

APPENDIX B.

EMISSION MEASUREMENT AND CONTINUOUS MONITORING FOR PULP AND PAPER COMBUSTION SOURCES

B.1 INTRODUCTION

Between July 1991 and November 1994, EPA gathered emissions data from a variety of information sources in support of a NESHAP for combustion sources in the pulp and paper industry. Sources of information included:

1. An emissions test program sponsored by NCASI;
2. An emissions test program for the Texas Paper Industry Environmental Committee (TPIEC);
3. An emissions test program sponsored by the International Paper Company; and
4. Selected emissions test reports in state agency compliance files.

The industry-sponsored test programs were specifically designed to provide data to: (1) determine the mass emission rates of HAP's from recovery furnaces, BLO units, SDT's, and lime kilns; and (2) determine control efficiencies of APCD's for HAP's.

Emissions testing was performed primarily using manual methods. Locations sampled included the inlet and outlet of the control device(s) where pollution controls were applied, and the effluent stack where they were not applied.

This appendix defines the methods used in the test programs to collect emissions data, discusses alternatives for monitoring emissions to indicate continuous compliance with any proposed

standards, and recommends procedures to demonstrate compliance with proposed standards.

B.2 MEASUREMENT METHODS USED IN DATA COLLECTION

This section presents a summary of measurement methods used to generate emissions data in approximately 29 source test reports. The data in these reports were used to support the development of emissions standards for combustion sources in the pulp and paper industry.

B.2.1 Scope of Test Programs

The types of samples and data collected at each test site, the measurement locations, and test methods used are summarized in Tables B-1 through B-8.¹⁻²⁹ Tables B-2 through B-8 summarize information and data collected as part of International Paper Company's nine-mill emissions test program. Table B-1 summarizes information contained in the remaining 20 emission test reports. Sample types and sampling locations are discussed in Section 2.1. The specific test methods used for collecting and analyzing the samples are discussed in Section 2.2.

B.2.1.1 Types of Samples and Data Collected. The samples collected during the test programs were primarily flue gas samples before or after emission control devices. Because a variety of source emissions test reports were used, a disparity exists in the number and type of pollutants measured at each source.

The source tests contained data for the following pollutants:

1. Metals, including antimony (Sb), arsenic (As), beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr) (total), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), thallium (Tl);
2. SO₂;
3. H₂S, methyl mercaptan, dimethyl sulfide, carbon disulfide, sulfuric acid;
4. Terpenes, α -terpinol, α , β -pyrene, 3-curene, p-cyrene;
5. HCl;
6. CO;

7. NO_x;
8. Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF);
9. Selected organic HAP's, such as acrolein, acetaldehyde, acetophenone, acetone, methanol, carbon tetrachloride, chloroform, chlorobenzene, chloromethane, bromomethanol, isobutyl ketone, methyl ethyl ketone, methylene chloride, 1,2-dichloromethane, trichlorofluoromethane, bromodichloromethane, formaldehyde, 1,1,1-dichloroethylene, 1,1,2-trichloroethane, 1,2,4-trichloroethane, tetrachloroethylene, styrene, toluene, xylenes, benzene; and
10. Semivolatile organics, such as acenaphthene, pyrene, benzo-a-anthracene, chrysene, benzo-b-fluoroanthene, benzo-a-pyrene, dibenzo-a,h-anthracene, benzo-g,h,i-pyrene, indeno-1,2,3-pyrene.

B.2.1.2 Emission and Process Sampling Locations. Flue gas stream samples consisted of uncontrolled gas streams from BLO tanks, SDT's, and recovery furnaces, and controlled streams from ESP outlets and scrubbers following lime kilns and recovery furnaces. Additionally, one test report contained analysis of a quench water process stream. This process stream was analyzed for PCDD/PCDF and metals.

B.2.2 Sampling and Analytical Methods Used

Sampling and analysis methods used at each mill are given in Tables B-1 and B-2. The discussion in this section groups the sampling and analytical methods into three categories:

(1) organic HAP methods, (2) metal HAP methods, and (3) HCl methods.

B.2.2.1 Organic HAP Methods. The methods used to gather organic HAP emissions data included EPA Methods 18 and 23 of 40 CFR 60 Appendix A; Methods 0010, 0011, and 0030 of SW-846; and two methods developed by NCASI. One of the methods developed by NCASI and validated by EPA Method 301 made use of a heated summa canister source sampling train (HSCSST) for collection of the gas sample for later laboratory analysis by gas chromatography (GC) and flame ionization detector (FID) or mass selective detector

(MSD).^{1,2,30,31} This method is capable of measuring a variety of organic HAP's. The HSCSST used a Summa® canister, heated to 130°C, for collecting gaseous samples. The system employed for the analysis of the Summa® canisters was consistent with the requirements of EPA Method TO14, except that the system bypasses the Nafion® permeation dryer.

The other method developed by NCASI and validated by EPA Method 301 made use of a water-filled impinger followed by silica gel traps for capturing methanol and other water-soluble organics such as acetaldehyde, acetone, and methyl ethyl ketone.^{1,32} The collected samples are later analyzed by GC/FID. The method is very similar to EPA's Method 308 for methanol, which is described in Section 4.4.

Differences among the methods include the ability to provide information on multiple pollutants and detection limits. Methods 18, 0010, 0030, and the HSCSST provided information on a greater number of pollutants. Methods 23 (dioxins), 0011 (aldehydes), and 308 (methanol) provided information on a very limited number of pollutants. Detection limits for most of the methods were generally acceptable. However, some of the data gathered using EPA Method 18 did not provide adequate detection limits because the GC set-up variables were not optimized.

B.2.2.2 Metal HAP Methods. At most plants, metal HAP compounds were collected and analyzed using EPA draft Method 29 (also known as draft Method 0012 of SW-846, the EPA combined metals train, or the EPA multimetals train). Differences were noted in some of the older test reports with respect to blank correction procedures and in the treatment of nondetect data. These differences were reconciled before the data were used further.^{33,34} The CARB Method 425 was used at six plants for determining hexavalent Cr emissions.^{16,17,29} At one plant, EPA Method 12 and a modified Method 5 train were used to determine Ni and Mn, and hexavalent Cr emissions, respectively.¹⁰ At this plant, a stainless steel probe was used instead of a glass probe. For this reason, high levels of Cr and Ni were present in the

blanks. The Cr and Ni emissions data at this mill were removed from the NESHAP data pool.

B.2.2.3 Hydrogen Chloride Methods. Hydrogen chloride emissions were determined using EPA Methods 26 and 26A in 40 CFR Part 60 Appendix A. The two methods are very similar, except that in Method 26A the gas sample is collected isokinetically, whereas in Method 26 a nonisokinetic procedure is used. Method 26A is preferred at locations downstream of scrubbers where acid-gas mists are present.

B.3 MONITORING SYSTEMS AND DEVICES

This section presents the various types of continuous monitoring systems and monitoring devices, including data acquisition and data processing systems, readily available on an "off-the-shelf" basis that could be used to monitor emissions. The applicability of these systems to the affected facilities or similar facilities is discussed. This discussion covers such factors as the accuracy, precision, repeatability, reliability, complexity, maintenance, the difficulty of installation and operation of these systems, and costs (capital and annualized). Cost estimates include the costs of setting up and operating the monitoring system, but not the cost of reporting any data collected. Performance specifications are provided, also, if available.

B.3.1 Opacity Monitoring

Opacity monitoring equipment has been routinely used to monitor the opacity of emissions from combustion sources for many years. These monitors are comparatively simple and are easy to install. They are usually installed in the breeching duct or in the discharge stack downstream of any particulate control device. Choice of an appropriate measurement location depends upon source-specific factors, such as effluent ductwork configuration, presence of vibration, ease of access to the location, etc. A detailed discussion of the accuracy, precision, repeatability, reliability, and maintenance requirements for these instruments will not be provided because this monitoring technique is well established.

Estimated initial costs (purchase, installation, performance testing, quality assurance program plan preparation) and annual costs (operation & maintenance, recordkeeping and reporting, program update, quality assurance) for an opacity monitor installed at a stack location are \$39,600 and \$18,800, respectively (all dollar amounts are in 1994 dollars).³⁵

Performance specifications for opacity monitors are contained in Performance Specification 1, Appendix B, 40 CFR Part 60. These requirements were first promulgated on October 6, 1975; substantial revisions were issued on March 30, 1983.

B.3.2 Hydrogen Chloride Monitoring

Emissions monitoring equipment for measuring gaseous HCl is commercially available; monitoring techniques include gas filter correlation (GFC) infrared analyzers, FTIR, ion mobility spectroscopy (IMS), ultraviolet (UV) spectroscopy, on-line specific ion electrodes (SIE), and mass spectrometric techniques. The mass spectrometric technique is not included in the discussion that follows because of its high cost. Detection limits for these instruments range from the low part per billion (ppb) range (e.g., IMS) to the low ppm range (e.g., FTIR). The FTIR and SIE systems are fairly complex systems, whereas the GFC and IMS are not. All of these systems are comparatively new, and, therefore, source-specific installation instructions are not well developed. All systems are prone to difficulties if condensed water is present in the sample delivery lines. Sample lines and other sample delivery components must be relatively inert to moist HCl and should be heated to prevent condensation. For HCl concentrations in the low ppm range, some HCl absorption in the sample delivery system is likely to occur upon monitoring system start up. However, after an initial conditioning period, the HCl instrument readings should become stable. Permapure dryers are the preferred method of moisture removal where moisture contents are high. Gas dilution to reduce the moisture content below the dew point of the gas mixture may also be used. However, the latter technique is not always successful if cold spots are present in the sample delivery system. The gas

dilution technique will dilute the sample below the HCl quantitation limit for some of the instrumental methods.

Limited information can be provided at this time about the accuracy, precision, repeatability, and reliability of HCl monitoring systems as applied to gas streams from pulp and paper mills. It should be noted that none of the aforementioned methods were developed for, or have yet been successfully applied to, measuring HCl emissions from recovery furnaces at kraft pulp mills. However, performance characteristics of GFC monitoring systems at hazardous waste incineration facilities have been studied by EPA and have been found to be acceptable.³⁶

The NCASI completed an evaluation of a TECO 15 GFC monitoring system using the dilution approach for moisture removal.³⁷ Method 26 data were gathered concurrently with the monitoring data. The investigators were unable to establish a good correlation between the GFC monitoring data and the EPA Method 26 data. Several factors may have been responsible for the poor results. For example, the HCl content of the gas stream may have been reduced to levels below the detection limit of the instrument by the dilution gases. It is possible to compensate for the lower gas concentrations by increasing the optical path length. However, sufficient details were not provided in the study to confirm this. Loss of HCl in the sampling lines is also a possibility due to the high moisture contents. Improved HCl recoveries may be achieved by using other moisture management schemes, such as a Nafion® drier at or near the stack. The Nafion® drier would remove moisture while the gas stream is still hot and significantly reduce the potential for water condensation in the sampling lines. Furthermore, the use of the Nafion® drier as an alternative to dilution gases lessens the potential for reducing the HCl concentrations below the GFC monitor detection limits.

Based on information generated in an EPA study of GFC monitoring systems, the initial costs (purchase, installation, performance testing, quality assurance program plan preparation) and annual costs (operation & maintenance, recordkeeping and

reporting, program update, quality assurance) for a GFC monitor installed at a stack location are \$144,500 and \$68,700, respectively.^{35,36} The estimated initial costs and annual costs associated with an FTIR monitoring system are \$162,000 and \$50,000, respectively, and those for an IMS system are approximately \$149,500 and \$68,700, respectively.^{38,39} The SIE systems have not been costed because their performance characteristics are not acceptable.

Performance specifications for HCl monitoring systems in stationary sources are contained in Performance Specification 13, which was proposed on April 19, 1996 along with regulations for hazardous waste combustion systems.⁴⁰

B.3.3 Methanol Monitoring

Emissions monitoring equipment for measuring vaporous methanol is currently commercially available; HAP specific monitors include on-line GC/FID and FTIR. The methanol quantitation limit for the GC/FID system is 2 to 3 ppm.¹ If lower detection limits are needed, an Entech concentrator can be used.

A GC-based monitoring system, called the hazardous organic mass emission rate (HOMER) monitor, is another type of monitoring system that combines EPA Methods 25A and 18 using a direct interface.⁴¹ A total hydrocarbon (THC) analyzer provides a continuous measurement of the THC concentration, as propane, in an extracted gas sample. The analyzer output is recorded by a personal computer-based data acquisition system (PC/DAS). A gas chromatograph equipped with a FID is programmed to semi-continuously analyze the same gas sample stream every 6 minutes, with the GC/FID results being recorded by the PC-DAS. The HOMER software program converts the continuous THC signal to provide a continuous read out of the speciated VOC concentrations (in this case, methanol) in the gas stream using the GC/FID results. This is done by determining the relative response factors (RRF's) for each target VOC on the THC analyzer from gaseous standards of the compound at known concentrations. The GC/FID response determines the proportion of each target VOC in the gas stream. The EPA

recently sponsored a demonstration study of this monitoring system and showed that the HOMER monitor is a viable way to provide continuous information on speciated organic compounds.⁴¹

For emission sources where the correlation between methanol emissions and THC emissions can be established, continuous on-line FID monitors are readily available as surrogate monitors.

Current technical data indicate that the above monitoring systems are applicable for monitoring methanol emissions from SDT's and recovery furnace vents, as well as other pulp and paper vent streams.^{1,2} Although no long-term continuous monitoring data are available, sufficient short-term integrated data have been gathered to establish that both the GC/FID system and the FTIR system can successfully measure methanol emissions from the above sources.^{1,2,42} Data were recently submitted to EPA to demonstrate that the techniques can meet EPA Method 301 criteria.^{30,31,42} It should be noted that none of the monitoring systems suggested for continuous monitoring of methanol emissions have been used for long-term monitoring of combustion sources at kraft or soda pulp mills. Therefore, long-term studies are required to determine the accuracy, precision, repeatability, and costs of setting up and operating the monitoring systems.

The initial costs (purchase, installation, performance testing, quality assurance program plan preparation) and annual costs (operation & maintenance, recordkeeping and reporting, program update, quality assurance) for a HOMER monitoring system installed at a stack location are \$135,300 and \$64,500, respectively.³⁹ The estimated costs associated with an THC monitoring system would be approximately \$115,300 and \$59,800, respectively.³⁹ The estimated costs associated with a FTIR monitoring system would be approximately \$162,000 and \$50,000, respectively.³⁹

Performance specification 8A for THC systems can be found in the background information document which supports proposed regulations for hazardous waste combustion systems.⁴³ Additional performance specifications for THC systems and GC systems were proposed on October 22, 1993 in 58 FR 54648.⁴⁴ The FTIR sampling

and analysis protocols for measuring gaseous organic compounds, such as methanol, can be found in EPA Method 318.^{45,46}

B.3.4 Parametric Monitoring Systems

Scrubber performance is easily monitored with off-the-shelf monitoring equipment for pH and liquid flow rate. There are various techniques for measuring liquid flow rate in a wet scrubber including ultra sonic detection mounted externally on the inflowing water pipe and turbine devices that are mounted within the pipe, both of which generate an electrical signal that can be logically displayed in a control room.³⁸ For liquid streams containing less than 1 percent solids, a paddle wheel sensor can be used to measure the flow rate. If the solids content of the liquid flow stream is greater than 1 percent, an insertion type of sensor must be used to determine flow rate.

The cost of the liquid flow rate monitoring equipment can vary from \$2,000 to \$25,000 depending on the device sensitivity and device location from the control room.³⁵ A complete paddle wheel flowrate monitoring system will cost approximately \$1,200.³⁸ The initial cost of a flow rate monitoring system with an insertion type sensor is approximately \$3,750.³⁸ The initial cost for a pH monitoring system is estimated to be \$5,000.³⁸

B.4 PERFORMANCE TEST METHODS

The following subsections discuss the test methods recommended for measuring emissions of particulates, metal HAP's, opacity, methanol, and HCl. This discussion covers available sampling procedures and analytical techniques. Costs to conduct performance testing using each of the methods are also presented. These costs include preparation of the final test report. In cases where alternate test methods or procedures have been evaluated, comments are provided on the relationships between the data obtained by the alternate methods and the data obtainable by the proposed reference methods. As appropriate, factors that could prevent the use of the reference methods to determine compliance are identified.

B.4.1 Particulate Matter and Metal HAP Emissions

Emissions of HAP metals and PM can be measured simultaneously using EPA Method 29.^{47,48} Because of potential losses of Hg during sample desiccation, it is recommended that PM and Hg not be measured simultaneously. If these two species must both be measured, one of the two following options should be used:

1. Method 5⁴⁹ or Method 17⁴⁹ for PM and Method 29⁴⁸ for Hg and other trace metals of interest, or
2. Method 101A⁴⁸ for Hg and Method 29⁴⁸ for PM and other trace metals of interest.

Method 3, using the integrated sampling techniques, or Method 3A are recommended for measuring O₂ and CO₂.⁴⁹ The concentrations of these gases are necessary for correcting the particulate matter emission rate to a standard basis.

The sampling and analytical cost for three Method 5 runs with associated Method 3 testing is estimated to be \$8,500 (all dollar amounts are expressed in 1994 dollars).⁴⁷ Method 17 may be used as an alternative to Method 5 if a constant value of 0.009 g/dscm (0.004 gr/dscf) is added to the results of Method 17 and the stack temperature is no greater than 205°C (400°F).⁴⁹ No sampling and analytical cost is available for Method 17 test runs. If a three-run Method 29 test for all trace metals and Hg is run in conjunction with a Method 5 test for PM, the additional cost of the Method 29 test would be approximately \$8,750.⁴⁷ The estimated cost for three Method 29 runs for PM and trace metals with associated Method 3 testing is \$12,000.⁴⁷ The additional cost for three Method 101A runs in conjunction with PM/metals testing is estimated at \$5,500.⁴⁷

B.4.2 Opacity

Method 9 should be used to determine the opacity of emissions.⁴⁹ The estimated cost for conducting three Method 9 observations in conjunction with PM emissions testing is \$1,060.⁴⁷

B.4.3 Hydrogen Chloride Emissions

Methods 26 or 26A should be used to determine the HCl emissions.⁴⁹ If the measurement point is downstream of a wet scrubber, Method 26A must be used. The estimated cost to conduct a three-run performance test using Method 26 or 26A is \$9,100.⁵⁰ However, if the Method 26A test is run in conjunction with a Method 5 test, the additional cost for the Method 26A test would be approximately \$600 (above the cost of a Method 5 test) for analyzing the HCl impingers after the PM filters.⁵⁰

B.4.4 Methanol Emissions

Method 308 or the Methanol Sampling Train (MST) should be used to determine methanol emissions.^{32,51} The Method 308 sampling train consists of an unheated Teflon® line, two 30-milliliter (mL) water-filled midget impingers in an ice bath, and one glass adsorbent tube packed in two sections containing 520 milligrams (mg) and 260 mg of silica gel, respectively. The gas sample is nonisokinetically extracted from the sampling point in the stack, and methanol is collected in deionized distilled water and adsorbed on silica gel. The sample is returned to the laboratory, where the methanol in the water fraction is separated from other organic compounds with a GC and is then measured by an FID. The fraction adsorbed on the silica gel is extracted with an aqueous solution of n-propanol and is then separated and measured by GC/FID. The analytical limit of quantitation (LOQ) in the water impinger samples is 0.50 nanograms (ng) (equivalent to about 0.5 ppm methanol in a 20-liter (L) sample of source gas). The overall LOQ for the method is 1.6 ppm of methanol for a 20-L sample of source gas.⁵¹

The MST consists of a glass-lined heated probe, two condensate knockout traps in an ice bath, and three sorbent cartridges packed with Anasorb® 747. A 1:1 mixture of carbon disulfide (CS₂) and N,N-dimethylformamide (DMF) is used to desorb methanol from the Anasorb® samples. The condensate traps also collect a significant amount of methanol, if water is present. Condensate and desorption samples are analyzed by GC/FID. The analytical LOQ in the CS₂/DMF samples is 0.69 ng (equivalent to

about 0.5 ppm methanol in a 20-L sample of source gas). The overall LOQ for the MST is 3 ppm of methanol for a 20-L sample of source gas.⁵¹

The estimated cost to conduct a three-run performance test using Method 308 in conjunction with other performance testing is \$9,500.³⁵ A three-run performance test using the MST in conjunction with other performance testing should cost about \$9,500 and offers the additional advantage that other chemical compounds can be measured simultaneously using the same sampling train, if desired.⁵² Compounds in the emission matrix can be identified by mass spectral library matching if the desorbed samples are analyzed on a GC equipped with an MSD and appropriate computer software.

TABLE B-1. SUMMARY OF PULP AND PAPER COMBUSTION SOURCES TEST PROGRAMS

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
NCASI Test Program: Mill C 3/19/93-3/24/93	Smelt dissolving tank w/AirPol venturi scrubber on vent; scrubber is single-pass (once-through) and uses weak wash as the scrubbing fluid; spent scrubbing fluid is routed to the smelt dissolving tank.	Smelt dissolving tank scrubber outlet	Flue gas/heated Summa® canister source sampling train	Acetone, methanol, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, tetrachloroethylene, styrene, toluene, xylene, benzene, alpha- and beta-pinene, methyl isobutyl ketone, methyl ethyl ketone
			Flue gas/National Council midget impinger train	Acetaldehyde, methanol, acetone, methyl ethyl ketone
NCASI Test Program: Mill H 6/9/93-6/11/93	Babcock & Wilcox NDCE Recovery Furnace (firing rate: 1,200 tons BLS/day) equipped w/ dry-bottom Koppers electrostatic precipitator (ESP)	Recovery furnace ESP outlet	Flue gas/heated Summa® canister source sampling train	Acetone, methanol, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, tetrachloroethylene, styrene, toluene, xylene, benzene, alpha- and beta-pinene, methyl isobutyl ketone, methyl ethyl ketone
	<p>Three sources tested for identical pollutants:</p> <p>Combustion Engineering cascade DCE recovery furnace (firing rate: 2.4 million lb BLS/day at 64-69 percent dry solids, corresponding to a wood pulping rate of 800 ton/day), with 2 combustion air zones; Wheelabrator-Frye wet- bottom ESP with 50 percent solids oxidized liquor. Natural gas used for auxiliary fuel.</p> <p>2-stage Black Liquor Oxidation (BLO) system; Retention times: 1st stage: 2 hours 2nd stage: 3 hours Liquor temperature: 1st stage: 190°F 2nd stage: 175°F</p> <p>Combustion Engineering NDCE recovery furnace (firing rate: 2.4 million lb BLS/day at 64-68 percent dry solids) with 2 combustion air zones; Wheelabrator-Frye wet bottom ESP w/68 percent solids unoxidized black liquor; combustion air and auxiliary fuel configuration identical to No. 3 recovery furnace.</p>	<p>BLO tank vents Nos. 1 and 2;</p> <p>No. 3 recovery furnace ESP outlet</p> <p>No. 4 recovery furnace ESP outlet</p>	Flue gas/heated Summa® canister source sampling train	Acetaldehyde, acetone, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, methylene chloride, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl sulfide, dimethyl disulfide, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, trichloroethylene, tetrachloroethylene, styrene, toluene, m,p-xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone, acrolein

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Champion-Lufkin, TX 4/29/92 - 9/16/92	Fuller gas-fired rotary lime kiln, diameter = 10.5', length = 275', chain section length = 37.5'; produces 125-140 tons/d CaO. Controlled with venturi scrubber (max pressure drop: 19" H ₂ O) which uses fresh water for makeup and throughout the causticizing system. Precoat drum washer (length = 14', diameter = 10') used for mud washing. NCG's are burned in the kiln. (NOTE: all listed emission test methods were run both with and without NCG burning in the kiln).	Kiln stack	Flue gas/M16	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide, dimethyl disulfide
			Flue gas/M18	Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene
			Flue gas/SW-846 M0030	Chloromethane, bromomethane, methylene chloride, acetone, carbon disulfide, chloroform, trichlorofluoromethane, dimethyl disulfide, dimethyl sulfide, n-hexane, 2-butanone, bromodichloromethane, trichloroethene, benzene, toluene, ethylbenzene, a-pinene, b-pinene, p-cymene
			Flue gas/SW-846 M0011	Formaldehyde, acetaldehyde, acetone, acetophenone, methyl isobutyl ketone, acrolein, benzaldehyde
			Flue gas/M29	Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, selenium, thallium
Flue gas/M26	Hydrogen chloride			

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Champion-Lufkin, TX (continued)	Gotaverken NDCE Recovery furnace (black liquor firing rate: 1000 lb BLS/hr or 177 gal/min, saltcake addition rate: 720 lb/hr, black liquor fired at 68% solids); dry-bottom Flakt ESP.	Recovery Furnace No. 14 ESP outlet	Flue gas/M29	Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, phosphorous, silver, selenium, thallium
			Flue gas/M26	Hydrogen chloride
			Flue gas/M26A	Sulfuric acid mist
	Smelt dissolving tank vent on the No. 14 recovery furnace; emissions controlled with low pressure venturi scrubber (pressure drop = -1 in w.c.); scrubber liquor flowrate = 200 gal/min).	Smelt dissolving tank vent scrubber outlet	Flue gas/M29	Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, phosphorous, silver, selenium, thallium
Champion-Sheldon, TX 6/9/92 - 6/24/92	Two-stage black liquor oxidation system Retention times: 1st stage: 460 min 2nd stage: 140 min. Air provided by compressor to each stage. Compressor flow rates: primary stage: 6,760 CFM, secondary stage: 9,000 CFM. Vent gases pass through four Impco foam breakers on the primary stage, and cyclone separator on the secondary stage.	BLO vent	Flue gas/M16 Flue gas/M18	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide dimethyl disulfide Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene
			Flue gas/SW-846 M0030	Chloromethane, bromomethane, methylene chloride, acetone, carbon disulfide, chloroform, trichlorofluoromethane, dimethyl disulfide, dimethyl sulfide, n-hexane, 2-butanone, bromodichloromethane, trichloroethene, benzene, dibromomethane, toluene, ethylbenzene, o-xylene, m-/p-xylene, a-pinene, b-pinene, p-cymene

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Champion-Sheldon, TX (continued)	Combustion Engineering DCE recovery furnace [firing rate: 2,100,000 lb black liquor solids (BLS) per day, corresponding to a wood pulping rate of 575 tons/d; primary and secondary combustion air zones; BL fired at 65 percent solids by weight; 0.003 gal/lb BLS sodium added in the form of sodium acetate; 4 natural gas-fired starter burners located just above primary air ports; brine from tall oil plant added to liquor; BL Btu content = 5800 Btu/lb BLS; recovery furnace temperature range: 1850-1950 °F.] Equipped with ESP; PM concentration in flue gases typically around 0.026 gr/SDCF. <u>Representative process conditions:</u> liquor firing rate: 42 tons BLS/hour sulfidity (green liquor): 65-70% Excess air or O ₂ in furnace: 1-2% Makeup chemicals and addition rates: Sodium acetate @ 4 gal/min* CO, NO _x , SO ₂ , TRS in the furnace @ 8% O ₂ : CO: 175-275 ppm NO _x : 40 ppm SO ₂ : 75-100 ppm TRS: 10-15 ppm *(NOTE: test methods M16, M18, M26 and M0011 were also performed under the conditions of no sodium acetate being added to the furnace.)	Recovery furnace ESP outlet	Flue gas/M16 M0030	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide, dimethyl disulfide
			Flue gas/M18	Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Champion-Sheldon, TX (continued)	DCE recovery furnace (continued)	Recovery furnace ESP outlet (continued)	Flue gas/SW-846 M0030	Chloromethane, bromomethane, methylene chloride, acetone, carbon disulfide, chloroform, trichlorofluoromethane, dimethyl disulfide, dimethyl sulfide, n-hexane, 2-butanone, bromodichloromethane, trichloroethene, benzene, dibromomethane, toluene, ethylbenzene, o-xylene, m-/p-xylene, a-pinene, b-pinene, p-cymene
			Flue gas/M26	Hydrogen chloride
			Flue gas/M26A	Sulfuric acid
			Flue gas/SW-846 M0011	Formaldehyde, acetaldehyde, acetone, acetophenone, 2-butanone, methyl isobutyl ketone, acrolein, benzaldehyde
	Flue gas/M29	Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, phosphorous, silver, selenium, thallium		
	Smelt dissolving tank, equipped with Munters mist eliminators (scrubbing liquid: fresh water); sprays weak wash to flue gas; weak wash contains unstripped condensate, used to dissolve smelt; fumes from tall oil plant enter the tank vent at a point 10' below the bottom showers. <u>Representative process conditions:</u> BLS firing rate: 42 tons BLS/hr Scrubbing liquid flow rate: 30 gal/min Pressure drop in particulate control device: 8 in. H ₂ O Particulate control device: Chevron type demister	Smelt dissolving tank demister outlet	Flue gas/M16	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide dimethyl disulfide

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Champion-Sheldon, TX (continued)	Smelt dissolving tank, continued	Smelt dissolving tank demister outlet, continued	Flue gas/M18	Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene
			Flue gas/M29	Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, phosphorous, silver, selenium, thallium
Inland-Orange Orange, TX 7/13/92 - 7/21/92	Traylor rotary natural gas-fired lime kiln, diameter = 12', length = 260'. Noncondensable gases are normally burned in the kiln. Kiln produces 283 tons/d CaO (equivalent to 1,400 tons/d of unbleached pulp). PM emission controlled w/ variable throat venturi scrubber using fresh mill water. Scrubber pressure drop =14 in w.c. Makeup rate= 68 gal/min <u>Representative process conditions:</u> hot-end temp: 2,284-2,425°F cold-end temp: 721-768°F oxygen in kiln: 4.9%-6.3% lime mud solids: 69.4%-74.4% Na content of mud: 8.3-12.8%	Lime kiln scrubber outlet	Flue gas/M16	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide, dimethyl disulfide
			Flue gas/M18	Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene
			Flue gas/SW-846 M0030	Bromomethane, methylene chloride, acetone, carbon disulfide, acrolein, dibromomethane, 2-butanone, benzene, toluene, styrene

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Simpson-Pasadena-Pasadena, TX 5/18/92-6/25.92	Babcock & Wilcox cyclone DCE recovery furnace with two chamber, eight-field/chamber wet-bottom ESP. Particulate level entering ESP: 15 - 20 gr/CF. Black liquor is oxidized in 2 stages and fired at 62 to 65% solids. Furnace temperature: >2000 °F. Pulp production capacity: 550 tons/d BLS density: 12 lb/gal Liquor firing rate: 60.9 - 66.7 lb BLS/hr Sulfidity (green liquor): 29.9% BL Btu content: 5830 Btu/lb Makeup chemicals: sodium hydrosulfide plus sodium hydroxide Emission data: O ₂ : 7.8% - 8.3% SO ₂ : 58 ppm - 111 ppm TRS: 0.7 ppm - 1.1 ppm	Recovery furnace ESP stack	Flue gas/M16	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide dimethyl disulfide
			Flue gas/M18	Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene
			Flue gas/SW-846 M0030	Chloromethane, bromomethane, methylene chloride, acetone, carbon disulfide, chloroform, trichlorofluoromethane, dimethyl disulfide, dimethyl sulfide, iodomethane, isooctane, n-hexane, 2-butanone, benzene, toluene, ethylbenzene, styrene, m-p- xylene, acrolein, a-pinene, b-pinene, p-cymene
			Flue gas/SW-846 M0011	Formaldehyde, acetaldehyde, acetone, acetophenone, 2-butanone, methyl isobutyl ketone, acrolein, benzaldehyde

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Simpson-Pasadena Pasadena, TX continued	DCE recovery furnace, continued	Recovery furnace ESP stack, continued	Flue gas/SW-846 M0010	A-pinene, b-pinene, 1,2,4-trichlorobenzene, a-terpineol, naphthalene, di-n-butylphthalate, phenol, 2-methylphenol, 1,2,4-trichlorobenzene, naphthalene, di-n-butylphthalate, bis(2-ethylhexyl)phthalate
	Smelt dissolving tank with scrubber; uses fresh water as scrubbing medium.	Smelt dissolving tank scrubber outlet	Flue gas/M16	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide, dimethyl disulfide
			Flue gas/M18	Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene
			Flue gas/SW-846 M0030	Chloromethane, bromomethane, methylene chloride, acetone, carbon disulfide, chloroform, dimethyl disulfide, dimethyl sulfide, iodomethane, isooctane, n-hexane, 2-butanone, 2-chloro-1,3-butadiene, bromodichloromethane, trichloroethane, tert-butyl methyl ether, tetrachloroethene, benzene, toluene, ethylbenzene, styrene, o-xylene, m-p- xylene, a-pinene, b-pinene, cumene, p-cymene
		Flue gas/SW-846 M0010	A-pinene, b-pinene, 1,2,4-trichlorobenzene, a-terpineol, naphthalene, di-n-butylphthalate, butylbenzylphthalate, 2-methylnaphthalene, benzyl alcohol, 1,2,4-trichlorobenzene, naphthalene, di-n-butylphthalate, bis(2-ethylhexyl)phthalate	

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Simpson-Pasadena, TX (continued)	<p>Natural gas-fired rotary lime kiln, diameter = 11.5', length = 275, chain section length = 75'. No NCG's burned in kiln. CaO production rate: 195 tons/d. PM emissions controlled with 2-chamber dry bottom ESP with 6 fields per chamber. Eimco belt filter (length = 16', diameter = 10') used for mud washing and dewatering.</p> <p><u>Representative process conditions:</u> CaO production: 8.1 tons CaO/hr Fuel: natural gas at 56,000 cf/hr Btu/ton product: 7.1 MMBtu/ton of lime Cold end temp: 360°F Hot end temp: 2000°F Solids content of mud: 70% Na₂S and soda content of mud: 0.29% Na₂O</p>	Lime kiln ESP outlet	Flue gas/M16	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide, dimethyl disulfide
			Flue gas/M18	Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene
			Flue gas/SW-846 M0011	Formaldehyde, acetaldehyde, acetone, acetophenone, 2-butanone, methyl isobutyl ketone, acrolein, benzaldehyde

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Temple-Inland Silsbee, TX 7/9/92 - 7/21/92	<p>Combustion Engineering recovery furnace, modified to noncontact configuration. Average firing rate: 1.5 million lb BLS/day, corresponding to a wood pulping rate of 500 tons/d. Primary, secondary, and tertiary air. Black liquor fired at 68% - 70% solids. No makeup sulfur necessary. Recovery boiler temperatures usually >1800°F. Wet bottom ESP; exhaust particulate concentration: 0.047 gr/SDCF.</p> <p><u>Representative process conditions:</u> liquor firing rate: 120 gal/min Sulfidity (green liquor): 4.30 Primary, secondary: 66% primary, 34% secondary Excess air or O₂ in furnace: 7% Black liquor Btu content: 5600 Btu/lb NO_x: 0.10 lb/MMBtu @ 39 ppm TRS: 10 ppm average SO₂: 64 ppm</p>	Recovery furnace ESP outlet	Flue gas/M16	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide, carbon disulfide, dimethyl disulfide
			Flue gas/M18	Methanol, ethanol, acetone, 2-propanol, 2-butanone, chloroform, benzene, bromodichloromethane, toluene, ethyl benzene, m-, p- xylene, o-xylene, cumene, alpha-pinene, beta-pinene, 3-carene, terpenes (unspecified), p-cymene
			Flue gas/SW-846 M0030	Methylene chloride, acetone, n-hexane, 2-butanone, benzene, dibromomethane, toluene, styrene, o-xylene, m-p- xylene, a-pinene, b-pinene, p-cymene
			Flue gas/SW-846 M0011	Formaldehyde, acetaldehyde, acetone, acetophenone, 2-butanone, methyl isobutyl ketone, acrolein, benzaldehyde

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
NCASI Test Program: Mill G 1/27/94- 1/28/94	Babcock & Wilcox NDCE recovery furnace; 4 oscillating liquor guns. Black liquor fired at 65% solids, Btu value = 5400 Btu/lb. 2050 lb BLS produced per ton oven dried pulp. BL inorganic content = 47%. BL from softwood kraft, hardwood kraft, semi-chem pulp lines are mixed before evaporation. Brine used for sulfur make-up. Brine added to BL between evaporators and concentrators. A wet-bottom precipitator, with BL in the bottom, is used for particulate control. <u>Test run-average process information:</u> BLS firing rate: 1343 ton BLS/day BL temperature: 235 °F Air distribution: Primary: 39% Secondary: 45% Tertiary: 16% Boiler CO conc.: 46 ppm Boiler O ₂ conc.: 0.97% Gas Exit Temp: 393 °F	Recovery furnace ESP outlet	Flue gas/heated Summa® canister source sampling train	Acetaldehyde, acetone, acrolein, methanol, mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl disulfide, dimethyl sulfide, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, tetrachlorobenzene, styrene, toluene, m-,p- xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone, n-hexane
			Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
NCASI Test Program: Mill D 5/8/93-5/11/93	Babcock & Wilcox short-body DCE recovery furnace (No. 1 furnace), design capacity: 2.1 million lb/day BLS. BL exits BLOx system at 50% BLS, flows through wet-bottom ESP. Liquor then passes through cyclone-type DCE, where solids content is raised to 65% prior to feed to recovery furnace. <u>Test run-average process conditions:</u> firing rate: 2.7 million lb BLS/day BL temperature: 216 °F BLS concentration: 66.6% Air distribution: primary: 34% secondary: 45% tertiary: 21% Boiler CO conc.: 7 ppm Boiler O ₂ conc.: 3.6%	Recovery furnace ESP outlet	Flue gas/heated Summa® canister source sampling train	Acetone, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl disulfide, dimethyl sulfide, 1,1,1-trichloroethane, 1,2,4-trichlorobenzene, tetrachloroethylene, trichloroethylene, styrene, toluene, m-,p-xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone
			Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde
4/27/93 - 4/30/93	Two-stage black liquor oxidation (BLO) system for No. 1 DCE recovery furnace; air sparged through heavy black liquor in 2 stages connected in series. BL in second stage fed to foam tank, then to No. 1 furnace. During testing, considerably more air was fed to the first oxidation stage than to the second stage (oxidizing BL equally in each stage caused firing problems in the recovery furnace). Design air flow rate = 550 ACFM @ 72°F; oxidation efficiency = 85%; retention time at operating temperature = 9.4 hours <u>Test run-average process conditions:</u> BL flow rate: 236 gal/min BL temperature: 215 °F BL solids conc.: 48%	BLO tank vents Nos. 1 and 2; BLO foam tank vents A and B	Flue gas/heated Summa® canister source sampling train	Acetone, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl disulfide, dimethyl sulfide, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, tetrachloroethylene, trichloroethylene, styrene, toluene, m-,p-, xylenes, o-xylenes, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
NCASI test program: Mill D (continued) 4/29/93- 5/4/93	BLO system, continued	BLO system vents, continued	Flue gas/National Council Midget Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde
	No. 1 and No. 2 smelt dissolving tanks. SDT vent gases are routed through orifice scrubber, with weak wash as scrubbing medium. Scrubber effluent flows into the smelt dissolving tanks. <u>Test run-average operating conditions:</u> No. 1 tank: Recovery firing rate: 1.62 million lb BLS/day Scrubber makeup flow rate: N/A No. 2 tank: Recovery firing rate: 2.89 million lb BLS/day Scrubber makeup flow rate: 377 gal/min	No. 1 and No. 2 smelt dissolving tank scrubber outlets	Flue gas/heated Summa® canister source sampling train	Acetone, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane 1,2- dichloroethylene, dimethyl disulfide, dimethyl sulfide, 1,1,1-trichloroethane, 1,1,2-trichlorobenzene, tetrachlorobenzene, tetrachloroethylene, trichloroethylene, styrene, toluene, m-,p-xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone
			Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde
Potlatch Corp.; Cloquet, MN 4/26/89- 4/27/89	No. 8 B&W NDCE Recovery Boiler - steaming capacity: 250,000 lb/hr. PM emissions controlled with Flakt electrostatic precipitator (maximum outlet loading: 0.023 gr/dscf; inlet loading: 10 gr/dscf; maximum opacity: 10% @ 182,000 ACFM; specific collection area = 28 ft ² CA/KACFM; gas velocity = 2.49 ft/sec; treatment time = 11.82 seconds). Cleaned flue gas exhausted to atmosphere through radial steel stack, height = 249', internal diameter = 7' - 10'.	Recovery furnace ESP outlet	Flue gas/M12	Nickel, manganese
			Flue gas/Modified M5	Chromium species

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Potlatch Corp., (continued)	NDCE recovery furnace, continued	Recovery furnace ESP outlet, continued	Flue gas/Modified M5	Hydrogen chloride
			Flue gas/modified NIOSH Method 3500	Formaldehyde
			Flue gas/SW-846 M0030	Chloroform
			Flue gas/M8270	Acenaphthene, pyrene, benzo-a-anthracene, chrysene, benzo-b-fluoranthene, benzo-a- pyrene, dibenzo-a,h, i-pyrene, indeno-1,2,3- pyrene
			Flue gas/modified M5; SW846 M0010; M8290	polychlorinated dibenzo-p-dioxins (PCDD's) and polychlorinated dibenzofurans (PCDF's)
NCASI test program: Mill J 8/4/93- 8/8/93	Three sources were tested for same pollutants: No. 3 DCE recovery recovery furnace w/ wet-bottom ESP and venturi scrubber. Black liquor fired at 55% solids. No. 4 NDCE recovery furnace w/ dry-bottom ESP. Black liquor fired at 63% solids. No. 1 lime kiln, natural gas or oil-fired, produces 250 tons CaO per day; venturi scrubber on outlet.	No. 3 recovery furnace ESP outlet No. 4 recovery furnace ESP outlet No. 1 lime kiln scrubber outlet	Flue gas/ heated Summa® canister source sampling train	Acetaldehyde, acetone, acrolein, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl disulfide, dimethyl sulfide, 1,1,1- trichloroethane, 1,1,2-trichloroethane, 1,2,4- trichlorobenzene, tetrachloroethylene, trichloroethylene, styrene, toluene, m-,p- xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone
			Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde
NCASI test program: Mill K 10/1/93- 10/5/93	B&W NDCE recovery furnace; 4 oscillating liquor guns; black liquor fired at 67% solids; black liquor BTU value = 5800 BTU/lb. PM emissions controlled with dry-bottom ESP. <u>Test run average operating conditions:</u> BLS firing rate: 1560 tons/d BL temp: 239°F BL solids content: 68.7% CO emissions: 17 ppm O ₂ content in furnace: 3.7% Flue gas exit temp: 378°	Recovery furnace ESP outlet	Flue gas/heated Summa® canister sources sampling train	Acetaldehyde, acetone, acrolein, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl disulfide, dimethyl sulfide, 1,1,1- trichloroethane, 1,1,2-trichloroethane, 1,2,4- trichlorobenzene, tetrachloroethylene, trichloroethylene, styrene, toluene, m-,p- xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone, n- hexane
			Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
NCASI test program: Mill L 11/11/93- 11/18/93	Babcock & Wilcox DCE recovery furnace (No. 1) w/direct contact cyclone evaporators and wet bottom precipitator. Precipitator uses concentrated BL (solids content: 52 percent). <u>Representative operating conditions:</u> Firing rate: 1005 tons BLS/day BLS content: 62% - 63% BL Btu content: 5550 Btu/lb BL temperature: 240°F Furnace oxygen content: 2.5%-3.0% Stack oxygen content: 6.0%-6.5% <u>Test run-specific operating parameters (average):</u> BLS firing rate: 1013 tons BLS/day BL solids contents: 63% BL temperature: 215°F	Recovery furnace ESP outlet	Flue gas/heated Summa® canister source sampling train	Acetaldehyde, acetone, acrolein, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl disulfide, dimethyl sulfide, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, tetrachloroethylene, trichloroethylene, styrene, toluene, m-,p-xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone, n-hexane
			Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde
NCASI test program: Mill L (continued)	No. 3 Lime Kiln, 300'Lx11.5'D, slope = 7/16" per foot. Retention time = 2.5 hrs, process rate = 275 tons lime/day; 1 rpm. Mechanical dust collector + venturi scrubber + cyclonic separator on gas outlet stream. Mill water (200 gal/min) used as scrubbing medium. <u>Test run-specific operating parameters:</u> Production: 277 tons CaO/day Lime mud solids content: 75%-80%.	Lime kiln cyclonic separator outlet	Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
NCASI test program: Mill M 12/7/93 - 12/16/93	Two sources tested for same pollutants: 1) Babcock & Wilcox NDCE Recovery Furnace w/dry bottom ESP, firing rate = 5.4 million pounds of BLS/day. BL at 73% solids is fed to product flash tank, then to furnace. <u>Representative operating parameters:</u> BLS Production: 3600 lb BLS/ODTP Liquor sulfidity: 25%-30% Soda and sulfur makeup: Saltcake from R8 ClO ₂ generator, added to precipitator mix tank No. of liquor guns: 4 Auxiliary fuel: Natural gas or No. 1 fuel oil Combustion air: 4 levels of combustion air BLS firing rate: 237,000 lb BLS/hr BL temp: 252°F ESP O ₂ : 1.5 % Stack TRS: 1ppm	Recovery furnace ESP outlet Inlet and outlet of lime kiln scrubber	Flue gas/Summa® canister source sampling train	Acetaldehyde, acetone, acrolein, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl disulfide, dimethyl sulfide 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, tetrachloroethylene, trichloroethylene, styrene, toluene, m-,p-xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone, n-hexane
NCASI test program: Mill M (continued)	(continued) 2) Lime kiln; can use either natural gas or fuel oil; receives NCG's; PM emissions controlled with single chamber, 3-field ESP followed by wet scrubber with 8% caustic for SO ₂ removal. <u>Test run-specific operating parameters (average):</u> Kiln throughput: 553 tons CaO/day Cold end temp: 1210°F Hot end temp: 2535°F Exit TRS concentration: 3.9 ppm Exit VOC concentration: 8.7 ppm Exit SO ₂ concentration: 56 ppm	(continued) Recovery furnace ESP outlet Lime kiln cyclonic separator outlet	Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, acetone, methyl ethyl ketone, formaldehyde

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Federal Paper Board August, GA 5/30/91	Two sources tested for HCl: 1) No. 2 recovery furnace, DCE (cyclone) with wet-bottom ESP; BLS firing rate: ≈1.6 million lb BLS/d; BLS content = 65%. <u>Test run-specific operating parameters (average):</u> Stack temperature: 351°F Stack flow rate: 99,255 DCFM O ₂ concentration: 8.4% 2) No. 3 recovery furnace, NDCE with dry-bottom ESP; BLS firing rate ≈4.65 million lb BLS/d; BLS content = 65%. <u>Test run-specific operating parameters (average):</u> Stack temperature: 356°F Stack flow rate: 175,414 DCFM O ₂ concentration: 9.2%	No. 2 recovery furnace ESP outlet No. 3 recovery furnace ESP outlet	Flue gas/M26	Hydrogen chloride
Consolidated Papers 11/29/89-12/1/89	Recovery furnace No. 2; DCE (cascade) w/ wet-bottom ESP; design capacity: 1.5 million lb BLS/d <u>Test run-specific operating parameters (average):</u> Pulp production: 858 tons/d BL firing rate: 106 gal/min BL solids concentration: 70% Stack temperature: 262°F O ₂ concentration: 6% Stack gas flow: 51,000 dscfm Average total PM emissions: 0.0069 gr/dscf	Recovery furnace ESP outlet	Flue gas/CARB M425 Flue gas/EPA proposed multi-metals method	Total PM, Chromium species Barium, beryllium, cadmium, chromium, nickel

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Boise-Cascade, International Falls, MN 2/4/91 - 2/9/91	B&W NDCE Recovery furnace w/ dry-bottom ESP; can be fired with BLS, natural gas, or distillate oil; firing rate: 2,300,000 lb BLS/hr. Environmental Elements ESP with 8 fields, design particulate removal efficiency: 99.9%. <u>Test run-specific operating parameters (average):</u> Steam generation: 322,433 lb/hr BL solids firing rate: 43.4 tons/hr O ₂ concentration: 7.2% CO concentration: 0.0% Flue gas temperature: 417 °F	Recovery furnace ESP outlet	Flue gas/EPA document "Methodology for the Det. of Metals Emissions in Exhaust Gases from Stationary Source Combustion Processes"	Nickel, manganese, total chromium
			Flue gas/EPA document "Suggested Operating Procedure for Det. of Formaldehyde Emissions from Stationary Sources"	Formaldehyde
Boise Cascade (continued)	NDCE recovery furnace, (continued)	Recovery furnace ESP outlet, (continued)	Flue gas/NCASI "Method for the Sampling and Analysis of Chloroform Emitted Directly to the Atmosphere from Bleach Plant Point Sources"	Chloroform
			Flue gas/M26	Hydrochloric acid
			Flue gas/modified M5, w/ M8290	dioxins, furans and PAH's
			Flue gas/CARB M425	hexavalent chromium

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
NCASI test program: Mill N 11/0/293	Lime Kiln; lime mud from precoat filter fed to kiln, clean mill water used as shower water on precoat filter; contaminated evaporator condensate used in the lime mud clarifier; foul condensate from evaporators is steam stripped, and gases from steam stripper burned in the kiln; all other NCG's burned in NCG thermal oxidizer. Kiln design firing rate: 400 tons CaO/day. PM emissions from kiln are controlled with an ESP <u>Operating conditions during sampling (average):</u> Production rate: 301 tons CaO/day Lime mud solids content: 74% Natural gas firing rate: 75,700 scfm Hot end temp: 2,141°F Cold end temp: 406°F Exit TRS: 2.6 ppm Exit O ₂ : 11%	Lime kiln ESP outlet	Flue gas/heated Summa® canister	Acetaldehyde, acrolein, acetone, methanol, methyl mercaptan, carbon tetrachloride, chlorobenzene, chloroform, dichloromethane, 1,2-dichloroethane, 1,2-dichloroethylene, dimethyl disulfide, dimethyl sulfide, 1,1,1-trichloroethane, n-hexane, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, tetrachloroethylene, styrene, toluene, m,p-xylene, o-xylene, benzene, terpenes, methyl isobutyl ketone, methyl ethyl ketone
			Flue gas/National Council Midget Impinger Train	Acetaldehyde, methanol, formaldehyde, acetone, methyl ethyl ketone

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Westvaco-Covington, VA 2/5/90 - 4/02/93	<p>Five sources were tested for methanol and acetone on a yearly basis over a 3-year period. These sources include:</p> <p>1) No. 1 C-E DCE Recovery Furnace (cascade DCE); black liquor solids firing rate = 4.6 million lb/day at 72% solids; PM emissions controlled with wet-bottom ESP, 2 chambers w/ 5 fields per chamber; each ESP chamber has separate stack</p> <p>2) Smelt dissolving tanks associated with the No. 1 DCE recovery furnace; furnace has two SDT's; emissions from SDT vents controlled with identical venturi scrubbers. Prior to 11/91, "unstripped" evaporator condensates were used as part of the SDT scrubbing liquor. After 11/91, condensate used in the scrubbers was routed through a stripper (for methanol removal) before being sent to the scrubbers.</p> <p>(3) No. 2 Gotaverken NDCE recovery furnace; black liquor solids firing rate = 6 million lb/day at 75% solids; PM emissions controlled with a dry-bottom ESP; ESP has two chambers, 3 fields per chamber.</p> <p>(4) Smelt dissolving tank associated with the No. 2 NDCE recovery furnace; emissions from SDT vent controlled with venturi scrubber.</p> <p>(5) BLOx system: single-stage air-sparging system, uncontrolled vent.</p>	<p>Outlet of DCE recovery furnace ESP-2 separate stacks</p> <p>Outlets of both of the No. 1 DCE recovery furnace SDT scrubbers</p> <p>No. 2 NDCE recovery furnace ESP outlet</p> <p>Outlet of the No. 2 NDCE recovery furnace SDT scrubber</p> <p>BLOx system vent</p>	Flue gas/modified NIOSH Method 2000	Methanol, acetone
Louisiana-Pacific, Samoa, CA 12/13/90	Smelt dissolving tank	SDT exhaust stack	Flue gas/EPA combined metals train	Arsenic, total chromium, copper, cadmium, mercury, selenium, beryllium, nickel, lead, manganese
			Flue gas/CARB 425	Hexavalent chromium
Simpson Paper Co., Eureka, CA 12/10/90	Babcock and Wilcox DCE Recovery Furnace (Firing rate: 60 tons BLS/day) equipped with an ESP and wet scrubber.		Flue gas/EPA combined metals train	Arsenic, total chromium, copper, cadmium, mercury, selenium, beryllium, nickel, lead, manganese
			Flue gas/CARB 425	Hexavalent chromium

TABLE B-1. (continued)

Test site/dates	Process unit and control system description	Sampling location	Sample type/method	Pollutants/parameters measured
Simpson Paper Co., Anderson, CA 11/27/90	Lime kiln		Flue gas/EPA combined metals train	Arsenic, total chromium, copper, cadmium, mercury, selenium, beryllium, nickel, lead, manganese
			Flue gas/CARB 425	Hexavalent chromium
Gaylord Container Corp., Antioch, CA 11/14/90	NDCE Recovery Furnace equipped with a dry bottom ESP. Unknown PM return system.		Flue gas/EPA combined metals train	Arsenic, total chromium, copper, cadmium, mercury, selenium, beryllium, nickel, lead, manganese
			Flue gas/CARB 425	Hexavalent chromium

TABLE B-2. SUMMARY OF COMBUSTION SOURCES TEST PROGRAM AT INTERNATIONAL PAPER MILLS

Process unit and control system description ^a	Sampling location	Sample type	Method Used to Measure Pollutants												
			Metals ^b	Total hydrocarbons	Ammonia	Hydrochloric acid	Speciated organics ^c	Sulfuric acid mist	Total reduced sulfur	Nitrogen oxides	Carbon monoxide	Sulfur dioxide	Aldehydes and ketones ^d	Dioxins and furans ^e	Oxygen
Moss Point Mill, Moss Point, MS Test dates: 04/28/93-05/15/93															
Nos. 1 & 2 recovery furnaces	Combined stack outlet	Flue gas	M29			M26	M18					M10	M6		
No. 3 East recovery furnace	Outlet	Flue gas	M29			M26	M18						M6		
No. 3 West recovery furnace	Outlet	Flue gas	M29			M26	M18					M10	M6		
Nos. 1 and 2 smelt dissolving tanks	Scrubber outlet	Flue gas			Mod M6		M18								
	Scrubber solution	Liquid					M25D								
Black liquor oxidation tank	Vent	Flue gas					M18						RTI DNPH		
Lime kiln	Scrubber outlet	Flue gas	M29				M18								
	Scrubber outlet	Liquid					M25D								
Androscoggin Mill, Jay, ME Test dates: 07/09/93-07/23/93															
Recovery furnace	Combined stack	Flue gas				M26	M18								
No. 1 smelt dissolving tank	Scrubber outlet	Flue gas					M18						M6		
	Weak wash scrubber solution	Liquid					M25D								
A-side lime kiln	Scrubber outlet	Flue gas					M18								

TABLE B-2. (continued)

	Sampling location	Sample type	Method Used to Measure Pollutants											
			Metals ^b	Total hydrocarbons	Ammonia	Hydrochloric acid	Speciated organics ^c	Sulfuric acid mist	Total reduced sulfur	Nitrogen oxides	Carbon monoxide	Sulfur dioxide	Aldehydes and ketones ^d	Dioxins and furans ^e
Erie Mill, Erie PA Test dates: 08/26/93-08/31/93														
Smelt dissolving tank	Scrubber outlet, East	Flue gas		M25A	Mod M6		M18							
Recovery furnace		Flue gas		M25A		M26	M18							
Lime Kiln	Venturi scrubber	Flue gas		M25A			M18				M10			
Pine Bluff Mill, Pine Bluff, AR Test dates: 03/19/93-04/06/93														
No. 3 recovery furnace	Outlet	Flue gas	M29			M26	M18	NCASI 106			M10	M6		
No. 4 recovery furnace	Outlet	Flue gas	M29			M26	M18	NCASI 106			M10	M6		
No. 3 smelt dissolving tank	Outlet	Flue gas			Mod. M6		M18							
No. 4 smelt dissolving tank	Outlet	Flue gas					M18							
	Scrubber liquor	liquid					M25D							
Black liquor oxidation tank	Vent	Flue gas					M18		M16				RTI DNH	
Lime kiln	Scrubber outlet	Flue gas	M29				M18				M10			
Georgetown Mill, Georgetown, SC Test dates: 12/02/92-12/15/92 & 01/08/93-01/13/93														
No. 2 Recovery furnace	Scrubber inlet	Flue gas	M29											M23
	Scrubber outlet	Flue gas	M29											M23
	Scrubber liquid	Liquid					M25D							

TABLE B-2. (continued)

Process unit and control system description ^a	Sampling location	Sample type	Method Used to Measure Pollutants												
			Metals ^b	Total hydrocarbons	Ammonia	Hydrochloric acid	Speciated organics ^c	Sulfuric acid mist	Total reduced sulfur	Nitrogen oxides	Carbon monoxide	Sulfur dioxide	Aldehydes and ketones ^d	Dioxins and furans ^e	Oxygen
No. 2 Smelt dissolving tank	Scrubber outlet	Flue gas		M25A	Mod. M6		M18		M16						
	Scrubber solution	Liquid					M25D & M305								
Black liquor oxidation system	First stage vent	Flue gas		M25A			M18		M16				RTI DNPH		
	Second stage vent	Flue gas		M25A			M18		M16						
No. 1 lime kiln	Scrubber outlet	Flue gas	M29	M25A			M18							M23	
	Scrubber solution	Liquid					M25D								
No. 2 lime kiln	Scrubber outlet	Flue gas		M25A			M18								
	Scrubber solution	Liquid					M25D & M305								
Ticonderoga Mill, Ticonderoga, NY Test dates: 10/21/93-11/03/93															
Recovery furnace		Flue gas	M29	M25A		M26	M18		M16	M7E	M10	M6	RTI DNPH	M23	M3A
Smelt dissolving tank	Vent	Flue gas		M25A	Mod. M6		M18		M16						
		Liquid					M25D & M305								
Lime kiln		Flue gas	M29	M25A			M18		M16	M7E	M10			M23	M3A
		Liquid					M25D								
Riverdale Mill, Selma, AL Test dates: 09/09/93-09/24/93															
No. 3 lime kiln	Scrubber outlet	Flue gas					M18								
		Process liquid					M25D								
No. 1 recovery furnace		Flue gas				M26	M18								
No. 2 recovery furnace		Flue gas				M26	M18								

TABLE B-2. (continued)

Process unit and control system description ^a	Sampling location	Sample type	Method Used to Measure Pollutants													
			Metals ^b	Total hydrocarbons	Ammonia	Hydrochloric acid	Speciated organics ^c	Sulfuric acid mist	Total reduced sulfur	Nitrogen oxides	Carbon monoxide	Sulfur dioxide	Aldehydes and ketones ^d	Dioxins and furans ^e	Oxygen	
No. 1 smelt dissolving tank	Scrubber outlet	Flue gas					M18		M16							
No. 2 smelt dissolving tank	Scrubber outlet	Flue gas					M18		M16							
Natchez Mill, Natchez, MS Test dates: 03/04/93-04/01/93																
No. 7S recovery furnace	ESP outlet	Flue gas	M29													
No. 7N recovery furnace	ESP outlet	Flue gas	M29													
No. 4 smelt dissolving tank	Scrubber outlet	Flue gas			Mod. M6		M18									
		Scrubber liquid					M25D									
No. 5 smelt dissolving tank	Scrubber outlet	Flue gas			Mod. M6		M18									
		Scrubber liquid					M25D									
No. 6 smelt dissolving tank	Scrubber outlet	Flue gas			Mod. M6		M18									
		Scrubber liquid					M25D									
No. 7S smelt dissolving tank	Scrubber outlet	Flue gas			Mod. M6		M18									
		Process liquid					M25D									
Black liquor oxidation	Vent	Flue gas					M18						RTI DNPH			
		Process liquid					M25D									
No. 3 lime kiln	Scrubber outlet	Flue gas	M29													

TABLE B-2. (continued)

Process unit and control system description ^a	Sampling location	Sample type	Method Used to Measure Pollutants												
			Metals ^b	Total hydrocarbons	Ammonia	Hydrochloric acid	Speciated organics ^c	Sulfuric acid mist	Total reduced sulfur	Nitrogen oxides	Carbon monoxide	Sulfur dioxide	Aldehydes and ketones ^d	Dioxins and furans ^e	Oxygen
Mobile Mill, Mobile, AL Test date: 04/28/93-05/17/93															
No. 1 recovery furnace	Stack A outlet	Flue gas	M29			M26	M18					M10	M6		
No. 1 recovery furnace	Stack B outlet	Flue gas	M29			M26	M18					M10	M6		
No. 4 recovery furnace	Outlet	Flue gas	M29			M26	M18					M10	M6		
No. 1 smelt dissolving tank	Scrubber outlet	Flue gas			Mod. M6		M18								
No. 4 smelt dissolving tank	Scrubber outlet	Flue gas			Mod. M6		M18								
Black liquor oxidation	Vent	Flue gas					M18						RTI DNPH		
No. 1 lime kiln	Scrubber outlet	Flue gas	M29				M18								
No. 3 lime kiln	Scrubber outlet	Flue gas	M29				M18								

^aSee Table 3 for average process conditions during the tests of each process unit.

^bSee Table 4 for the specific metals analyzed by Method 29 at each mill.

^cSee Table 5 for the volatile organic compounds speciated with Method 18 testing at each mill. See Table 6 for the volatile organic compounds speciated by liquid injection using either M25D or M305.

^dSee Table 7 for the aldehydes and ketones analyzed by the RTI DNPH procedure at each mill.

^eSee Table 8 for the dioxin and furan congeners analyzed using Method 23.

TABLE B-3. AVERAGE PROCESS DATA FROM EMISSIONS TESTING AT INTERNATIONAL PAPER MILLS

Mill/process unit	Pulp production rate, ADTUBPH	Gas exit temperature, °F	Gas exit flow rate, dscfh	Gas moisture content, % v/v	Gas oxygen content, % v/v	Gas carbon dioxide content, % v/v
<u>Moss Point Mill</u>						
Nos. 1 & 2 recovery furnaces stack outlet	17.44	329	7,085,664	32	12.0	9.2
No. 3 East recovery furnace outlet	16.72	242	1,744,008	34	13.2	8.0
No. 3 West recovery furnace outlet	16.72	255	1,758,572	35	13.2	7.8
Nos. 1 & 2 smelt dissolving tank scrubber outlet	17.44	133	1,542,931	16	20.8	0.0
Black liquor oxidation vent	32.29	179	1,750,248	50	20.9	0.0
Lime kiln scrubber outlet	34.32	162	1,664,038	33	8.2	18.0
<u>Androscoggin Mill</u>						
Recovery furnace	40.35	191	19,143,100	18	9.0	12.5
No. 1 smelt dissolving tank	16.24	175	384,656	40	20.9 ^a	0.0
A-side lime kiln	21.86	162	972,759	31	12.0	17.7
<u>Erie Mill</u>						
Smelt dissolving tank scrubber outlet, east	31.25	148	677,982	23	20.9	0.0
Recovery furnace	31.25	358	6,165,520	19	7.5	13.5
Lime kiln venturi scrubber outlet	31.25	161	1,393,670	31	10.4	12.1
<u>Pine Bluff Mill</u>						
No. 3 recovery furnace outlet	15.17	335	4,350,588	28	9.6	9.5
No. 4 recovery furnace outlet	48.65	317	4,250,988	42	7.1	11.2
No. 3 smelt dissolving tank scrubber outlet	16.71	152	498,800	25.37	20.83	0.0
No. 4 smelt dissolving tank scrubber outlet	51.92	141	1,834,000	20.93	20.80	0.0
Black liquor oxidation tank vent	69.17	182	1,613,403	53.40	20.80	0.0
Lime kiln scrubber outlet	32.25	165	1,210,800	32	8.3	11.5

TABLE B-3. (continued)

Mill/process unit	Pulp production rate, ADTUBPH	Gas exit temperature, °F	Gas exit flow rate, dscfh	Gas moisture content, % v/v	Gas oxygen content, % v/v	Gas carbon dioxide content, % v/v
<u>Georgetown Mill</u>						
No. 2 recovery furnace scrubber inlet	46.13	348	9,600,000 ^b	36.16	9.80	10.08
No. 2 recovery furnace scrubber outlet	36.88	160	9,600,000 ^b	30.55	6.68	14.08
No. 2 smelt dissolving tank scrubber outlet	61.15	175	502,200 ^c	51.0	20.8	0.0
Black liquor oxidation system first stage vent	70.98	180	505,000	51.0	20.8	0.0
Black liquor oxidation system second stage vent	70.98	150	547,000	25.0	20.8	0.0
No. 1 lime kiln scrubber outlet	58.2	153	1,010,750	0.0	7.08	17.13
No. 2 lime kiln scrubber outlet	60.05	159	1,665,000	31.1	12.5	15.3
<u>Ticonderoga Mill</u>						
Recovery furnace	17.42	408	3,990,000	24.5	5.5	12.0
Smelt dissolving tank	28.90	127	466,500	25.1	20.8	0
Lime kiln	29.80	160	694,500	25.3	6.25	20.25
<u>Riverdale Mill</u>						
No. 3 lime kiln scrubber outlet	58.50	169	771,000	38	5.5	19.0
No. 1 recovery furnace	23.30	380	6,228,416	21	5.2	10.7
No. 2 recovery furnace	28.50	358	9,015,060	25	8.2	11.2
No. 1 smelt dissolving tank scrubber outlet	23.30	161	634,572	32	20.8 ^a	0.0
No. 2 smelt dissolving tank scrubber outlet	28.50	174	531,800	41	20.8 ^a	0.0
<u>Natchez Mill</u>						
No. 7S recovery furnace ESP outlet	23.59	365	3,876,000	25	7.6	12.2
No. 7N recovery furnace ESP outlet	23.59	368	4,356,000	25	5.9	13.9
No. 4 smelt dissolving tank scrubber outlet	7.69	144	982,000	21	20.8	0.0
No. 5 smelt dissolving tank scrubber outlet	7.69	145	780,000	21	20.8	0.0
No. 6 smelt dissolving tank scrubber outlet	18.47	152	766,000	27	20.8	0.0
No. 7S smelt dissolving tank scrubber outlet	11.80	151	1,137,000	22	20.8	0.0
Black liquor oxidation vent	33.80	176	978,000	47	20.8	0.0
No. 3 lime kiln scrubber outlet	19.13	166	1,632,000	30	9.7	9.0

TABLE B-3. (continued)

Mill/process unit	Pulp production rate, ADTUBPH	Gas exit temperature, °F	Gas exit flow rate, dscfh	Gas moisture content, % v/v	Gas oxygen content, % v/v	Gas carbon dioxide content, % v/v
<u>Mobile Mill</u>						
No. 1 recovery furnace Stack A outlet	33.20	337	3,712,152	32	3.9	14.8
No. 1 recovery furnace Stack B outlet	32.67	337	3,828,036	34	7.2	13.0
No. 4 recovery furnace outlet	13.41	304	3,533,208	31	10.2	9.7
No. 1 smelt dissolving tank scrubber outlet	31.92	158	946,140	31	20.8	0.0
No. 4 smelt dissolving tank scrubber outlet	14.83	161	270,960	33	20.8	0.0
Black liquor oxidation vent	59.95	174	717,729	44	20.8	0.0
No. 1 lime kiln scrubber outlet	17.42	165	686,832	35	7.5	16.3
No. 3 lime kiln scrubber outlet	18.58	170	497,652	40	6.1	16.9

^aThis oxygen content was assumed in the test report.

^bThe gas flow rate was estimated based on historical data; it was not measured during the emission test.

^cThe gas flow rate was measured a few days after the emissions sampling.

TABLE B-4. METALS ANALYZED BY EPA METHOD 29 IN TESTING AT INTERNATIONAL PAPER MILLS^a

Metals	Mills ^b			
	Moss Paint and Mobile	Pine Bluff	Georgetown	Natchez
Antimony	✓	✓	✓	✓
Arsenic	✓	✓	✓	✓
Beryllium	✓	✓	✓	✓
Cadmium	✓	✓	✓	✓
Chromium	✓	✓	✓	✓
Cobalt	✓	✓	✓	✓
Copper		✓		✓
Lead	✓	✓	✓	✓
Manganese	✓		✓	
Mercury	✓	✓	✓	✓
Nickel	✓	✓	✓	✓
Selenium	✓	✓	✓	✓
Silver		✓		

^aThe same metals were analyzed for in all samples at a particular mill, regardless of the process unit.

^bNo metals testing was conducted at the Androscoggin, Erie, and Riversdale Mills. At Ticonderoga, the metals compounds were not identified.

TABLE B-5. VOLATILE ORGANIC COMPOUNDS SPECIATED BY METHOD 18 IN TESTING AT INTERNATIONAL PAPER MILLS^a

Volatile organic compounds	Mills							
	Moss Point	Androscoggin	Erie	Pine Bluff and Natchez	Georgetown	Ticonderoga	Mobile	Riverdale
Acetaldehyde	✓	✓	✓					✓
Acetone	✓	✓	✓			✓	✓	✓
Acetone/Acrolein ^b				✓	✓			
Acetophenone	✓	✓	✓	✓	✓	✓	✓	✓
Acrolein		✓	✓			✓	✓	✓
Benzene	✓	✓	✓	✓	✓	✓	✓	✓
Carbon tetrachloride	✓	✓	✓	✓	✓	✓	✓	✓
Catechol	✓							
Chlorobenzene	✓	✓	✓	✓	✓	✓		✓
Chloroform	✓	✓	✓	✓	✓	✓	✓	✓
m-Cresol						✓		
o-Cresol	✓	✓	✓	✓	✓	✓	✓	✓
Cumene	✓	✓	✓		✓		✓	✓
1,2-Dichlorethane	✓					✓		
1,2-Dichloroethylene	✓					✓		
Dimethyl disulfide	✓	✓	✓	✓	✓	✓	✓	✓
Dimethyl sulfide	✓	✓	✓	✓	✓	✓	✓	✓
Ethanol	✓	✓	✓	✓	✓		✓	✓
Ethyl benzene	✓	✓	✓			✓	✓	✓
Ethyl benzene/ m,p-cresol ^b				✓	✓			
Hexachlorocyclopentadiene	✓			✓	✓	✓		
Hexachloroethane				✓	✓	✓		
Hexachloroethane/ m,p-cresol ^b	✓	✓	✓				✓	
n-Hexane	✓	✓	✓	✓	✓	✓	✓	✓
Isopropyl alcohol	✓	✓	✓			✓	✓	✓
Isopropyl alcohol/acrolein				✓	✓			
Methanol	✓	✓	✓			✓	✓	✓
Methanol/acetaldehyde				✓	✓			
Methly chloroform	✓	✓	✓	✓	✓	✓	✓	✓
Methylene chloride	✓	✓	✓	✓	✓	✓	✓	✓
Methyl ethyl ketone	✓	✓	✓	✓	✓	✓	✓	✓
Methyl isobutyl ketone	✓	✓	✓	✓	✓	✓	✓	✓
Methyl mercaptan	✓	✓	✓	✓	✓	✓	✓	✓
Napthalene/a-terpineol ^b	✓	✓	✓	✓	✓		✓	
Phenol	✓	✓	✓		✓	✓	✓	✓
a-Pinene					✓	✓		
b-Pinene					✓	✓		
a-Terpineol						✓		

TABLE B-5. (continued)

Volatile organic compounds	Mills							
	Moss Point	Androscoggin	Erie	Pine Bluff and Natchez	Georgetown	Ticonderoga	Mobile	Riverdale
Terpenes	✓	✓	✓	✓			✓	✓
Toluene	✓	✓	✓	✓	✓	✓	✓	✓
Trichlorobenzene	✓					✓		
1,1,2-trichloroethane	✓	✓	✓	✓	✓	✓	✓	✓
Trichloroethylene	✓	✓	✓	✓	✓		✓	✓
m,p-Xylene	✓	✓	✓	✓	✓	✓	✓	✓
o-Xylene	✓	✓	✓	✓	✓	✓	✓	✓

^aAll samples analyzed by Method 18 at a particular mill were analyzed for the same compounds, regardless of the process unit from which the samples were collected.

^bCompounds listed together were coelutants.

TABLE B-6. VOLATILE ORGANIC COMPOUNDS SPECIATED BY LIQUID INJECTION TESTING AT INTERNATIONAL PAPER MILLS

Volatile organic compounds	Mills ^a							Riverdale
	Moss Point	Androscoggin	Pine Bluff and Natchez	Georgetown		Ticonderoga		
				Recovery furnace & lime kiln No. 1	Smelt dissolving tank & lime kiln No. 2	Smelt dissolving tank	Lime kiln	
Total VOC		✓		✓		✓	✓	
Total chlorine				✓		✓	✓	
Total hydrocarbons				✓		✓	✓	
Acetaldehyde	✓		✓					✓
Acetone	✓		✓					✓
Acetone/Acrolein ^b								
Acetophenone	✓		✓					✓
Acrolein			✓					✓
Benzene	✓		✓					✓
Carbon tetrachloride	✓		✓					✓
Carbon tetrachloride/benzene ^b					✓	✓		
Catechol	✓		✓					
Catechol/Naphthalene ^b					✓	✓		
Chlorobenzene	✓		✓		✓	✓		✓
Chloroform	✓		✓					✓
Chloroform/n-Hexane ^b					✓	✓		
m,p-Cresol			✓		✓	✓		
o-Cresol	✓		✓		✓	✓		✓
Cumene	✓							
Cumene/a-terpineol ^b								✓
1,2-Dichloroethane	✓		✓		✓	✓		
1,2-Dichloroethylene	✓		✓		✓	✓		
Dimethyl disulfide	✓		✓					✓
Dimethyl sulfide	✓		✓					✓
Ethanol	✓		✓					✓
Ethyl benzene	✓		✓		✓	✓		✓
Ethyl benzene/m,p-Cresol ^b								
Hexachlorocyclopentadiene	✓		✓		✓	✓		✓
Hexachloroethane			✓					
Hexachloroethane/m,p-Cresol ^b	✓							✓
n-Hexane	✓		✓					✓
Isopropyl alcohol	✓		✓					✓

TABLE B-6. (continued)

Volatile organic compounds	Mills ^a							Riverdale
	Moss Point	Androscoggin	Pine Bluff and Natchez	Georgetown		Ticonderoga		
				Recovery furnace & lime kiln No. 1	Smelt dissolving tank & lime kiln No. 2	Smelt dissolving tank	Lime kiln	
Isopropyl alcohol/ Acrolein ^b								
Methanol	✓		✓					✓
Methanol/ Acetaldehyde ^b								
Methyl chloroform	✓		✓					✓
Methylene chloride	✓		✓		✓	✓		✓
Methyl ethyl ketone	✓		✓		✓	✓		✓
Methyl isobutyl ketone	✓		✓		✓	✓		✓
Methyl mercaptan	✓		✓					✓
Naphthalene			✓					
Naphthalene/ a-Terpineol ^b	✓							✓
Phenol	✓				✓	✓		✓
a-Pinene					✓	✓		
b-Pinene					✓	✓		
a-Terpineol			✓		✓	✓		
Terpenes	✓		✓					✓
Toluene	✓		✓					✓
Trichlorobenzene	✓		✓		✓	✓		
1,1,2-Trichloroethane	✓		✓		✓	✓		✓
Trichloroethylene	✓		✓					✓
m,p-Xylene	✓		✓		✓	✓		✓
o-Xylene	✓		✓		✓	✓		✓

^aNo liquid samples were collected from the recovery furnaces, lime kilns, smelt dissolving tanks, or black liquor oxidation tanks at the Mobile and Erie Mills.

^bCompounds listed together were coelutants.

TABLE B-7. ALDEHYDE AND KETONE COMPOUNDS ANALYZED BY RTI DNPH
PROCEDURE IN TESTING AT INTERNATIONAL PAPER MILLS

Aldehydes and ketones	Mills ^a	
	Moss Point, Pine Bluff, Natchez, and Mobile	Georgetown
Acetaldehyde	✓	✓
Acetone	✓	✓
Acetophenone	✓	✓
Acrolein	✓	✓
Benzaldehyde	✓	✓
Crotonaldehyde	✓	
Cyclohexanone	✓	
Formaldehyde	✓	✓
Methyl ethyl ketone	✓	✓
Methyl isobutyl ketone	✓	✓
Pentanal	✓	
Propionaldehyde	✓	✓

^aNo aldehyde and ketone testing was conducted at the Androscoggin, Erie, and Riverdale Mills. The aldehyde and ketone compounds analyzed by this method at the Ticonderoga Mill were not identified.

TABLE B-8. DIOXIN AND FURAN COMPOUNDS ANALYZED BY METHOD 23 AT INTERNATIONAL PAPER MILLS^a

2378	-	Tetrachlorodibenzo-p-dioxin (TCDD)
12378	-	Pentachlorodibenzo-p-dioxin (PeCDD)
123478	-	Hexachlorodibenzo-p-dioxin (HxCDD)
123678	-	Hexachlorodibenzo-p-dioxin (HxCDD)
123789	-	Hexachlorodibenzo-p-dioxin (HxCDD)
1234678	-	Heptachlorodibenzo-p-dioxin (HpCDD)
		Octachlorodibenzo-p-dioxin (OCDD)
2378	-	Tetrachlorodibenzofuran (TCDF)
12378	-	Pentachlorodibenzofuran (PeCDF)
23478	-	Pentachlorodibenzofuran (PeCDF)
123478	-	Hexachlorodibenzofuran (HxCDF)
123678	-	Hexachlorodibenzofuran (HxCDF)
234678	-	Hexachlorodibenzofuran (HxCDF)
123789	-	Hexachlorodibenzofuran (HxCDF)
1234678	-	Heptachlorodibenzofuran (HpCDF)
1234789	-	Heptachlorodibenzofuran (HpCDF)
		Octachlorodibenzofuran (OCDF)
		Total Tetrachlorodibenzo-p-dioxins (TCDD)
		Total Pentachlorodibenzo-p-dioxins (PeCDD)
		Total Hexachlorodibenzo-p-dioxins (HxCDD)
		Total Heptachlorodibenzo-p-dioxins (HpCDD)
		Total Tetrachlorodibenzofurans (TCDF)
		Total Pentachlorodibenzofurans (PeCDF)
		Total Hexachlorodibenzofurans (HxCDF)
		Total Heptachlorodibenzofurans (HpCDF)

^aThis is a list of congeners from the analysis at the Georgetown Mill. At Ticonderoga, the congeners were not identified.

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