5
TOTAL	3210	2080 [2] (1475)	526	250

***** See license for actual limits

[1] Actual summer emissions during the summer will likely be 70% (1414 lb/hr) of that stated in the table due to reduced production of the Power Boilers. Assuming that emissions are proportional to production, 70% of 2020 is 1414 lb/hr.

[2] Total emissions may be 1475 lb/hr in the summer.

[3] PM emissions may not be reduced proportionally as they are for SO_2 so no additional reduction is extrapolated.

SECTION 3.0 TECHNICAL APPROACH

3.1 Objective and Goals

The primary objective of the project is to develop a PEMS for the WFI that can be used to forecast PM and stay within emission limits. A secondary objective is to develop a PEMS of the stack SO_2 and NO_X emissions as well as Steaming Rate (SR). Steaming rate is a measure of the steam produced by the WFI and is important because this is the primary measure of production for the WFI. The PEMS for SO_2 and NO_X can be used to forecast emissions and stay within emission limits. The PEMS for the steaming rate will simplify maintaining the maximum stable steaming rate (SR) at optimum bark, sludge and oil consumption rates, while also minimizing emission rates. Steaming rate is used by IP to measure production of the WFI. Additional goals include testing an experimental PM CEM during the mill trial (IP is in negotiations with a vendor of PM CEMS to supply a demonstration unit for the PEMS development phase), improving ease of operation, and improving visibility of process responses.

A further goal for IP and of this project is to determine if a more affordable method such as Modified Method 5B is acceptable for PEM verification. A description of the Modified Method 5B is presented in Section 4.6 and a detailed description is found in the attachment to the example bid package found in Appendix B Through Project XL, IP hopes to achieve a cost savings in annual testing costs while at the same time greatly increasing public access to emissions information.

3.2 General Experimental Strategy

3.2.1 Response and Process Variables

For purposes of developing the PEMS, the primary response variables for the WFI to be examined are Particulate Matter (PM), NO_X, SO_2, Steaming Rate (SR), and secondary variables are CO and CO_2. Many additional variables that will be measured and recorded during the experiment and are listed in Appendix A. The PM CEMS will likely be utilized as a novel instrument during the experiment (and is further discussed in Section 4.6.)

The process variables, or parameters, that have been identified and potentially having an impact on WFI emissions are listed in Appendix A. For each process variable the table lists the range (full and normal), where the data is collected, whether or not the variable is adjustable, the recording frequency, comments and response time.

Based on the processes incorporated in the overall WFI design (see drawing in Appendix B), it was decided to break the overall experimental program up into four areas for testing:

1. Dryer/Feed/Boiler Experiment
2. Scrubber Experiment
3. Boiler Operational Experiment
4. Bump Tests (On/Off tests)

This will permit focusing on variables known to be important in each process area, while reducing the number of variables in any one process area from being manipulated simultaneously. It provides some measure of variation in variables which are of interest but lesser importance, and also addresses questions about how boiler operating configuration effects emissions. Bump tests seeks to evaluate process control variables that are either in the "on" or "off" position. The control variable is either "bumped" (turned) to the on position or "bumped" (turned) to the off position.

3.2.2 Process Variables which effect Particulate Matter and Steaming Rate

Thermodynamic and stoichiometric principles indicate that the heating values and moisture contents of the fuels, the fuel feed rates, the fuel/air ratio and atmospheric conditions will dictate the combustion efficiency in the furnace. However, the overall thermal efficiency will depend on cooling water change in temperature (delta T) available for steam production, the amount of solids accumulation on the tube banks, and the pressure drop (delta P) the fans can generate and must overcome in the furnace. All of these variables either directly or indirectly determine the generation rate of combustion particulates and the steaming rate.

The outlet gas temperature that is achieved and wet fuel moisture content determine the equilibrium moisture content of the fuels that can be achieved via the rotary dryer. These variables also determine the consistency of the dried fuel and the amount of particulates that are carried by the dryer outlet gas. The separation efficiency of the cyclones is affected by the temperature, moisture content and particulate load of the dryer outlet gas, all of which combine to determine the particulate load entering the scrubber.

Scrubber efficiency for the WFI is determined by the total flowrate and solids load of the incoming flue gas, the relative feed rates of the recycled scrubber water to the gas conditioner and the venturi, the raw water make up rate, the scrubber water pH and the scrubber water purge rate to the sewer. Currently, the WFI is operated at a maximum steaming rate and the power boilers pick up the changes in demand.

3.2.3 Key Control Variables

A review of the previous considerations together with historical process knowledge of the WFI lead to the following initial selections of Key Control Variables for the experiments in each process area. These variables represent the primary control strategy actually to be tested over the indicated levels. For each experimental run, those variables which will not be varied, but will be active in another experimental run will be held constant. Those variables which are not intentionally varied in any experiment may be held constant, or simply tracked.

The table below shows the key control variables to be used in the experiment along with the anticipated "normal" range. The "normal" range for this experiment is being defined as the upper and lower levels at which the WFI is operated which to produce steam for paper making purposes and which is not likely to cause upset conditions. The WFI is generally not operated outside the ranges presented below.

Run Set	Key Control Variable (to be manipulated)	Lowest Range	Highest Range	Number of Experimental Runs
1.0	**Dryer/Feed/Boiler Experiment**			**19**
	Sludge Feed rate (# of sludge presses)	0	4 or 8	
	Bark Feed Rate (tons per hour)	20	70	
	Bark Species Mix Hardwood/Softwood	0%H 100%S	40%H 60%S	
	Oil Flow (GPM)	4	15	
	Undergrate Damper (% open)	20	80	
	Oil Burner Damper (% open)	20	80	
	New "Lee" Damper (% open)	20	80	
2.0	**Scrubber Experiment**			**19**
	Gas Conditioner Flow (gpm)	50	150	
	Venturi Flow (gpm)	500	1500	
	Recycle Drain Flow (gpm)	150	350	
	Caustic Add Rate (gpm)	0.5	2	
	Scrubber Pressure Drop (inches)	15	25	
	Burner Tip Size	small	large	
	(Or Oil Flow) (gpm)	(4)	(16)	
3.0	**Boiler Operational Experiment**			**6**
3.1	Small oil Burner Tip, 275 MMBtu range			

	Bark feed rate	20	70	
	Oil Flow (gpm)	1.5	3	
3.2	Large oil burner tip, 300 MMBtu			
	Bark feed rate	20	70	
	Oil Flow	4	15	
4.0	**On/Off tests**			
	Sludge Feed Rate	0	8	1
	ID Fan Speed	0.2	0.7	1
	Caustic Add Rate (if included in experimental design)	0.5	2	1
	Knots and Screenings	include	none	1
	Soot Blowing (for each of 8 blowers)	on	off	8
	Bark Dryer Dampers	open	shut	1
	Bark Flow though Dryers	0	100	1
	Total Number of Runs			**64**

Continued review of the Key Control Variables, independent variables and their potential response may lead to modifications to this experimental design. The key control variables as well as the number of experimental runs may be modified by IP but only upon prior written notification through E-mail or facsimile to the Technical Review Team.

Those Key Control Variables which will be tracked throughout the experiment will be recorded and provisions made to place them in a database if they are not conveniently recorded now. All the Key Control Variables listed in Appendix A, will be recorded throughout the entire four experiment types (in the PEMS development phase).

Nuisance variables by definition cannot be directly controlled or their levels set, but can have an effect on the results, which may limit the range of applicability of models based on the particular levels that occur randomly during the experiment. For the PM, SR experiment, those factors include: operator shifts, operators, weather conditions, bark source and sludge source. These variables will also be recorded, primarily to compare with future predictions as these variables change levels.

IP will determine whether or not "scouting" (preliminary tests) runs are needed to test the factors and levels selected. Even if the factors selected have effects on PM and SR, the levels selected for the design may need to be checked to verify that the design will cover the intended range. If determined to be necessary, IP will notify the Technical Review Team in writing, and identify each specific "Preliminary Test." If IP determines that a preliminary set of tests need to be performed, IP will identify the tests and notify the Technical Review Team through E-mail, or preferably by facsimile at least two days prior to the tests.

3.3 Data Analysis Methods (for PEMS Development)

Once the sampling and testing for PEMS development have been conducted, the data will be available electronically, and will be distributed across multiple data bases. To make the data available for modeling, it will be necessary to assemble all the Key Control Variables as column variables in a single large data matrix, in which the rows are the values of all the Key Control Variables at a particular time. The activity of building this matrix as a single ASCII file requires assembly and time synchronization of data, manual entry spreadsheets, log sheets and the statistical database. This manual data editing process results in the data matrix, which will be shared among all modelers.

At present, only neural and statistical models are planned, however, the database will be available to support future use by any modeling procedure. The neural models will provide on-line PM (and other pollutants) and SR predictions to operators so they can rapidly initiate corrective action. The statistical models will be used off-line to summarize the overall pattern of PM and SR variability and their dependence on individual PVs and to provide management with a "black box" cause and effect model of PM and SR variability.

The results of the neural models will be presented to operators and management through the process control computer system and the results will be available both instantly and archivally. The results of the statistical models will be restricted to data gathered during the designed experiment and off-line predictions made using current or forecast key control variable settings, and the results presented using conventional statistical plots and tabular output.

3.4 Testing Limitations for Protection of NAAQS

The ME DEP has performed modeling to determine whether NAAQS impacts might occur both at licence limits, and with the WFI emitting at twice the license limit with the other stacks operating at levels measured during 1998 stack tests. (See Section 2.5). Conclusions from the modeling indicate that if IP maintains their emissions at the levels of their last stack test (which was at maximum output and shown in Table 2 for SO_2 and PM) NAAQS impacts will not occur.

IP has agreed to put controls on their facility operations during testing so that NAAQS will not be impacted. These shall include:

- Operating the Power Boilers at not more than 70% of their maximum output (see Table 2), although, if other sources at the facility are operated at a reduced load, a proportional increase in the Power Boilers may be acceptable with written notification to the technical review team,
- Stopping testing if weather conditions may increase potential for NAAQS impacts. ME DEP and IP will meet prior to testing to discuss potential weather situations that would require cessation of testing,
- Operating all other stacks at emissions or operating levels not greater than the levels of the last stack test (see Table 2). This would be performed by maintaining production at less than or equal to 1998 production levels as measured during the stack test,
- Maintaining some flow through the scrubber conditioner system such that it is never shut off completely and the scrubber system continues to maintain some pollution control capability (scrubber conditioner flow would not decrease below 100 GPM), and
- Additional controls as agreed to by the Technical Review Team will be added as necessary to prevent NAAQS violations.

However, if as planned Androscoggin Energy LLC comes on line and produces steam sufficient to reduce Power Boilers #1 and #2 loads by more than 50%, the controls listed above may be reduced, modified or eliminated based on a written recommendation from the ME DEP.

IP will notify the Technical Review Team in writing (including either by E-mail or facsimile transmission) that the above conditions are being met prior to any testing as discussed in this Test Plan. ME DEP will monitor the facility and production from other IP stacks to assure that they are being operated in accordance with the above conditions.

3.5 Testing Description and Tentative Sampling Schedule

Table 3 shows the testing protocol and tentative sampling schedule for the actual PEMS development (PEMS calibration and testing occurs later in the process and is discussed in Section 4). The key control variables presented in Section 3.2.3 are varied within their "normal" range. As an example, the oil firing rate is varied from 3 gallons per minute to 13 gallons per minute, and scrubber flow is varied from 100 gallons per minute to 500 gallons per minute. Note that as an example of "normal" conditions scrubber flow is never turned off because the WFI would never operate without the scrubber operating at some level to assure that the surrounding environment is never negatively impacted by emissions from this source.

Table 3 also sets forth the number of Modified Method 5 Particulate Matter analyses (see Section 4.6 for a brief description, and the attachment to the Bid Package in Appendix B for a detailed discussion on Modified Method 5 analysis) per operating condition. Between 1 and 4 analyses are performed for each condition.

The estimated duration of each condition is also provided. Durations range between 15 minutes to 3 hours depending on the estimated response time of the WFI as well as to account for any potential variability in the WFI response. The entire experiment is anticipated to take place over 12 days although this may be extended if there are unanticipated delays or if it is determined that additional information should be collected. The schedule may also be altered because of such things as weather or coordination with operational considerations with the rest of the mill. The Technical Review Team will be notified in writing (including either by E-mail or facsimile transmission) of any changes to the schedule.

Table 3
Testing Description and Tentative Schedule

Test Day	**Test Description (description of variables being tested)**	**Number of modified method 5's**	**Test Duration (hours)**	**Estimated hours per day**
Day 1	Normal Operating Conditions (NOC)	4	1.25	
	3.5; Soot blow, one blower	1	.25	
	3.2; Furnace Draft 0.7"	4	1.25	
	transition to 1-1[6]	3	3	
	1-1; 2 sludge presses, 42.5 tons bark/hr, 20% hardwood, 8 gpm oil	4	1.25	8 hours
	Night move to test 1-2			
Day 2	1-2; 0 sludge presses, 20 tons bark/hr, 40% hardwood, 13 gpm oil	4	1.25	
	1-4; 0 sludge presses, 20 tons bark/hr, 40% hardwood, 3 gpm oil	4	3	
	transition to 1-15	4	1.25	
	1-15; 4 sludge presses, 20 tons bark/hr, 40% hardwood, 3 gpm oil	4	1.25	8 hours
	Night move to test 1-13			

Table 3 (cont'd)
Testing Description and Tentative Schedule

Day 3	1-13; 4 sludge presses, 65 tons bark/hr, 0% hardwood, 3 gpm oil	4	1.25	
	1-9; 4 sludge presses, 65 tons bark/hr, 0% hardwood, 13 gpm oil	4	1.25	
	Transition to 1-16	3	3	
Test Day	**Test Description (description of variables being tested)**	**Number of modified method 5's**	**Test Duration (hours)**	**Estimated hours per day**
Day 3 cont'd	1-6; 0 sludge presses, 65 tons bark/hr, 0% hardwood, 3 gpm oil	4	1.25	
	1-11; 0 sludge presses, 65 tons bark/hr, 0% hardwood, 13 gpm oil	4	1.25	8 hours
	Night move to test 1-10			
Day 4	1-10; 2 sludge presses, 42.5 tons bark/hr, 20% hardwood, 8 gpm oil	4	1.25	
	Transition to NOC	3	3	
	NOC	4	1.25	
	3.6; soot blow one blower	1	.25	
	3.3 Caustic addition	4	1.25	8 hours
	Night move to test 1-18			
Day 5	1-8; 4 sludge presses, 65 tons bark/hr, 40% hardwood, 13 gpm oil	4	1.25	
	1-14; 4 sludge presses, 65 tons bark/hr, 40% hardwood, 3 gpm oil	4	1.25	
	transition to 1-7	3	3	
	1-7; 0 sludge presses, 65 tons bark/hr, 40% hardwood, 3 gpm oil	4	1.25	

Table 3 (cont'd)
Testing Description and Tentative Schedule

	1-12; 0 sludge presses, 65 tons bark/hr, 40% hardwood, 13 gpm oil	4	1.25	8 hours
	Night move to test 1-16			
Day 6	1-16; 0 sludge presses, 20 tons bark/hr, 0% hardwood, 3 gpm oil	4	1.25	
Test Day	**Test Description (description of variables being tested)**	**Number of modified method 5's**	**Test Duration (hours)**	**Estimated hours per day**
Day 6 cont'd	1-18; 0 sludge presses, 20 tons bark/hr, 0% hardwood, 13 gpm oil	4	1.25	
	Transition1-3	3	3	
	1-3; 4 sludge presses, 20 tons bark/hr, 0% hardwood, 13 gpm oil	4	1.25	
	1-5; 4 sludge presses, 20 tons bark/hr, 0% hardwood, 3 gpm oil	4	1.25	8 hours
	Night move to test 1-19			
Day 7	1-19; 2 sludge presses, 42.5 tons bark/hr, 20% hardwood, 13 gpm oil	4	1.25	
	1-20; 2 sludge presses, 42.5 tons bark/hr, 20% hardwood, 1 gpm oil	4	1.25	
	1-21; 2 sludge presses, 42.5 tons bark/hr, 20% hardwood, 8 gpm oil	4	1.25	
	Transition to NOC	3	3	
	NOC	4	1.25	
	3.7; Soot blow one blower	1	.25	
	3.13; bark dryer dampers	4	1.25	10 hours
	Night move to NOC			

Table 3 (cont'd)
Testing Description and Tentative Schedule

Day 8	NOC	4	1.25	
	3.8; Soot blow one blower	1	.25	
	3.14; TBD	4	1.25	
	NOC	4	1.25	
	3.9; Soot blow one blower	1	.25	
Test Day	**Test Description (description of variables being tested)**	**Number of modified method 5's**	**Test Duration (hours)**	**Estimated hours per day**
Day 8 cont'd	Transition to 3.4	3	3	
	3.4; Knots and screens in	4	1.25	8.5 hours
	Night move to NOC			
Day 9	NOC	4	1.25	
	3.10; Soot blow one blower	1	.25	
	Transition too 3.15	3	3	
	3.15; Paper out	4	1.25	6 hours
	Night move to NOC			
Day 10	NOC	4	1.25	
	3.11; Soot blow one blower	1	.25	
	3.16; Damper open/closed	4	1.25	
	NOC	4	1.25	
	3.12; Soot blow one blower	1	.25	
	Transition to 3.1	3	3	
	3.1; eight sludge presses	4	1.25	9 hours
	Night move to test 2-1			

Table 3 (cont'd)
Testing Description and Tentative Schedule

Test Day	Test Description (description of variables being tested)	Number of modified method 5's	Test Duration (hours)	Estimated hours per day
Day 11	2-1; Scrubber, 300 gpm condition flow, 1000 gpm venturi, 250 gpm recycle, 20 inch Dp, 9.5 gpm oil flow	2	.75	
	2-2; Scrubber, 500 gpm condition flow, 500 gpm venturi, 150 gpm recycle, 25 inch Dp, 15 gpm oil flow	2	.75	
Day 11 cont'd	2-3; Scrubber, 100 gpm condition flow, 1500 gpm venturi, 350 gpm recycle, 25 inch Dp, 4 gpm oil flow	2	.75	
	2-4; Scrubber, 100 gpm condition flow, 500 gpm venturi, 350 gpm recycle, 25 inch Dp, 15 gpm oil flow	2	.75	
	2-5; Scrubber, 500 gpm condition flow, 500 gpm venturi, 350 gpm recycle, 15 inch Dp, 15 gpm oil flow	2	.75	
	2-6; Scrubber, 100 gpm condition flow, 1500 gpm venturi, 150 gpm recycle, 15 inch Dp, 4 gpm oil flow	2	.75	
	2-7; Scrubber, 500 gpm condition flow, 500 gpm venturi, 350 gpm recycle, 25 inch Dp, 4 gpm oil flow	2	.75	
	2-8; Scrubber, 100 gpm condition flow, 1500 gpm venturi, 350 gpm recycle, 15 inch Dp, 15 gpm oil flow	2	.75	
	2-9; Scrubber, 100 gpm condition flow, 500 gpm venturi, 250 gpm recycle, 25 inch Dp, 4 gpm oil flow	2	.75	

Table 3 (cont'd)
Testing Description and Tentative Schedule

	2-10; Scrubber, 300 gpm condition flow, 1000 gpm venturi, 250 gpm recycle, 20 inch Dp, 9.5 gpm oil flow	2	.75	7.5 hours
	Night move to test 2-11			
Day 12	2-11; Scrubber, 100 gpm condition flow, 500 gpm venturi, 150 gpm recycle, 15 inch Dp, 15 gpm oil flow	2	.75	
Test Day	**Test Description (description of variables being tested)**	**Number of modified method 5's**	**Test Duration (hours)**	**Estimated hours per day**
Day 12 cont'd	2-12; Scrubber, 500 gpm condition flow, 1500 gpm venturi, 150 gpm recycle, 15 inch Dp, 15 gpm oil flow	2	.75	
	2-13; Scrubber, 100 gpm condition flow, 1500 gpm venturi, 150 gpm recycle, 25 inch Dp, 15 gpm oil flow	2	.75	
	2-14; Scrubber, 500 gpm condition flow, 1500 gpm venturi, 350 gpm recycle, 15 inch Dp, 4 gpm oil flow	2	.75	
	2-15; Scrubber, 500 gpm condition flow, 1500 gpm venturi, 150 gpm recycle, 25 inch Dp, 4 gpm oil flow	2	.75	
	2-16; Scrubber, 500 gpm condition flow, 500 gpm venturi, 150 gpm recycle, 15 inch Dp, 4 gpm oil flow	2	.75	
	2-17; Scrubber, 500 gpm condition flow, 1500 gpm venturi, 350 gpm recycle, 15 inch Dp, 4 gpm oil flow	2	.75	
	2-18; Scrubber, 100 gpm condition flow, 500 gpm venturi, 350 gpm recycle, 15 inch Dp, 4 gpm oil flow	2	.75	

Table 3 (cont'd)
Testing Description and Tentative Schedule

	2-19; Scrubber, 300 gpm condition flow, 1000 gpm venturi, 250 gpm recycle, 20 inch Dp, 9.5 gpm oil flow	2	.75	6.75 hours

Emission testing will take place hourly during the transition to the next experimental point.

SECTION 4.0 PEMS EVALUATION

PEMS development will be primarily focused on particulate matter (PM) because there is currently no method to determine PM emissions on a continuous basis for incinerators equipped with wet scrubbers. PEMS will also be developed for SO_2, NO_x, CO_2 and CO (as well as steaming rate) although Continuous Emission Monitors (CEMs) already exist and are in operation for the two of the regulated pollutants (SO_2 and NO_x). PM emissions are currently monitored through stack testing once per year (based on a Town of Jay requirement; the state and federal requirement are once every two years). In order for these PEMS to serve as an alternative monitoring method, the PEMS will have to meet accuracy and reliability specifications discussed more fully below. Evaluation of the steaming rate will be performed by International Paper and be independent of this project, although the results will be used to optimize overall WFI operations.

The accuracy and precision of the PEMS will be determined through a three-phased formal validation test by using the Draft Model Specifications (attached as Appendix C) developed by the EPA Office of Air Quality, Planning and Standards (OAQPS). All five parameters (PM, SO_2, NO_x, CO_2 and CO) will be evaluated by these Model Specifications which statistically evaluate the variability between the measured and predicted emission rates. This formal validation process is expected to start approximately 6 months after project initiation and last for 6 months. An annual Model Specification Test will be performed 12 months after the last formal validation to confirm that the PEMS is not susceptible to drift and remains accurate.

To assure that the PEMS remains reliable and is not impacted by drift, Model Specification tests will be performed three months and six months after the first formal validation test to assure that the PEMS remains accurate. Gas cylinder audits at the current rate will continue to be required for these CEMS. The CEMS for SO_2, NO_x, CO_2 and CO will remain in place until the criteria (as discussed more fully in the FPA) are met. If there are significant divergences between the results of the CEMs and PEMS, the CEMs will be considered but the Model Specification tests will be used to establish the accuracy of the PEMS.

For purposes of evaluating the performance of the PEMS, the decision whether the PEMS passes the specifications will be made on a pollutant by pollutant basis such that the PEMS may be found for example to accurately predict emissions for particulate matter but not predict emissions accurately for carbon monoxide.

4.1 Testing Methods During PEMS Development

For the PEMS development phase, testing for the pollutants of interest will be performed by the following methods:

PM	Modified EPA Method 5B (Stationary Source Procedure)
SO_2:	EPA Method 6C (Instrumental Analyzer Procedure)
NOx:	EPA Method 7E (Instrumental Analyzer Procedure)
CO:	EPA Method 10 (Stationary Source Procedure)

CO_2 & O_2: EPA Method 3A (Instrumental Analyzer Procedure)

Particulate matter will be collected by a Modified Method 5B as described in Section 4.6 as well as in Appendix B. The modification reduces the sampling time from one hour per sample to 10 to 30 minutes per sample. As many as 250 Modified Method 5B tests may be required for PEMS development. All SO_2, NOx, CO, CO_2, and O_2 data will also be collected continuously during each condition with the use of CEMs. Initial particulate results must be provided to IP within 2 hours of test completion. Overall results of this phase will be provided to the Technical Review Team once they have been tabulated but no more than two months after the tests have been completed. The source tester for IP will submit a Source Emission Test Protocol (SETP) to the ME DEP for review prior to testing.

In addition, IP has agreed to install a PM CEM at EPA's request to gather data on this type of technology. It may be used to determine PM concentrations during the model development phase, the formal validation phase and at other times. Continued use of this monitoring device will be determined by the Technical Review Team to help determine its accuracy and reliability. The final decision on how to use this device will be determined by IP and EPA throughout the project.

4.2 Reference Methods

Once the PEMS is developed, PEMS accuracy for PM, SO_2, $NO_{x,}$ CO_2 and CO will be evaluated by the Model Specifications found in Appendix C and further discussed in the subsequent sections. Model Specification testing for the first test in the formal validation phase will be performed by the following methods from 40 CFR Part 60:

- US EPA Method 1 Sample and velocity traverses for stationary sources,
- US EPA Method 2 Determination of stack gas velocity and volumetric flow rate (Type S Pitot tube),
- US EPA Method 3 Gas Analysis for carbon dioxide, oxygen and excess air and dry molecular weight,
- US EPA Method 3A Determination of oxygen and carbon dioxide concentrations in emissions from stationary sources (Instrument analyzer procedure),
- US EPA Method 4 Determination of moisture content in stack gases,
- US EPA Method 5B Determination of particulate emissions from stationary sources,
- US EPA Method 6C Determination of sulfur dioxide emissions from stationary sources,
- US EPA Method 7E Determination of nitrogen oxide emissions from stationary sources.

See Section 4.6 for alternative PM testing methods that may take the place the methods described above. IP may make revisions to the above methods through notification in writing via E-mail or facsimile transmission to the Technical Review Team. The source tester for IP will submit a Source Emission Test Protocol (SETP) to the ME DEP for review prior to testing.

4.3 PEMS Formal Validation

The three PEMS formal validation tests for PM, SO_2, $NO_{x,}$ CO_2 and CO will be performed through stack testing and comparison with the Model Specifications provided in "Example Specifications for

Predictive Emission Monitors (PEMS)" (Appendix C). These specifications are similar to relative accuracy tests for CEMS in that they require a minimum of nine Reference Method tests and require a statistical comparison of the results from the PEMS to the Reference Method (15 Reference Method tests are required for PM.) See the Appendix C for specific details pertaining to this test. The PEMS will be informally evaluated against the existing CEMS for drift as a general performance comparison. The NO_x and SO_2 CEMS (and perhaps PM CEMS) as well as other potential methods may be used by IP and the Technical Review Team to evaluate drift of the PEMS.

4.4 Model Specifications

This Section summarizes the Draft "Example Specifications for Predictive Emission Monitoring System (PEMS)" found in Appendix C and developed by OAQPS. The PEMS for PM, SO_2, NO_x, CO_2 and CO will be evaluated against EPA's Model Specifications which will be used to evaluate PEMS performance at a point in time. Periodic tests at specified intervals will also be performed to consider long term acceptability and is discussed in subsequent sections. The Model Specifications state that performance tests should be performed over a range of operations that are greater than the predicted range of "normal" operations. For example, if the emissions unit is predicted to have operated between 70 and 90% of the permitted limit, the operator should perform tests that at a minimum range from 50 to 100% of the permitted limit. A general discussion of these "Model Specifications" is provided in Sections 4.4.1 through 4.4.5 below. Appendix C contains the complete document.

Please note that the Model Specifications are scheduled to be revised by OAQPS in the next several years. Any revisions to the specifications that are made by OAQPS during the life of this XL project will be incorporated by IP and the Technical Review Team to evaluate the PEMS as discussed in this Test Plan.

4.4.1 PEMS Relative Accuracy

The Relative Accuracy (RA) as specified in the Model Specifications is a statistical analysis comparing the output from the PEMS to the reference method. Specifically, the RA of the PEMS must be no greater than 20 percent of the mean value of the reference method test data in terms of the units of the emission standard or 10 percent of the applicable emission standard - whichever is greater. For emissions below 1/4 of the applicable emission standard, 20 percent of the standard must be used. The reference method tests must be performed in such a way that they will yield results that are representative of the emissions of the source and can be correlated to the PEMS data.

4.4.2 Correlation of Reference Method and PEMS Data

The PEMS and Reference Method test data must be correlated as to time and duration by first determining from the PEMS final output the integrated average pollutant concentration or emission rate for each pollutant reference method test period. Response time must be considered; additionally the results must be correlated to constant units (i.e., O_2).

4.4.3 Number of Tests

For all pollutants except PM, a minimum of nine tests sets of the reference method must be performed. Three sets must be conducted at low emission rates, three at normal levels, and three at high levels. However, 15 Reference Method tests will be performed for PM, with 5 tests at each level. International Paper may choose to perform more than nine tests. If this option is chosen, the tester may at their discretion discard a maximum of three sets of the test results so long as the total number of test results used to determine the relative accuracy is greater or equal to nine, but all data including the rejected data must be reported.

4.4.4 Sensor Drift

A demonstration of the ability to identify failed sensors must be made and if applicable, to reconcile failed sensors while maintaining the PEMS drift to less than 20% of the applicable standard. International Paper may be able to develop methods, independent of the Model Specifications, to assure sensor reliability and accuracy; these must be approved by the Technical Review Team. IP may also develop a separate system to assure minimal drift of the sensors. The schedule and method for sensor evaluation will be determined as the tests proceed.

4.4.5 Inputs into PEMS

International Paper anticipates that there will be over 50 variables that are input into development of the PEMS (see Appendix A). The PEMS development process will use all these variables to develop the model. Once the model is completed, a statistical analysis will be performed to identify the variables that impact emission rates for PM, $SO_{2,}$ $NO_{x,}$ CO_2 and CO. This will also be combined with operation requirements to finalize a list of variables that must be input into the PEMS to predict emissions. International Paper will determine which of these variables will be input into the PEMS electronically and which will be entered manually. As an example, chemical composition of the oil being fired into the WFI will likely continue to be entered manually (because the analysis is performed infrequently at an offsite laboratory.) Fuel flow to the WFI burners will likely be input to the completed PEMS electronically. The information is provided to the PEMS either through sensors with electronic transmission, or the information is recorded after visual inspection and then the data is entered manually.

4.5 Test Frequency and Schedule

Model Specification tests will be performed by International Paper (or its contractors) in two phases. The first is the “Formal Validation Phase” and comprises three tests over six months. The second phase is the annual Model Specification test to be performed approximately18 months after the PEMS is developed to assure that the PEMS remains accurate (See also Section 1.5, Project Timeline).

4.5.1 Formal Validation Phase

The first 3 sets of tests are called the formal validation phase and will be performed once the PEMS system is fully operational and considered “stable” by IP. The first test will be performed as specified in the Model Specifications and will use Reference Methods to determine whether the PEMS accurately predicts emissions for PM, SO_2, and $NOx_,$ CO_2 and CO. If the PEMS passes the test (for each specific constituent), a second test will be performed after three months. After an another three months the third test will be performed. During this six month phase, the CEMs already in place will be used for comparison purposes by the Technical Review Team. This proposed schedule may be modified dependant on weather and operational considerations and as approved by the Technical Review Team.

After the first test according to the Model Specification and using Reference Methods, IP may use alternative monitoring methods (such as using Modified Method 5B, CEMs or other methods) to reduce costs while assuring accuracy - but only after written request and approval from the Technical Review Team.

4.5.2 Annual Model Specification Test

One Model Specification test of the PEMS will occur approximately 12 months after the third formal validation test is completed. The results will be provided to the Technical Review Team for their analysis as they become available (but not more than six weeks after it has been performed).

4.5.3 Further Data Collection for PEM

The neural network program has the ability to automatically "learn" new information and further refine the program that establishes the relationship between variables. IP may use the CEMs and results from the data validation tests to provide additional data to further develop the PEMS program during the life of the XL Project.

4.6 Alternative Particulate Matter Analysis Methods

Alternative methods may be used for particulate matter Model Specification sampling and analysis methodologies once the first formal validation test has been completed and the PM PEMS has passed as approved by the Technical Review Team. One potential method that may be used is a modified Method 5B for Particulate Matter which will also be used during PEMS development (see the detailed description in Appendix B). It is similar to Method 5B except the sample collection period is decreased from 1 hour to less than 30 minutes.

EPA is currently evaluating PM CEMS at a number of different sources with the eventual goal of developing standards and requirements for them. EPA has requested their use at this facility to test and gather data on PM CEMs use at this type of stack. If the PM CEMS is found to be accurate and reliable in this application, IP with concurrence from EPA, ME DEP and the Town, may choose to use this method in its evaluation of the PM PEMS after the first test in the formal validation phase (in place of method 5B). Note that there is currently no federally approved CEM for PM analysis as they continue to undergo evaluation by EPA.

4.7 Gold Disc

The use of a "gold disc" or registered model will be evaluated for use as a mechanism to assure accuracy of estimates, check for model drift, as well as its use as a mechanism for outside sources (such as regulators) to efficiently confirm that the output from the PEMS matches anticipated emission rates at the time of the "check." The "gold disc" will include on a computer diskette all the variable setting such that the PEMS can take these values and determine the emission rates. The settings provided by the gold disc would include several conditions representing "normal operating conditions" as well as several other conditions to confirm the PEMS is operating within the anticipated range. Possible variable ranges could include "high" and "low" ranges, plus or minus one standard deviation of normal operating conditions, or other variant to confirm that the PEMS was operating correctly and providing the correct emission projections. This "gold disc" could be used in conjunction with relative accuracy tests or the PM CEMs. IP will work with the stakeholders and in conjunction with the rest of the Technical Review Team to develop performance specifications for the "gold disc" as well as evaluate its performance during the period of this project.

4.8 Reports, Documents and Submissions

Table 4 below is a summary of reports and submissions IP is to provide for this XL project. Note that times from FPA signing may change but can be used to conceptualize the approximate timing of events. Please note that IP may choose to rerun any failed test, with the following conditions: IP must notify the Technical Review Team of their intent, provide the results of any failed tests, and complete the test rerun within 45 days of the originally scheduled test. Please note that all notifications by IP to the Stakeholders may be done through facsimile or Email, and in many cases this method of notification may also be used for EPA, ME DEP and the Town of Jay.

Table 4 Summary of Reports, Documents and Submissions

Time from Project Start	Document	Description	Submitted to:	Due Date	Response
Month 0	Notification to commence testing*	Letter notifying EPA that IP will commence testing for PEMS development	EPA, State, and Town	14 days prior to testing	none
Month 2	Summary results	Results of testing for PEMS Development	Technical Review Team	One month after testing is completed	none
Month 6 (and every six months after that)	Semiannual progress report	2 page description of activities to date with any analytical results attached (not previously submitted)	EPA, State, Town, Stakeholders, and WEB	every 6 months	none
Approximately month 7	Notification to commence validation test #1*	PEMS formal validation (test 31) - letter notifying EPA that IP will commence testing	EPA, State, and Town	14 days prior to testing	none
Approximately month 8 and ½	results of validation test #1 and statistical analysis	Results of formal validation (test #1) with data	EPA, State, Town, Stakeholders, and WEB	30 days after completion	EPA states whether PEMS passed and IP can move onto next step
Time from Project Start	**Document**	**Description**	**Submitted to:**	**Due Date**	**Response**

Month 10	notification to commence testing of validation #2*	PEMS formal validation (test #2) - letter notifying EPA that IP will commence testing	EPA, State, and Town	14 days prior to testing	none
Approximately month 11 and ½	results of validation #2 and statistical analysis	Results of validation #2 with data	EPA, State, Town, Stakeholders, and WEB	30 days after completion	EPA states whether PEMS passed and IP can move onto next steps
Month 13	notification to commence testing validation #3*	PEMS formal validation (test #3) letter notifying EPA that IP will commence testing	EPA, State, and Town	14 days prior to testing	none
Approximately month 14 and ½	results of validation #3 and statistical analysis	Results of validation (test #3) with data	EPA, State, Town, Stakeholders, and WEB	30 days after completion	EPA states whether PEMS passed and IP can move onto next steps
Month 24	notification to commence testing of annual test*	PEMS Annual Model Specification test - letter notifying EPA that IP will commence testing	EPA, State, and Town	14 days prior to testing	none
Month 25	Annual Model Specification test	results of annual Model Specification test	EPA, State, Town, Stakeholders, and WEB	30 days after completion	EPA analyzes data and states whether PEMS is successful

* Each notification letter will also include a statement that the conditions stated in Section 3.4 will be met during testing.

APPENDIX A

WFI PARAMETERS TO BE RECORDED WITH ESTIMATED RANGE AND DATA RECORDING FREQUENCY

APPENDIX B

EXAMPLE
INTERNATIONAL PAPER EXAMPLE BID PACKAGE
(for Stack Testing during PEMS Development)

APPENDIX C

EXAMPLE SPECIFICATIONS AND TEST PROCEDURES FOR PREDICTIVE EMISSIONS MONITORING SYSTEMS

APPENDIX C

EXAMPLE SPECIFICATIONS AND TEST PROCEDURES FOR PREDICTIVE EMISSIONS MONITORING SYSTEMS

(Developed by OAQPS)

1. APPLICABILITY AND PRINCIPLE

1.1 Applicability.

1.1.1 This specification is to be used for evaluating the acceptability of predictive emission monitoring systems (PEMS's) at the time of or soon after installation and whenever specified in the regulations. The PEMS may include, for certain stationary sources, a diluent (O_2 or CO_2) PEMS.

1.1.2 This specification is not designed to evaluate the installed PEMS performance over an extended period of time nor does it identify specific validation techniques and other auxiliary procedures to assess the PEMS performance. The source owner or operator, however, is responsible to validate, maintain, and operate the PEMS properly. To evaluate the PEMS performance, the Administrator may require, under Section 114 of the Act, the operator to conduct PEMS performance evaluations at other times besides the initial test.

1.1.3 The owner or operator may conduct this performance specification test in a restricted range of operation in accordance. For example, if the permitted range of operation of the emissions unit were between 50% and 100% of the possible range, and the owner or operator wishes to restrict the emissions unit to operation between 80% and 100% of the possible range for some reason (e.g. production schedules), the initial performance specification test may be performed for that restricted range. If, at a later date, the owner or operator elects to operate outside of the restricted range, then the owner or operator must conduct a relative accuracy (RA) test within 60 days of operation in that range to demonstrate that the PEMS can provide acceptable data when operating in the new range. The RA test at the new range is to be done by performing a single 9 point RA test within the new range using the appropriate test methods.

1.2 Principle. Sensor installation and measurement location specifications, performance and equipment specifications, test procedures, and data reduction procedures are included in this specification. Reference method tests and PEMS drift tests are conducted to determine conformance of the PEMS with the specification.

2. DEFINITIONS

2.1 Centroidal Area. A concentric area that is geometrically similar to the stack or duct cross section and is no greater than l percent of the stack or duct cross-sectional area.

2.2 PEMS. The total equipment required for the determination of a gas concentration or emission rate. The system consists of the following major subsystems:

2.2.1 Sensors and Sensor Interface. That portion of the PEMS used for the following: Process data acquisition; process data transportation between the sensors and the emission model(s); and sensor validation.

2.2.2 Emission Model(s). That portion of the PEMS that utilizes process data or reconciled process data and generates an output proportional to the gas concentration or emission rate. The emission model may generate emissions data in terms of the applicable emission limitation without the use of a diluent emission model.

2.2.3 Diluent Emission Model (if applicable). That portion of the PEMS that utilizes process data or reconciled process data and generates an output proportional to the diluent gas concentration (e.g., CO_2 or O_2).

2.2.4 Data Recorder. That portion of the PEMS that provides a permanent record of the analyzer output. The data recorder may
include automatic data reduction capabilities. The data recorder may include electronic data records, paper records, or a combination of electronic data and paper records

2.2.5 Sensor Validation System. That portion of the PEMS that analyzes the process data to ensure the accuracy of the gas concentration determined by the emission model(s) including any diluent emissions model(s), and to provide reconciled process data in the event of a failed sensor.

2.3 PEMS Drift (PD). The difference in the PEMS output readings from the reference value(s) due to the effect of sensor drift and the effect of utilizing reconciled process data for when a sensor or any combination of sensors has failed.

2,4 Reference value. Based on reference method testing, a baseline PEMS measurement during which time each sensor has been determined to be functioning properly.

2.5 Relative Accuracy (RA). The absolute mean difference between the gas concentration or emission rate determined by the PEMS and the value determined by the reference methods (RM's) plus the 2.5 percent error confidence coefficient of a series of tests divided by the mean of the RM tests or the applicable emission limit.

2.6 Representative Results. As defined by the RM test procedure outlined in this specification.

2.7 Failed Sensor or Sensor Failure. A sensor which, by comparison to the other sensors, has been determined to have failed or drifted such that the difference between PEMS output readings and reference values are beyond the allowable PEMS drift criteria.

3. INSTALLATION AND MEASUREMENT LOCATION SPECIFICATIONS

3.1 Sensor Installation. All sensors shall be installed at an accessible location in order to be able to perform, as necessary, repairs and replacements. Accessible locations does not require the installation of permanently installed platforms or ladders. Sensors may be at locations which require emission unit shutdown in order to repair or replace a failed sensor. After repair or replacement of a sensor, the process data from the sensor shall be, if necessary, corrected to provide process data which is representative of the process data obtained from the previously installed sensor.

3.2 Reference Method Measurement Location and Traverse Points.

3.2.1 Select, as appropriate, an accessible Reference Method (RM) measurement point at least two equivalent diameter downstream from the nearest control device, the point of pollutant generation, or other point at which a change in the pollutant concentration or emission rate may occur, and at least a half equivalent diameter upstream from the effluent exhaust or control device. When pollutant concentration changes are due solely to diluent leakage (e.g., air heater leakages) and pollutants and diluents are simultaneously measured at the same location, a half diameter may be used in lieu of two equivalent diameters.

Then select a traverse point or points that assure acquisition of representative samples over the stack or duct cross section. The following procedure is used to establish a traverse point which yields representative results: Establish the number and location of each traverse point for the sampling location in conformance with Test Method 1; Measure emissions in accordance with the applicable RM test method(s) at each traverse point for a period of two minutes plus the twice the test method's system response time; Determine the average of the emissions; and Locate the traverse point with emissions nearest the average of the emissions as the sampling location for the RM tests. Results from previous studies may be used.

In lieu of determining a single traverse point to provide representative emissions, the following procedure may be used to locate the traverse points for conducting the RM tests: Establish a "measurement line" that passes through the centroidal area and in the direction of any expected stratification; Locate a minimum of three traverse points at 16.7, 50.0, and 83.3 percent of the measurement line or, if the measurement line is longer than 2.4 meters, the tester may choose to locate the three traverse points on the line at 0.4, 1.2, and 2.0 meters from the stack or duct.

The tester may select other traverse points, provided that they can be shown to the satisfaction of the Administrator to provide a representative sample over the stack or duct cross section. Conduct all necessary RM tests within 3 cm (but no less than 3 cm from the stack or duct wall) of the traverse point or points.

4. PERFORMANCE AND EQUIPMENT SPECIFICATIONS

4.1 Data Recorder Scale. The PEMS data recorder response range must include a low-level (zero to 20% of the applicable emission standard) and a high-level value. The high-level value is chosen by the source owner or operator and is defined as follows:

4.1.1 For a PEMS intended to measure an uncontrolled emission (e.g., NO_x measurements at the stack of a natural gas fired boiler), the high-level value must be between 1.25 and 2 times the average potential emission level, unless otherwise specified in an applicable regulations. For a PEMS installed to measure controlled emissions, the high-level value must be between 1.5 and 2.0 times the pollutant concentration corresponding to the emission standard level. For a PEMS installed to measures emissions that are in compliance with an applicable regulation, the high-level value must be between 1.1 and 1.5 times the pollutant concentration corresponding to the emission standard level. If approved by the Permitting Authority. a lower high-level value may be used.

4.1.2 The data recorder output must be established so that the high-level value is read between 90 and 100 percent of the data recorder full scale. This scale requirement is not applicable to digital data recorders.

4.1.3 The PEMS design must allow the automatic or manual determination of failed sensors. At a minimum, an hourly determination must be performed.

4.1.4 In the event of a failed sensor(s), the PEMS design may include the automatic or manual reconciliation of the process data provided that the PEMS emissions have been demonstrated to not have drifted by more than 20 percent of the applicable emission standard.

4.2 PEMS Drift. The PEMS must not drift or deviate from the reference value by more than 20 percent of the applicable emission standard based upon a perturbation analysis of the effect of sensor drift and the effect of utilizing reconciled process data for when a sensor or any combination of sensors has failed. If the PEMS includes emission and diluent models, the PEMS drift (PD) must be determined separately for each.

4.3 PEMS Relative Accuracy. The RA of the PEMS must be no greater than 20 percent of the mean value of the RM test data in terms of the units of the emission standard or 10 percent of the applicable emission standard, whichever is greater. For emissions below 1/4 of the applicable emission standard, use 20 percent of the standard.

5. PERFORMANCE SPECIFICATION TEST PROCEDURES

5.1 Pretest Preparation. Install the PEMS, prepare the RM test site according to the specifications in Section 3, and prepare the PEMS for operation according to the manufacturer's written instructions.

5.2 PEMS DRIFT TEST PROCEDURE.

5.2.1 Prior to the initial Relative Accuracy, a demonstration of the ability of the PEMS to identify failed sensors and, if applicable, to reconcile failed sensors while maintaining the PEMS drift to less than 20% of the applicable standard shall be performed. This demonstration shall be conducted at a high-level reference value or a range of high-level reference values. The high-level reference value(s) must be between 75% to 100% of the pollutant concentration which corresponds to the applicable emission standard. The perturbation analysis shall be conducted as follows:

5.2.2 General Records. Record: the high-level reference value(s); the expected range of sensor values; the baseline sensor values at the reference values; the percent change in sensor value from the baseline sensor value established as the point at which the sensor is considered to have failed; and the sensor value which results in the sensor to be considered a failed sensor.

5.2.3 Analysis of Failed Sensor Values. Artificially perturb each sensor to the sensor value immediately prior to the sensor value which results in the sensor to be considered a failed sensor, and then record the sensor value and PEMS value. Calculate and record the PEMS drift for each sensor. The PEMS drift for each perturbed sensor value must be less than 20% of the applicable emission standard.

5.2.4 Analysis of Sensor Reconciliation. Artificially perturb each sensor to the sensor value which results in the sensor to be considered a failed sensor, and then record the calculated sensor value and PEMS value. Calculate and record the PEMS drift for each sensor. The PEMS drift for each reconciled sensor value must be less than 20% of the applicable emission standard. Repeat the procedure for the high-level reference value.

5.2.5 Analysis of Combinations of Failed Sensors. Artificially perturb combinations of sensors to the sensor values which result in the sensors to be considered failed sensors, and then record the reconciled sensor values and PEMS value. Calculate the PEMS drift for each combination of failed sensors analyzed. Determine each combination of failed sensors which result in a PEMS drift of less than 20% of the applicable emission standard. The PEMS drift for each combination of reconciled sensor values must be less than 20% of the applicable emission standard in order to be acceptable.

5.3 RELATIVE ACCURACY TEST PROCEDURE

5.3.1 Sampling Strategy for RM Tests. Conduct the RM tests in such a way that they will yield results representative of the emissions from the source and can be correlated to the PEMS data. In order to correlate the PEMS and RM data properly, mark the beginning and end of each RM test period of each run (including the exact time of the day) on the PEMS permanent record of output. Use the following strategies for the RM tests:

5.3.2 Instrumental Test Methods. For all types of emission units, instrumental test methods, e.g., Method 3A, Method 6C, and Method 7E, are recommended.

5.3.3 Non-instrumental Test Methods. For emission units with consistent emissions, integrated or grab non-instrumental test methods, e.g., Method 6 or Method 7, respectively, may be used. A test run for grab samples must be made up of at least three separate measurements. Note that for emission units with varying emissions, if non-instrumental test methods are to be used, then integrated non-instrumental test methods must be used since grab sampling techniques may not provide representative emissions data.

5.3.4 Note. At times, PEMS RA tests are conducted during new source performance standards performance tests. In these cases, RM results obtained during PEMS RA tests may be used to determine compliance as long as the source and test conditions are consistent with the applicable regulations.

5.3.5 Correlation of RM and PEMS Data. Correlate the PEMS and the RM test data as to the time and duration by first determining from the PEMS final output (the one used for reporting) the integrated average pollutant concentration or emission rate for each pollutant RM test period. Consider system response time, if important, and confirm that the pair of results are on a consistent moisture, temperature, and diluent concentration basis. Then, compare each integrated PEMS value against the corresponding average RM value. Use the following guidelines to make these comparisons.

5.3.6 If the RM has an instrumental or an integrated non-instrumental sampling technique, make a direct comparison of the RM results and PEMS integrated average value.

5.3.7 If the RM has a grab sampling technique, first average the results from all grab samples taken during the test run, and then compare this average value against the integrated value obtained from the PEMS during the run.

5.3.8 Number of RM Tests. Conduct a minimum of nine sets of all necessary RM tests. Three sets must be conducted at low-level gas concentrations or emission rates, three at normal-level, and three at high-level. Note: The tester may choose to perform more than nine sets of RM tests. If this option is chosen, the tester may, at his discretion, reject a maximum of three sets of the test results so long as the total number of test results used to determine the RA is greater than or equal to nine, but all data including the rejected data must be reported.

5.3.9 Reference Methods. Unless otherwise specified in an applicable regulations, the test methods contained in 40 CFR Part 60, Appendix A are required. The instrumental test methods, e.g., Methods 3A, 6C, and 7E, are recommended. The tester should ensure that the test method chosen will be able to provide accurate and precise emissions data.

5.3.10 Calculations. Summarize the results on a data sheet.
Calculate the mean of the RM values. Calculate the arithmetic differences between the RM and the PEMS output sets. Then calculate the mean of the difference, standard deviation, confidence coefficient, and PEMS RA, using Equations P-1, P-2, P-3, and P-4, respectively.

6. EQUATIONS

6.1 Arithmetic Mean. Calculate the arithmetic mean of the difference, d, of a data set as follows:

$$\bar{d}=\frac{1}{n}\sum_{i=1}^{n} d_i$$

(Eq. P-1)

Where: n = Number of data points.

d_i = Difference between RM test result and PEMS output

When the mean of the differences of pairs of data is calculated, be sure to correct the data for moisture, if applicable.

6.2 Standard Deviation. Calculate the standard deviation, S_d, as follows:

$$S_d=\left[\frac{\sum_{i=1}^{n} d_i^2-\frac{\left(\sum_{i=1}^{n} d_i\right)^2}{n}}{n-1}\right]^{1/2}$$

(Eq. P-2)

6.3 Confidence Coefficient. Calculate the 2.5 percent error confidence coefficient (one-tailed), CC, as follows:

$$CC=t_{0.975}\frac{S_d}{\sqrt{n}}$$

(Eq. P-3)

Where: $t_{0.975}$ = t-value (see Table P-1).

TABLE P-1. t-VALUES

n^a	$t_{0.975}$	n^a	$t_{0.975}$	n^a	$t_{0.975}$
2	20.706	7	2.447	20	2.201
3	4.303	8	2.365	13	2.179
4	3.182	9	2.306	14	2.160
5	2.776	10	2.262	15	2.145
6	2.571	11	2.228	16	2.131

[a] The values in this table are already corrected for n-1 degrees of freedom. Use n equal to the number of individual values.

6.4 Relative Accuracy. Calculate the RA of a set of data as follows:

$$RA = \frac{|\bar{d}| + |CC|}{\overline{RM}} \times 100$$

(Eq. P-4)

Where: $|\bar{d}|$ = Absolute value of the mean differences (from Eq. P-1).

|CC| = Absolute value of the confidence coefficient (from Eq. P-3).

$\overline{RM}$ = Average RM value or applicable standard.

7. REPORTING

At a minimum (check with the appropriate regional office, or State, or local agency for additional requirements, if any) summarize in tabular form the results of the PD tests and the RA tests or alternative RA procedure as appropriate. Include all data sheets, calculations, and charts (records of PEMS responses), necessary to substantiate that the performance of the PEMS met the performance specifications.