IV.D.2.a

Alstom Response to Technical Reviewers' Comments on NDIC Proposal

14 Nov 2013

H Andrus

Introduction

This note is in response to the Technical Reviewers' Comments to Alstom's recent proposal to North Dakota Industrial Commission (NDIC). Generally, the comments requested a more in depth discussion of the North Dakota lignite test program, e.g., test matrix, sampling protocols, sampling points and frequencies, and analytical techniques. The attached material augments Alstom's proposal and responds to the comments provided.

If awarded, the proposed North Dakota Lignite test will become an integral part of the US DOE/NETL-sponsored Advanced Oxy Phase II work. As a major project participant, NDIC will have all of the information generated by the project and, in addition, will be provided a specific topical report on the results of the ND Lignite test. The entire program value exclusive of requested NDIC's $500,000 contribution exceeds $10 million, with Alstom's cash contribution at over $2 million (20%). Therefore, the requested NDIC funding share would be about 5% of the total project budget.

Since the proposal submission, Alstom has discussed the proposal further with other LRC members. Attached in the document is a letter of support from Basin Electric, in addition to that of Great River Energy.

Objectives

Listed below are the specific technical objectives for the ND Lignite test program. These tests are aimed at quantifying the performance differences which may distinguish the ND lignite performance from that of a base coal of significantly different characteristics when fired in the LCL-C™ system. The objective is to develop understanding of how to successfully fire the ND lignite while determining its benefits and challenges. These objectives and the preliminary test matrix may be better defined in discussions with NDIC as the time for testing approaches.

- Develop information on fuel feeding requirements relative to moisture, by observing fuel feeder performance with and without mitigation per note 6, below;
- Determine carbon conversion and reactivity of North Dakota Lignite (run-of-mine and pre-dried) by gas CO_2 and the carbon content within the system;
- Determine carbon carryover from the Reducer to the Oxidizer compared with base fuel;
- Determine Reducer CO_2 stream composition, including CO_2, NOx, CO, CH_4, sulfur species, trace emissions (via mass spectrometer);
- Determine Reducer gas moisture condensation composition to provide a basis for water treatment requirements;
- Measure Hg emissions using a probe set up to minimize solids/gas interaction (e.g. Inertial Separation Probe (ISP)) and set up to allow Hg speciation (sorbent trap);
- Determine Oxidizer Stream composition, including O_2, NOx, CO, sulfur species, trace emissions (via mass spectrometer);

- Determine solids circulation performance and stability of high sodium vs low sodium fuels, with and without mitigation per note 8., above;
- Evaluate sulfur capture with Alstom's standard limestones compared to base coal. Is extra sulfur required to maintain adequate $CaSO_4$? What Ca/S molar ratio is required compared with base fuel;
- Measure solids leaving the system from the screw cooler, and cyclones for comparison with base fuel;
- Measure heat absorption and ash accumulation, blowing frequency using fouling probe. Compare performance and deposit composition with base coal; and
- Take data and samples as summarized on data acquisition summary to meet the objectives.

Preliminary Test Matrix

Table 1 lists the preliminary test matrix. The basic idea is to compare the performance of ND Lignite with the similarly tested standard test coal. Pittsburgh 8 is proposed for this comparison because it is different in a number of significant ways from ND Lignite (e.g. reactivity, sulfur and moisture level, sodium level) which need to be considered to make LCL-C™ a robust technology. Test campaigns for addressing technology gaps will provide performance data as the baseline for ND lignite testing. As shown in the Table, the prototype will be operated in a number of operating conditions including firing the ND lignite at high run-of-mine moisture content.

Table 1. Preliminary test matrix for ND lignite testing

Test condition	Limestone	Fuel feeding agent	Sorbent sodium purging agent	Sorbent activation	Reducer riser gas	Reducer temp (F)	Sulfur augmentation	Test duration (days)
Performance criteria		Fuel feed behavior	Solids transport performance	Sulfur capture; CO2 production	THC reduction; CO2 production	Sulfur capture; CO2 production		
Fill up								0.5
Warm-up								0.5
Dried lignite	Chemstone		CFB ash	On/off	N2/Steam/CO2	1750/1850	CFB ash /Sulfur/Gypsum	1.5
Dried lignite	Aragonite		CFB ash	On/off	N2/Steam/CO2	1750/1850	CFB ash /Sulfur/Gypsum	1.5
Run-of-mine	Chemstone	CFB ash	CFB ash	On/off	N2/Steam/CO2	1750/1850	CFB ash /Sulfur/Gypsum	1
Run-of-mine	Aragonite		CFB ash	On/off	N2/Steam/CO2	1750/1850	CFB ash /Sulfur/Gypsum	1
Half load	Chemstone		CFB ash					0.5
Shutdown								0.5
Total								7

Referring to the Table 1, we plan to employ two limestones (Chemstone and Aragonite) routinely used by Alstom to bracket limestone removal performance in CFBs. We expect that performance differences will result. Likewise, other parameters will be varied: 1) sorbent activation will be tested; 2) Reducer riser gas will be varied; 3) Reducer temperature will be varied. These variations are expected to impact carbon conversion, CO2 production, sulfur capture and pollutant performance and will serve to map the performance tradeoffs for consideration in system design and operation for ND lignite fuel. Load range (i.e. coal flow) will be varied as well.

It is expected that with the test conditions covering these parameters, the effect of unique properties of ND lignite (high sodium, high moisture) on LCL-C™ performance will be evaluated and used for future scale-up of the process to a demonstration scale.

Prototype operation and Data Acquisition

Below is the operating procedures and data acquisition procedure currently implemented at the LCL-C™ Prototype.

Startup and transition to full load operation

1. Fill with spent CFB ash
2. Start solids recycle
3. Start warm-up burners
4. Start oxidizer natural gas burners off
5. Ramp up coal flow
6. Shut down natural gas as CaS burns in oxidizer
7. Maintain reactor temperatures and chemical looping conditions feeding coal to reducer and air to oxidizer

Data acquisition and performance calculation

1. Measure input feeds and compositions
2. Measure reducer and oxidizer gas analyses
3. Test using N2 as a tracer in both reactors. This allows establishing species flow rates leaving in the reducer and oxidizer exit gases
4. During testing, sample solids within and leaving the reducer and oxidizer and measure solids leaving
5. Calculate carbon conversions and losses
6. Calculate CaS/CaSO4 conversions and losses
7. Calculate/analyzer solids transport performance
8. Analyze performance data including gas and solids species and conversions for cause and effect, system performance improvements, development of scale-up information and for use in the Phase II project.

All gas flows into and out of the Prototype are determined and analyzed. Elemental and species flows entering and leaving the unit are used to carbon conversions and sulfur capture within each reactor. Solid and liquid samples leaving and/or within the Prototype are routinely sampled for analysis to determine performance of carbon capture, sulfur capture, trace emissions, pollutant formation, etc.

This data is analyzed to provide a detailed picture of performance for the particular test point. Performing this analysis at multiple operating conditions provides a basis for improving operating procedures, improving system design and optimizing performance for the coal being fire; in this case ND lignite.

Solids and Gas sampling and Analytical Procedures

Solids and gas samples are withdrawn from various points around the system depending on specific test objectives. Figure 1 shows locations of sampling ports in the prototype system.

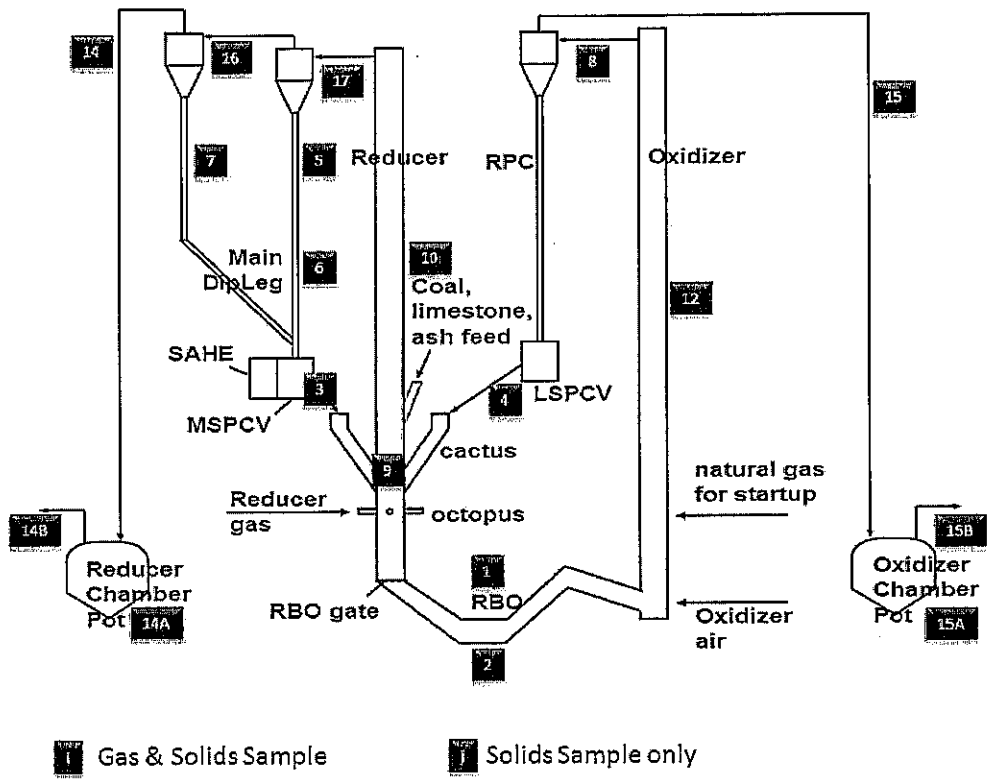


Figure 1. Schematic of prototype and sampling locations

Table 2 provides a list of the on-line gas analysis equipment that is used throughout the facility. In addition, gas samples are gathered in bulk for off-site analysis of trace species (e.g. sulfur, nitrogen, hydrocarbon species) via mass spectrometry.

Solids samples are withdrawn in bulk from various sampling points in the System including the following to determine the size distribution and composition of the circulating solids:

- Reducer and Oxidize seal pots,
- Reducer bottom outlet (RBO)

Solids are also extracted isokinetically from the Reducer and Oxidizer risers and into and out of the Reducer and Oxidizer cyclones. Gases can be sampled in bulk from these same locations for analysis via installed analyzers or via mass spectrometry.

Table 2. On-line gas analysis system at the facility

		BSF Econ. Rack ISBF Ctrl Rm	BSF H In/In Furn Gas Shed	BSF BH Out Gas Shed	BSF SO3/WB O2 SO3 Shed	C. L. ISBF Rack SBF Ctrl Rm	C. L. educer Rac Mezz.	C. L. Method 16 Mezz.	C. L. Oxidizer ITF Ctrl Rm	Bench Sc. Control Room	C.E.M.	Ranges	Output	Analyzer Method
Siemens Oxymat 5E S. N. 804-921 7MB1020-0BA10-0EA1-Z	O2	O2				O2				O2 - cl rack		1%, 5%, 10%, 25%	0-20 mA	Paramagnetic
Teledyne 3300 SN 280434	O2	-	O2				O2, AT 1B51			-		up to 25%	0-10 VDC	Micro Fuel Cell
CAI 110P from Rex Tech SN	O2	-		O2				O2, AT 1B57		-		25%	4-20 mA	Paramagnetic
Siemens Oxymat 6E SN 7MB2021-1EA00-0CA1	O2	-			O2				O2	O2		1%, 5%, 10%, 25%	0-20 mA	Paramagnetic
ZRH S.N. A3J1233T	CO2	-		CO2						-		20%, 100%	0-1 VDC	NDIR
ZRH S.N. ADH0093T	CO2	CO2				CO2		(CO2) No input		CO2 - cl rack		20%, 100%	0-1 VDC	NDIR
Servomex S.N. 01440D1/4366	CO2	-	CO2	-		-	CO2, AT 1B53	-	-	-		80%, 100%	4-20 mA	NDIR
ZRH S.N. A3C3700T	CO2	-	-	-	-				CO2	CO2		20%, 100%	0-1 VDC	NDIR
ZRF S. N. A4A1396T	CO ppm	CO ppm							CO ppm	CO ppm		1,000, 10,000	4-20 mA	NDIR
FUJI Model 3300	CO ppm	-				CO ppm	-	-	-	-		up to 10,000	0-10 VDC	NDIR
ZRH S.N. A3L2503T	CO %	-	-	-	-	CO %				CO %		20%	0-1 VDC	NDIR
ZRH S.N. A3C3701T	CO %	-								-		100%	0-1 VDC	NDIR
ZRH S.N. A2E0122T	CO %	-	CO 2%				CO 5%, AT 1B52			-		2%, 5%, 10%	0-1 VDC	NDIR
ZRH S.N.	CO %	-	CO 25%				CO 25%, AT 1B52			-		5%, 10%, 25%	0-1 VDC	NDIR
Siemens Ultramat 6E SN 7MB2121-1NG00-0AA1	SO2	SO2							SO2	SO2		500, 1,000, 5,000	0-20 mA	NDIR
Ultramat 5E SN F1-088	SO2	-	SO2				SO2, AT 1B56			SO2 - cl rack		500 & 5,000	0-20 mA	NDIR
Ultramat 5E SN F1-087	SO2	-		SO2				SO2, AT 1B58		-		500, 1,000, 2,000, 5,000	0-20 mA	NDIR
TECO 42i HL SN 0632619437	NOx	-	-	-	-	-	-	-	-	NOx		up to 10,000	0-10 VDC	Chemiluminescent
TECO 42i HL SN 0632619436	NOx	-	NOx (valved)	NOx (valved)		-	-	-	-	-		up to 10,000	0-10 VDC	Chemiluminescent
TECO 42i HL SN 0632619438	NOx	NOx								-		up to 10,000	0-10 VDC	Chemiluminescent
TECO 42H SN 42H-38463-253	NOx	-	-	-	-	-	-	-	NOx	-		up to 10,000	0-10 VDC	Chemiluminescent
Signal 3000 HM SN 14862	THC	-	THC	-	-	-	THC	-	-	THC		up to 10,000	0-10 VDC	lame Ionization Detect
Signal 3000 HM SN 15022	THC	THC						-	THC	-		up to 10,000	0-10 VDC	lame Ionization Detect
Horiba VIA 510 SN 41790660023	CH4	-	-	-	-		CH4, AT 1B55	-	-	-		5, 10, 50, 100%	0-10 VDC	NDIR
ABB AO 2020	H2	-	-	-	-		H2, AT 1B54			-		100%	4-20 mA	Thermal Conductivity
Ultramat 5F	N2O	-	-	-	-	-	-	-	N2O	-		200 ppm		NDIR
Ametek - Western ResearchModel 900	SO2	-	-	-	-	-	SO2	-	-	-		0-2%	0-10 VDC	Ultraviolet
Ametek - Western ResearchModel 900	SO2	-	-	-	-	-	-	-	SO2	-		0-2%	0-10 VDC	Ultraviolet
Agilent 3000 Micro GC	r % + N2	-	-	-	-	-	Ar +N2	-	-	-		0-100%		Gas Chromatograph
ZRH	CO2	-	-	-	-	-	-	-	-	-	CO2	20%, 100%	0-1 VDC	NDIR
Ametek - Western ResearchModel 900	SO2	-	-	-	-	-	-	-	-	-	SO2	200, 2000 ppm	0-1 + 0-10 VDC	Ultraviolet

Solids leaving the system are continuously weighed and periodically sampled for size distribution, composition and for other purposes such as solids transport testing, particle morphology studies, and bench testing.

Gas leaving the system are continuously analyzed for CH4, CO, CO2, H2, H2O, O2, total hydrocarbons, SO2, N2O, NO, NO2, as appropriate for the gas stream via on-line commercial analyzers. N2 and Ar tracers are measured via gas chromatograph. Total sulfur (oxidized and reduced forms) are measured via a modified EPA Method 16. Gas can also be gathered in bulk for analysis via mass spectrometer.

Extra care is given to the sampling of gas from reactive particle-laden gas streams. Gas-to-particle interaction is minimized by sampling gas while employing an inertial separation probe.

Gas flows into the unit are measured via mass flow meter or orifice pressure drop (as appropriate for the particular gas flow rate) following standard ASME procedures.

Analytical methods

Particle size distribution is performed using standard sieves for particles > 44 microns. For particles less than 200 microns, laser methods (e.g. Cilas) can be employed.

Porosity is determined via nitrogen chemisorption to determine BET surface area, pore size and pore volume. Layered deposits collected of internal surfaces and probes can be analyzed via SEM with local elemental composition determined via SEM/EDX (energy dispersive spectrometry).

Computer controlled SEM will be utilized to understand the morphology of oxygen carriers and speciation of sulfur species in the carrier particles.

Chemical composition of solids samples can be determines via the following methods:

- Carbon and carbonate: ASTM 6316
- Calcium: ASTM C-1301
- total sulfur: ASTM 5016 sulfur analyzer; or via oxidation/gravimetric method
- sulfide: via an Alstom modified procedure
- Ash composition: ASTM 6349

Alstom's Analytical Lab Capabilities

Attached is a slide presentation that describes the analytical capabilities of Alstom's Chemical Laboratory in Chattanooga, TN. Samples are routinely sent overnight for analysis.

Alstom Analytical Capabilities Feb 2013

Letters of Interest

a. Basin Electric

BASIN ELECTRIC POWER COOPERATIVE
[illegible]
BISMARCK, NORTH DAKOTA 58501
PHONE [illegible] FAX [illegible]

November 14, 2013

Dr. Shin Kang
Critical Technology Manager
Alstom Power Inc.
PO Box 500
Windsor, CT 06095

RE: Limestone-based Chemical Looping Combustion Development Proposal to NDIC

Dear Dr. Kang:

This letter is in response to Alstom's request for support in the subject proposal to the North Dakota Industrial Commission's (NDIC's) solicitation.

Basin Electric Power Cooperative has a particular interest in this program because we own and operate several units that utilize coal as a means to produce electricity. Coal will continue to play a major role in meeting energy demands well into the 21st century. We recognize, based on the currently available CO_2 capture technology data, that there is a need for further development of technologies that can provide CO_2 capture technologies that are efficient and economically acceptable.

Basin Electric is pleased to offer support in the form of a letter of interest, recognizing that the development provided by this project will help to advance technologies to efficiently and economically capture CO2 from coal-fired power stations. While we recognize that it may take ten or more years to advance the technology to be ready for commercial-scale, this project is a necessary step along that journey.

We hope that NDIC gives careful consideration to this project as there is a significant need for CO_2 capture technology development if North Dakota lignite use is to expand in the future. Again, we express our interest of the proposed project and look forward to seeing the project move forward with support from NDIC.

If you have any questions please contact Bob Erikson by phone at 701-557-5654 or by e-mail at berikson@bepc.com.

Sincerely,

Mark E. Greek
Senior Vice President, Generation

/tle

A Touchstone Energy® Cooperative

Equal Employment Opportunity Employer

BEPC Support Alstom Chemical Looping.pdf

BASIN ELECTRIC POWER COOPERATIVE
1717 EAST INTERSTATE AVENUE
BISMARCK, NORTH DAKOTA 58503
PHONE 701-223-0441 FAX 701-557-5336

November 14, 2013

Dr. Shin Kang
Critical Technology Manager
Alstom Power Inc.
PO Box 500
Windsor, CT 06095

RE: Limestone-based Chemical Looping Combustion Development Proposal to NDIC

Dear Dr. Kang:

This letter is in response to Alstom's request for support in the subject proposal to the North Dakota Industrial Commission's (NDIC's) solicitation.

Basin Electric Power Cooperative has a particular interest in this program because we own and operate several units that utilize coal as a means to produce electricity. Coal will continue to play a major role in meeting energy demands well into the 21st century. We recognize, based on the currently available CO_2 capture technology data, that there is a need for further development of technologies that can provide CO_2 capture technologies that are efficient and economically acceptable.

Basin Electric is pleased to offer support in the form of a letter of interest, recognizing that the development provided by this project will help to advance technologies to efficiently and economically capture CO2 from coal-fired power stations. While we recognize that it may take ten or more years to advance the technology to be ready for commercial-scale, this project is a necessary step along that journey.

We hope that NDIC gives careful consideration to this project as there is a significant need for CO_2 capture technology development if North Dakota lignite use is to expand in the future. Again, we express our interest of the proposed project and look forward to seeing the project move forward with support from NDIC.

If you have any questions please contact Bob Eriksen by phone at 701-557-5654 or by e-mail at beriksen@bepc.com.

Sincerely,

Matt E. Greek
Senior Vice President, Generation

/rle

αβχδ

b. Great River Energy

GREAT RIVER ENERGY

12300 Elm Creek Blvd • Maple Grove, Minnesota 55369-4718 • 763-445-5000 • Fax 763-445-5050 • www.GreatRiverEnergy.com

June 21, 2013

Ms. Angela Harshman
U.S. Department of Energy
National Energy Technology Laboratory
P.O. Box 10940
626 Cochrans Mill Road
Pittsburgh, PA 15236-0940

Subject: Letter of Support to continue development of Limestone Chemical Looping LCL-C™ process, a Phase II Proposal to the DOE/NETL under Cooperative Agreement No. DE-FE0009484 (Funding Opportunity No. DE-FOA-0000636, Phase II)

Dear Ms. Harshman,

Great River Energy (GRE) is pleased to submit this letter of support and interest to continue development of Limestone Chemical Looping LCL-C™ process, a Phase II Proposal to the DOE/NETL under Cooperative Agreement No. DE-FE0009484 (Funding Opportunity No. DE-FOA-0000636, Phase II). This proposed work thus far strongly suggests that it has the potential to meet the US DOE's objective to remove over 90% of the total carbon in the coal as CO_2 for use or sequestration at a 35% or less increase in the cost of electricity from existing or new coal-fired power plants. It therefore meets the criteria for near-zero emission and employs oxy-combustion technology which utilizes limestone as an oxygen carrier.

Great River Energy strongly supports Alstom's subject proposal to the DOE/NETL, which seeks to develop a transformational coal power technology with CO_2 capture and separation. Great River Energy plans to closely monitor the LCL-C™ program described in the enclosed proposal by Alstom.

Great River Energy is the wholesale electric supplier for 28 member cooperatives in Minnesota and Wisconsin. Great River Energy is concerned about the environment and is aware of the greenhouse gas emissions raised by the scientific community. With approximately 50% of the electric generation coming from coal-fired power plants, GRE recognizes the need to develop and demonstrate CO_2 mitigation options for the existing coal fired power generation fleet. GRE endorses the subject proposed program as an important step to develop and demonstrate lower cost CO_2 mitigation options such as chemical looping. This program has the potential to help allow the continued use of coal fuel, our nation's largest domestic energy resource.

We look forward to DOE/NETL's review of the Alstom proposal and partnering on this interesting and needed project.

Sincerely,

GREAT RIVER ENERG

Charles Bullinger, P.E.

GRE support 19June2013.pdf

GREAT RIVER
ENERGY

12300 Elm Creek Blvd • Maple Grove, Minnesota 55369-4718 • 763-445-5000 • Fax 763-445-5050 • www.GreatRiverEnergy.com

June 21, 2013

Ms. Angela Harshman
U.S. Department of Energy
National Energy Technology Laboratory
P.O. Box 10940
626 Cochrans Mill Road
Pittsburgh, PA 15236-0940

Subject: Letter of Support to continue development of Limestone Chemical Looping LCL-C™ process, a Phase II Proposal to the DOE/NETL under Cooperative Agreement No. DE-FE0009484 (Funding Opportunity No. DE-FOA-0000636, Phase II)

Dear Ms. Harshman:

Great River Energy (GRE) is pleased to submit this letter of support and interest to continue development of Limestone Chemical Looping LCL-C™ process, a Phase II Proposal to the DOE/NETL under Cooperative Agreement No. DE-FE0009484 (Funding Opportunity No. DE-FOA-0000636, Phase II). This proposed work thus far strongly suggests that it has the potential to meet the US DOE's objective to remove over 90% of the total carbon in the coal as CO_2 for use or sequestration at a 35% or less increase in the cost of electricity from existing or new coal-fired power plants. It therefore meets the criteria for near-zero emission and employs oxy-combustion technology which utilizes limestone as an oxygen carrier.

Great River Energy strongly supports Alstom's subject proposal to the DOE/NETL, which seeks to develop a transformational coal power technology with CO_2 capture and separation. Great River Energy plans to closely monitor the LCL-C™ program described in the enclosed proposal by Alstom.

Great River Energy is the wholesale electric supplier for 28 member cooperatives in Minnesota and Wisconsin. Great River Energy is concerned about the environment and is aware of the greenhouse gas emissions raised by the scientific community. With approximately 50% of the electric generation coming from coal-fired power plants, GRE recognizes the need to develop

and demonstrate CO_2 mitigation options for the existing coal fired power generation fleet. GRE endorses the subject proposed program as an important step to develop and demonstrate lower cost CO_2 mitigation options such as chemical looping. This program has the potential to help allow the continued use of coal fuel, our nation's largest domestic energy resource.

We look forward to DOE/NETL's review of the Alstom proposal and partnering on this interesting and needed project.

Sincerely,

GREAT RIVER ENERG

Charles Bullinger, P.E.

Chattanooga TTTM Chemical Laboratory

An Overview

POWER | ALSTOM

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Mission:

Support and Consulting Services including:

- Quality Assurance
- Research and Development Support
- Research and Development Realization
- Trouble Shooting

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Contacts:

Kurt Johnson
Section Head - Chemistry
+1 423 752 2108 (office)
+1 423 752 2552 (lab)

Ann-Mari Stromberg
Senior Chemical Engineer
+1 423 752 2516 (office)
+1 423 752 2552 (lab)

Jesse Cross
Materials Tech Specialist
+1 423 752 2941 (office)

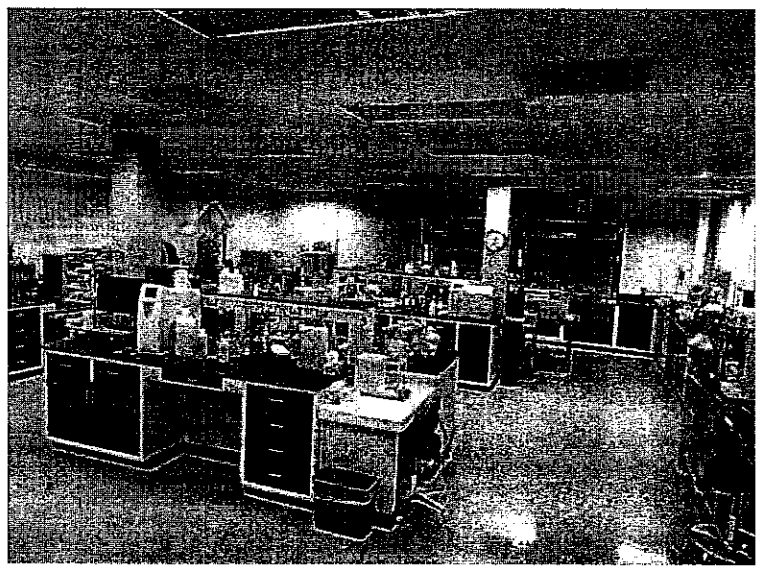
- Solid Fuel Chemistry
- Combustion System Forensics
- Analytical Chemistry Support
- Metal Testing and Chemistry
- Proposal, Warranty, Contract and Commissioning Support
- Customer Service and Field Support
- R&D Projects

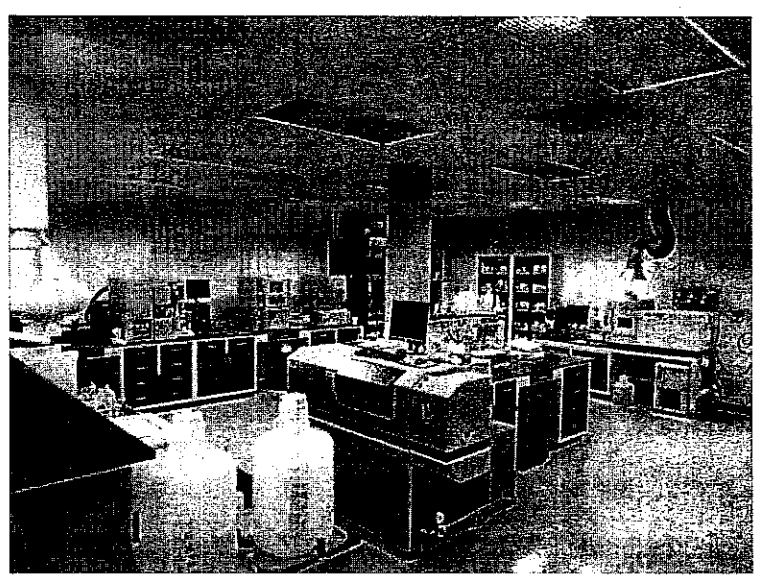
© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM – Chattanooga Chemical Laboratory

ALSTOM

- Newly Constructed (2010) Laboratory Facilities
- Modern Analytical Instrumentation and capabilities for fuels, power plant chemistry, and emissions control samples.
- Metals Chemistry Capabilities
- Modern SEM/EDS
- Extensive Physical Testing Capabilities
- Sample Preparation for Geological and Biomass materials





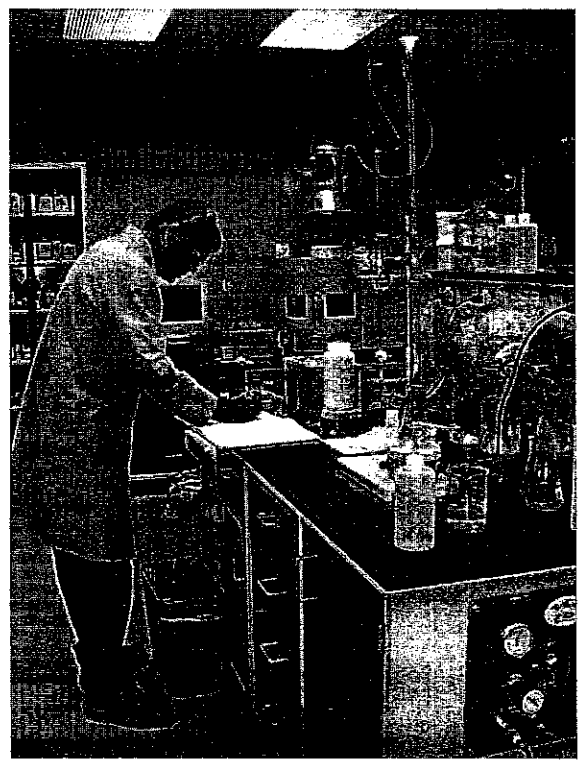
© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM – Chattanooga Chemical Laboratory

ALSTOM

The laboratory is equipped for
Chemical and Physical Testing including:

- TGA
- XRD
- ICP-OES
- IC
- XRF
- OES Metal Analyser
- SEM & EDS
- Physical Characterization (e.g. porosity, surface area, particle size, viscosity of heavy oils and melts)



Standard ASTM, ASME, EPRI methods

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

The Analytical Chemistry Laboratory Offers comprehensive testing of:

- Coal
- Petroleum
- Biomass Fuels
- Combustible Waste, and Other Alternative Fuels
- Boiler Emissions Sorbents including Lime, and Limestone
- Ash Deposits
- Internal Deposits
- Refractory Products
- Minerals
- Boiler Waters and Condensate
- Metal Alloys
- Field Emission Testing

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Routine Analyses:

- Proximate Analysis of solid fossil fuels, biomass, RDF
- Ultimate Analysis of liquid and solid fossil fuels, biomass, RDF, ashes, and deposits
- Calorific Values of liquid and solid fossil fuels, biomass, and RDF
- Ash Composition of liquid and solid fossil fuels, biomass, and RDF
- Halogen content in liquid and solid fossil fuels, biomass, RDF, ashes, deposits, and sorbents
- Carbonate in coal bi-products, sorbents, and ashes
- Forms of Sulfur in coals

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Routine Analyses (cont.)

- Particle Size Distribution of materials
- Dissolved and Suspended Solids in slurries and boiler water
- Acidity and Alkalinity in boiler water
- Anions and Cations in boiler water
- Sulfate and Sulfite Content in WFGD slurries
- Asphaltene, and Moisture Content in oil samples
- Limestone and Fuel Reactivity
- Identification of deposits
- Metal Alloy Composition
- Thermal weight changes in different atmospheres

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM – Chattanooga Chemical Laboratory

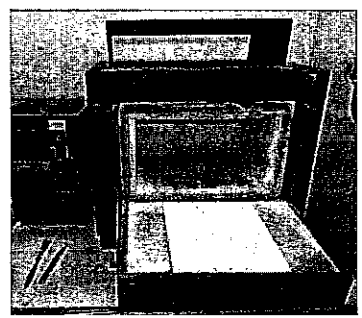
ALSTOM

Consulting Services:

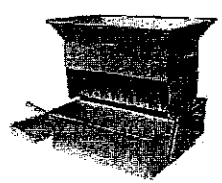
- Fuel Quality Assessment
- Sorbent Characterization and Assessment
- Evaluation of Fuel Ash Deposition
- Physical and Chemistry Related Process Problems
- Investigation of Fuel Related Erosion and/or Corrosion Problems
- Equipment Failure Analysis
- Coal Switching and Blending Studies
- Analytical Method Development

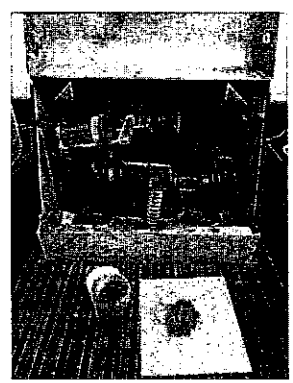
© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

Sample Preparation



- Dryers
- Crusher
- Mills
- Shredders
- Sieves
- Furnaces
- Riffles
- Pellet press



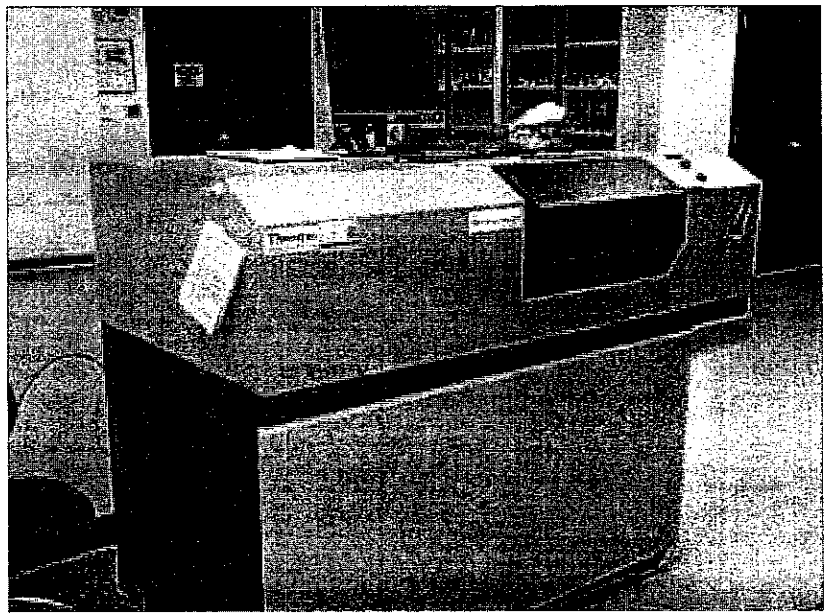


© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

OES Metal Analyzer
Thermo ARL 4460



Spark emission metals analysis

Used for :
Quality control of metals such as
- Steel alloys
- Aluminum and its alloys
- Copper and its alloys
- Nickel and its alloys

Features:
•Stable, accurate,
•Broad range of metals
•Advanced software

•Analysis of carbon, nitrogen and oxygen in steels at very low levels

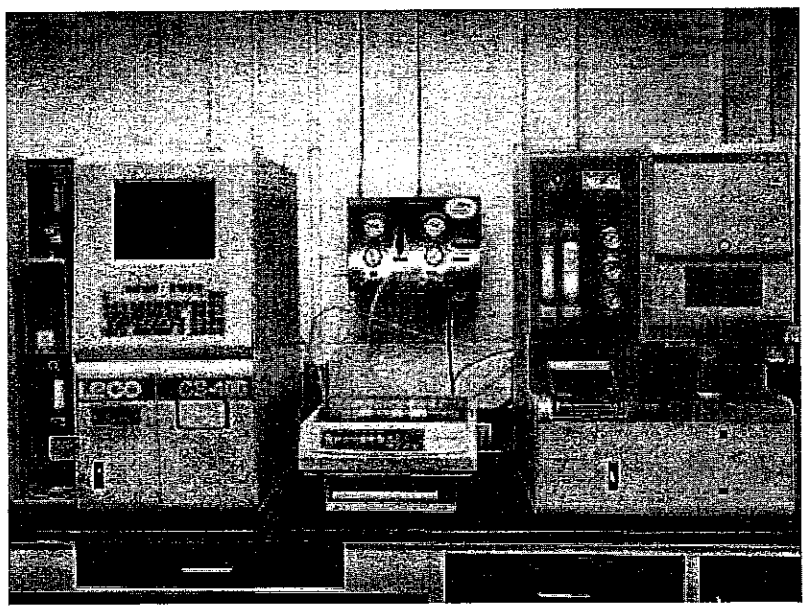
© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Carbon/Sulfur Analyzer LECO CS-400

2.2kW induction furnace coupled with IR absorption cells



Analysis of carbon and sulfur in steel, ferrous and non-ferrous metals, and non-metal solids

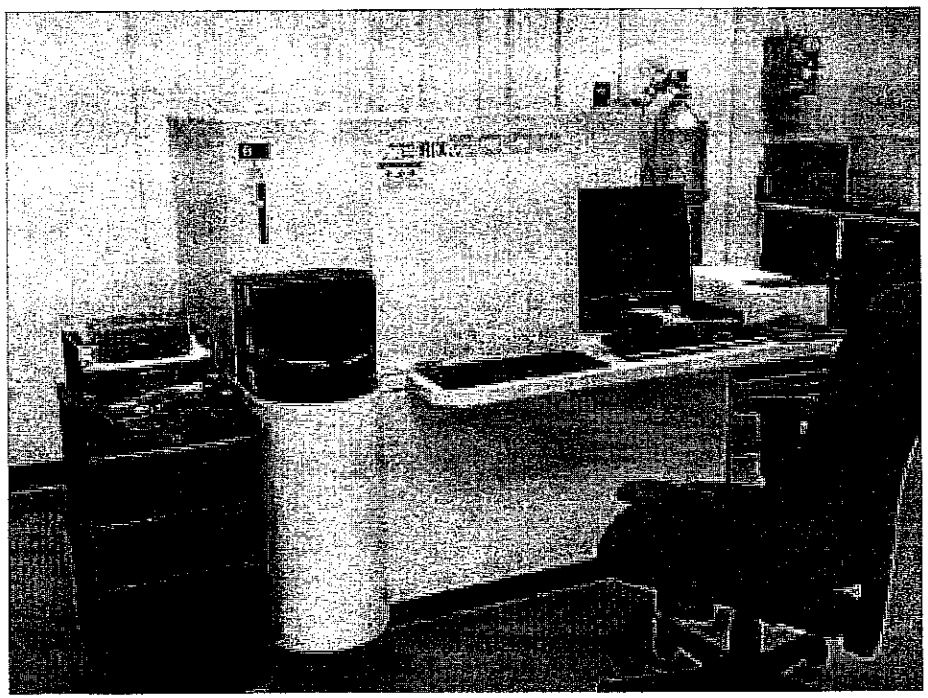
Nitrogen/Oxygen Analyzer LECO TC500

Electrode impulse furnace with IR and TC cells

Analysis of nitrogen and oxygen in steel, ferrous and non-ferrous metals, and non-metal solids

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

X-ray Fluorescence Spectrometer (XRF)
RIGAKU RIX 2000



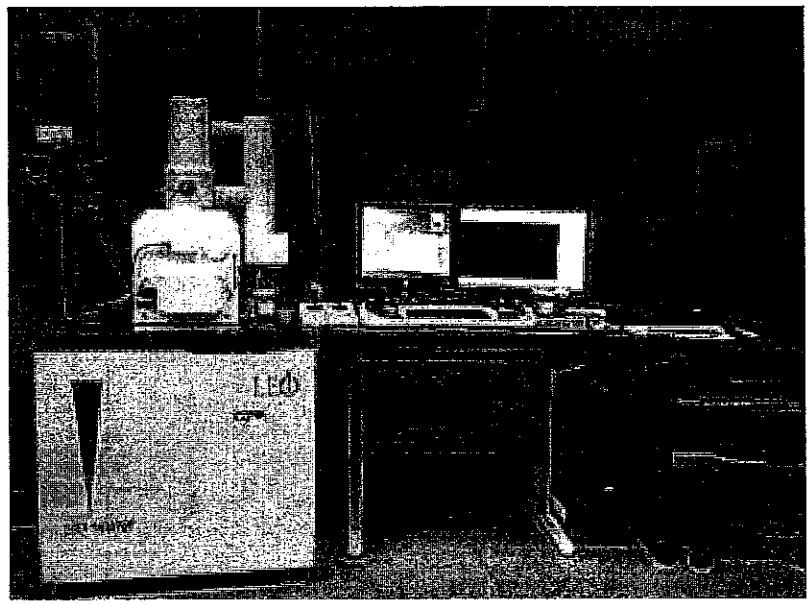
Elemental and chemical analysis of rocks, minerals, metals, deposits etc.

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Scanning Electron Microscope (SEM)
LEO 1450 VP
&
Energy Dispersive Spectroscopy (EDS)
OXFORD Inca 400



Used for:

SEM: High resolution imaging of surfaces

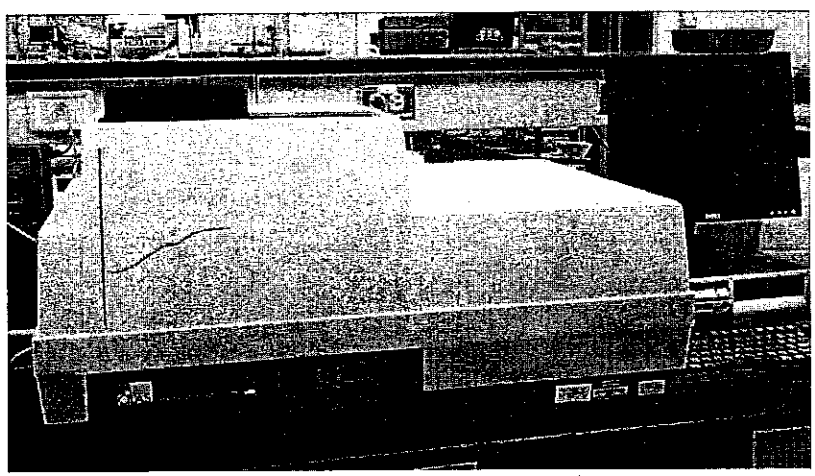
EDS: Elemental and chemical analysis of metals, deposits, coatings, minerals etc.

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Particle Size Analyzer
Cilas 1064

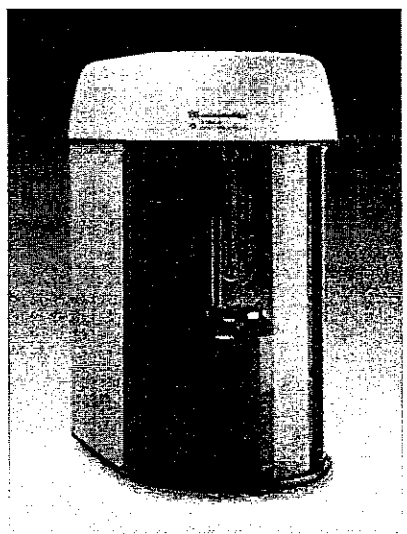


Particle size distribution in:

- Pulverized fossil fuels
- Ashes
- Flue gas absorbents
- Other pulverized material

  - 0.05 – 500 μm
  - Double Sequenced Laser System

Physisorption Analyzer
Micromeritics TriStar II 3020



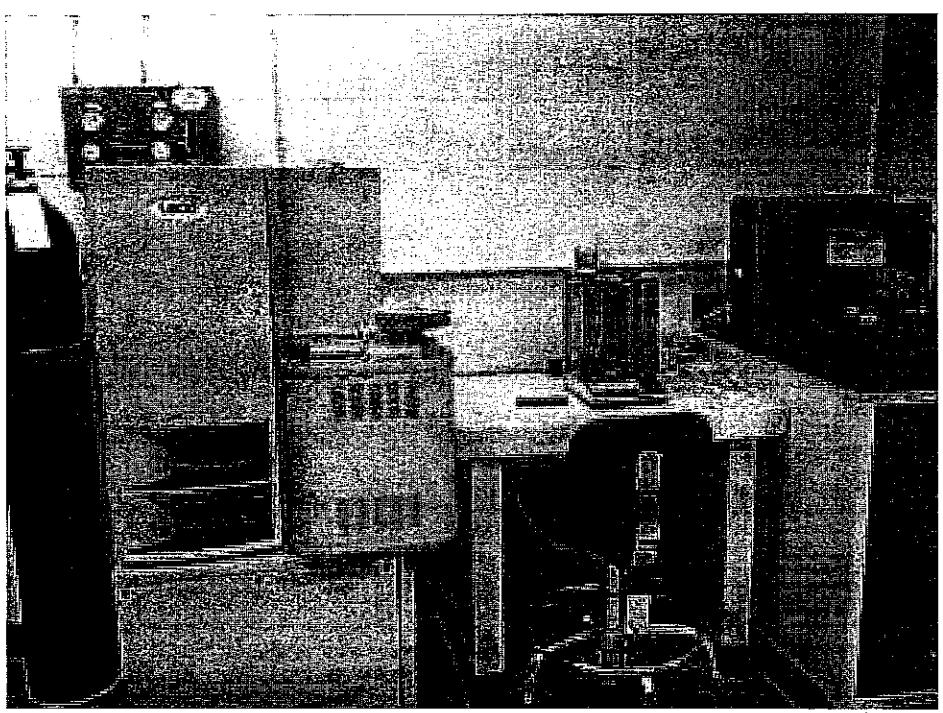
Determination of surface area and porosity of:

- Solid fossil fuels
- Lime and limestone
- Activated carbon
- Coke and ash
- Catalysts
- Coatings

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

Carbon/Hydrogen/Nitrogen Analyzer
LECO TruSpec

Direct combustion (950 °C) and IR and TC detection



Detection of

- carbon
- nitrogen
- hydrogen

in liquid and solid fossil fuels, ashes, biomass, refuse derived fuels, and deposits.

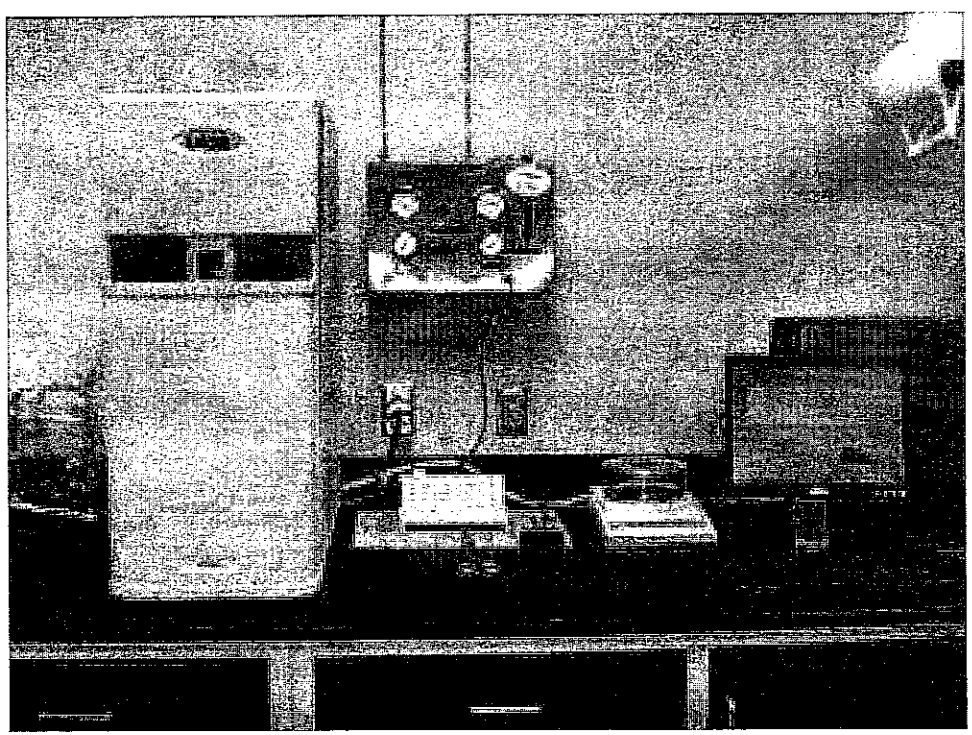
© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Carbon/Sulfur Analyzer
LECO SC632

Direct combustion and IR detection
Temperature: 1350 -1450 °C



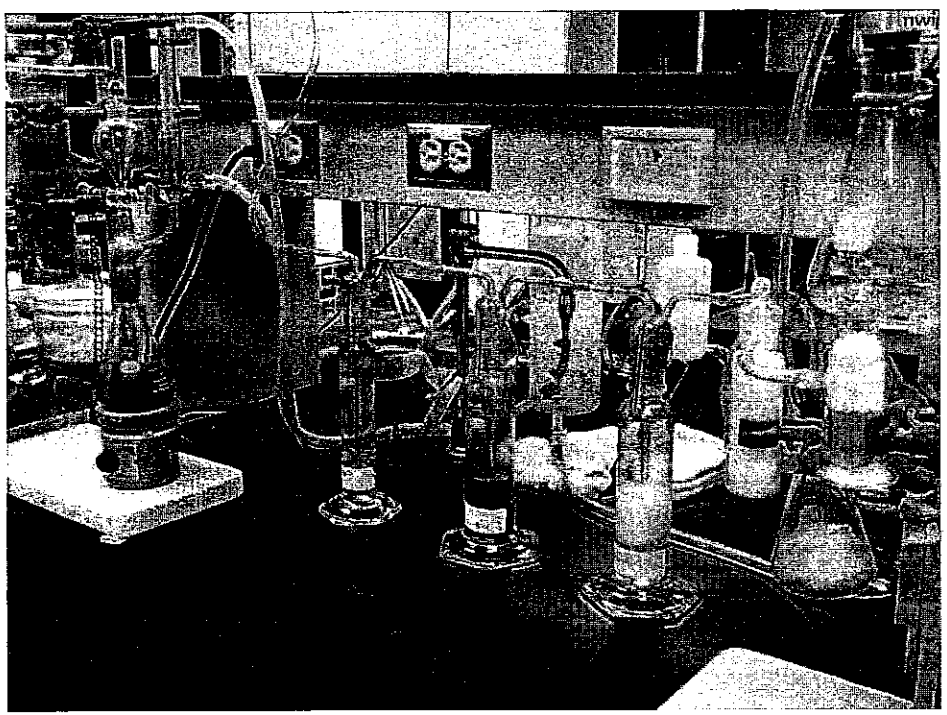
Detection of

- sulfur
- carbon

in solid and liquid fossil fuels, ashes, biomass, and deposits.

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

Gravimetric "CO_2 Train"



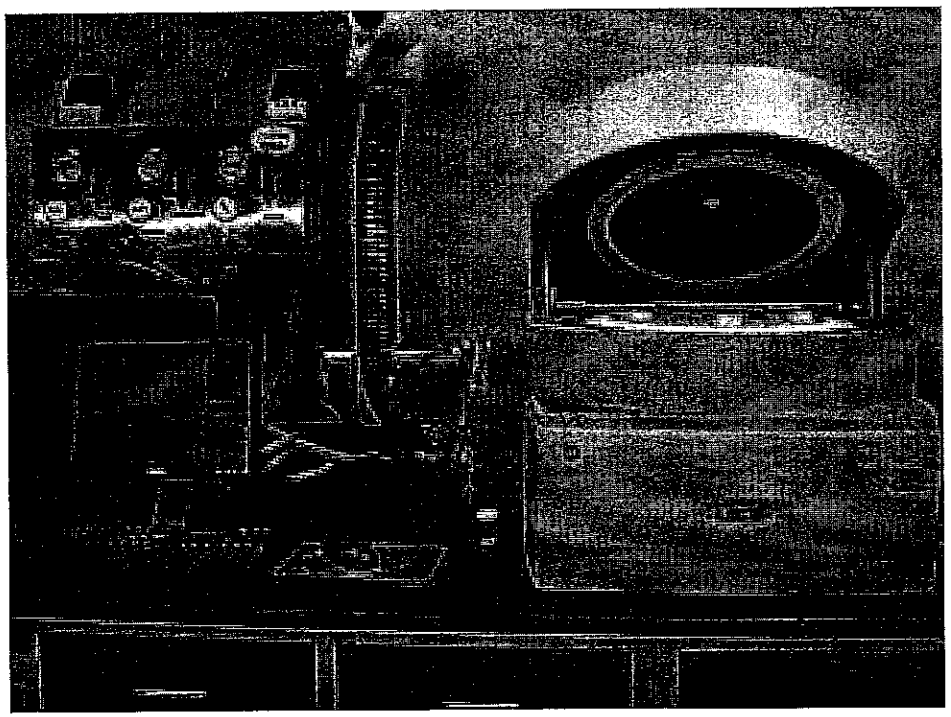
Determination of

- carbonate

in sorbents, ashes and fuels

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

Thermogravimetric Determinator LECO TGA 701



Gravimetric determination of:

- total moisture
- volatile matter
- ash content
- loss-on-ignition

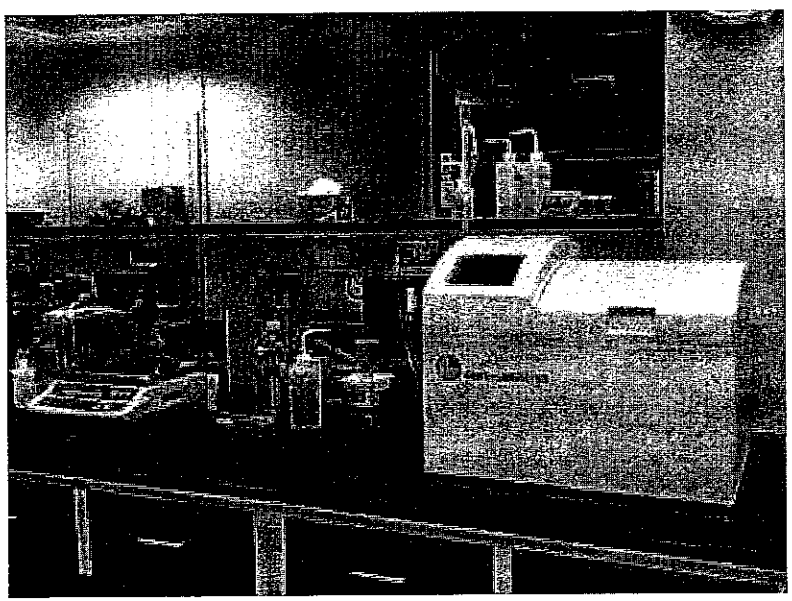
in solid fossil fuels, ashes, biomass, deposits and flue gas sorbents.

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Bomb Calorimeter
Parr 6200



Determination of

- calorific values in solid and liquid fossil fuels and biomass.

Also used for

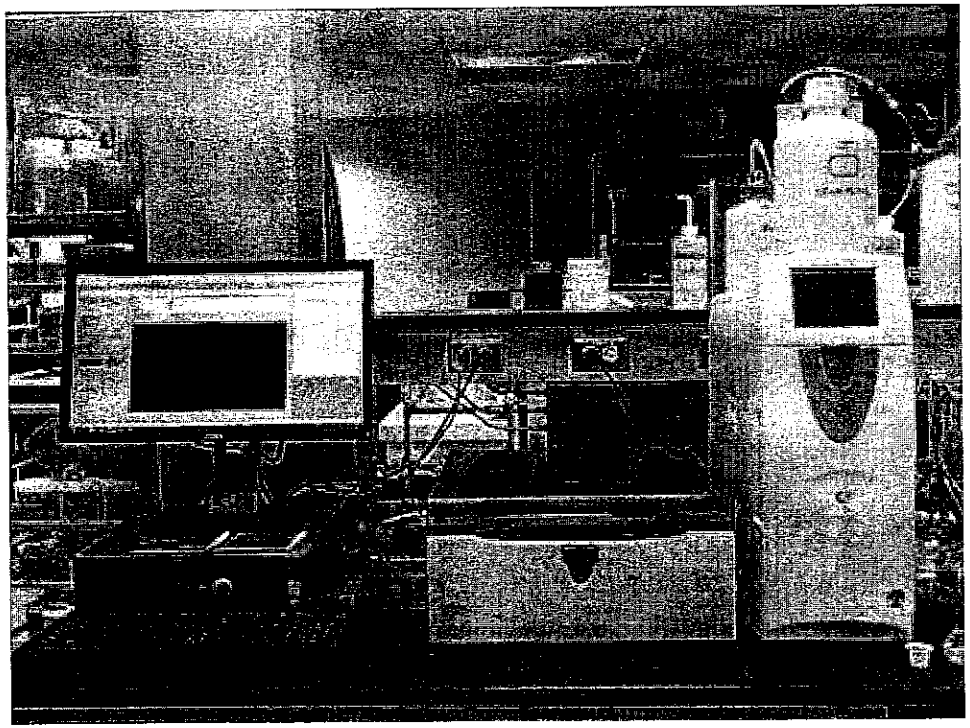
- digesting carbonaceous samples for analysis for IC
- digesting petroleum samples for trace element analysis by ICP.

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM - Chattanooga Chemical Laboratory

ALSTOM

Ion Chromatograph
Dionex ICS-1600



Isocratic separation, conductivity detection
Chromelion Management software
Auto sampler

Routine analysis of

- anions (F, Cl, Br, NO_2, NO_3, PO_4, SO_4)
- cations (Na, NH_4, K, Ca, Mg)

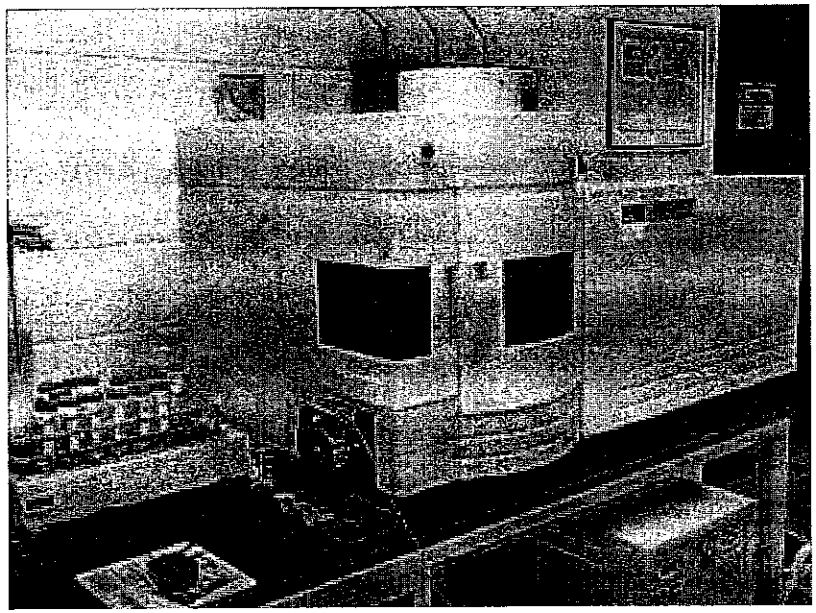
in aqueous solutions.

Also

- other ionic analyses using different columns and/or eluents

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

Inductively Coupled Plasma (ICP-OES)
Perkin Elmer Optima 2000DV



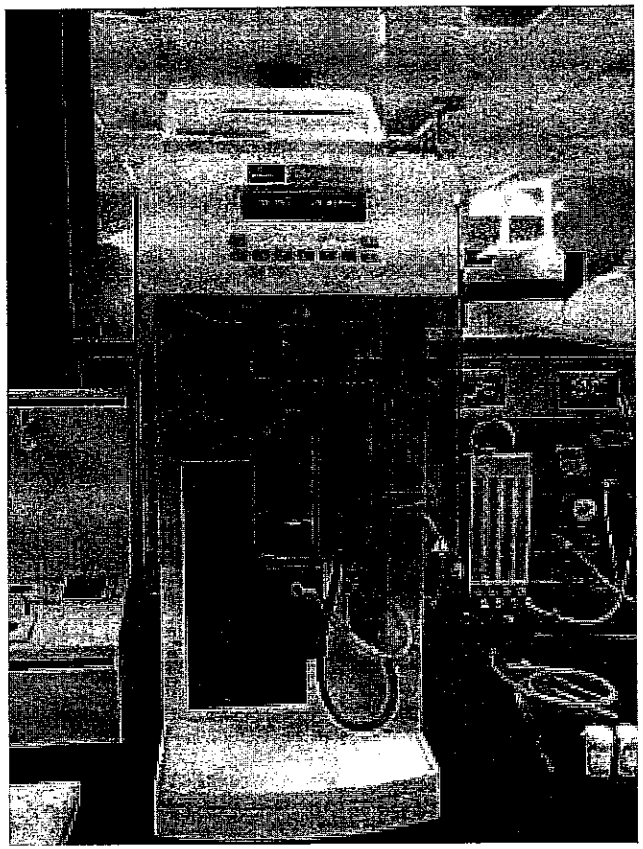
Scanning CCD based technology, background emission,
Ne spectrum active wavelength correction
Dual view (axial and radial)

Routinely used for:

- determination of major and minor elements in coal, oil, biomass, ashes, and geological samples
- determination of calcium and magnesium content in lime, limestone, and FGD material
- determination of other materials as required

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

Thermogravimetric Analyzer
Perkin Elmer Pyris 1TGA



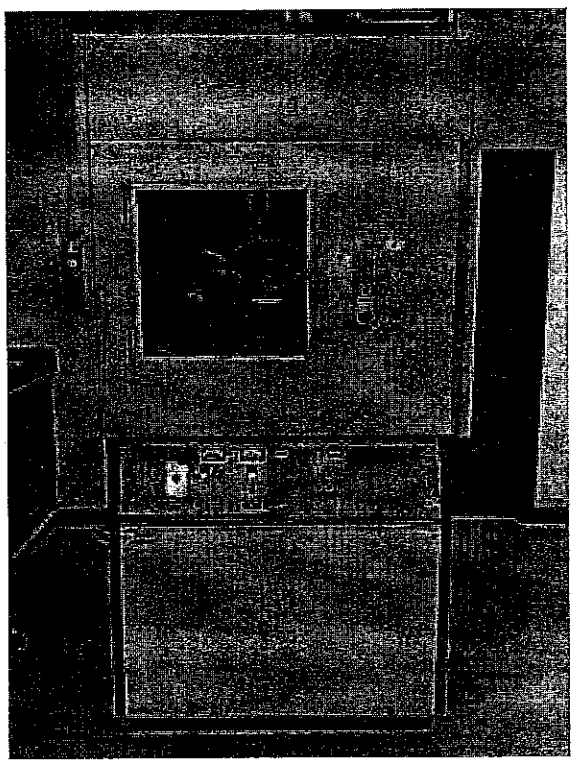
- Thermal stability/degradation investigation of inorganic materials
- Phase transition measurement at different atmospheres
- Reaction kinetics with reactive gases

➢ Temperature Range: 50 - 1400 °C

➢ Sample Atmosphere: Static or dynamic, including N_2, Ar, He, CO_2, Air, O_2, or other inert or reactive gases

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

X-ray Diffractometer Siemens D-500



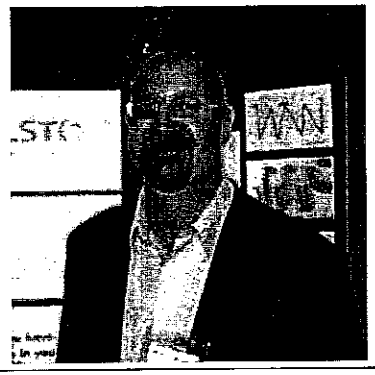
Detection and identification of polycrystalline phases in deposits, ashes, minerals, etc

- Cu X-ray tube
- Diffracted beam monochromator set for Cu radiation
- Materials Data Jade 9.1 search software and hardware updated in 2009

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM – Chattanooga Material's Laboratory

ALSTOM



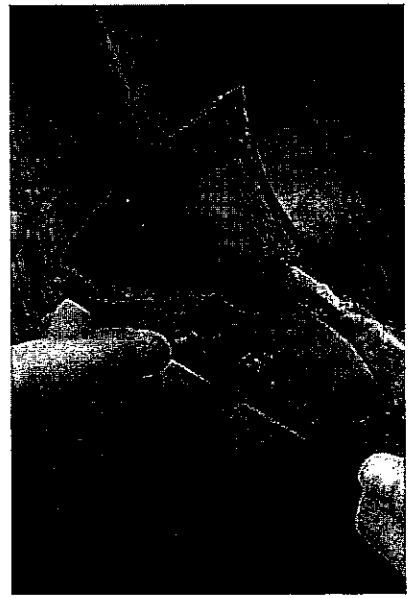
Contact
Randy Wilson
MTC Manager
+1 423 752 2946 (office)
+1 423 322 0424 (cell)

- Metallography and Microstructural Interpretations
- Forensic and Condition Assessment Analysis
- In-situ Metallographic Replication
- Welding
- Hot Corrosion and Steam Oxidation Testing
- Warranty, Contract and Commissioning Support
- NAM Specifications and Sourcing Support
- R&D projects

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

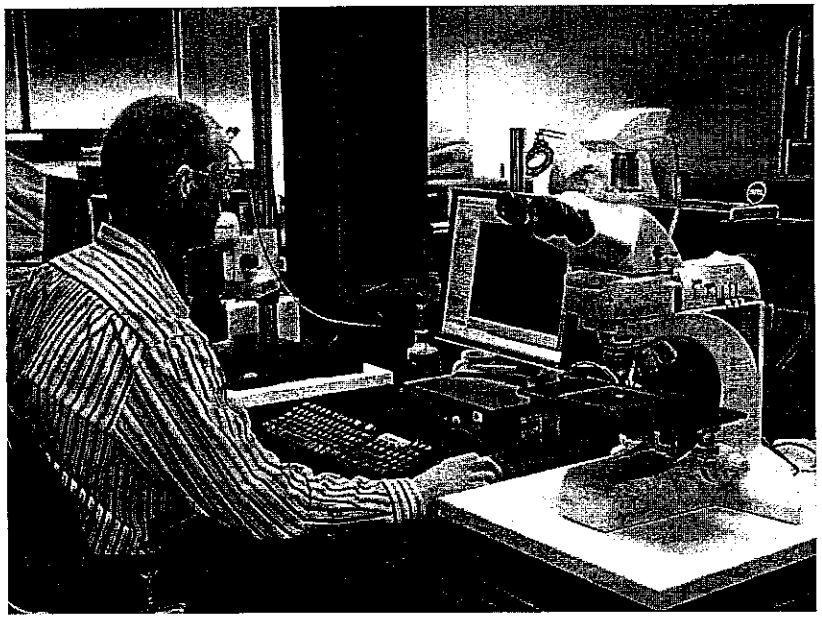
TTTM – Chattanooga Material's Laboratory

ALSTOM



Metallographic evaluation

- Microstructural analysis
  - Microstructural characterisation
  - Forensic analysis
  - Support for Ferrous alloys development group



- Facilities include:
  - Sectioning and metallographic preparation equipment
  - Lecia Microscopes with digital imaging cameras & software

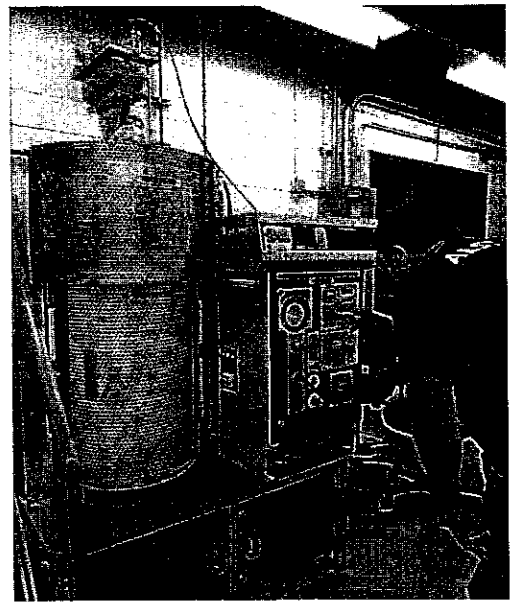
© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM – Chattanooga Material's Laboratory

ALSTOM

Mechanical properties testing

- Tension testing
- Hardness testing
- Charpy Impact testing
- Flattening, Flaring, Bend Tests
- Jet Erosion testing



Welding Lab

- Manual SMAW & GTAW
- Machine SAW, GMAW, GTAW
- Procedure Qualification & Testing
- Codes and Standards Testing

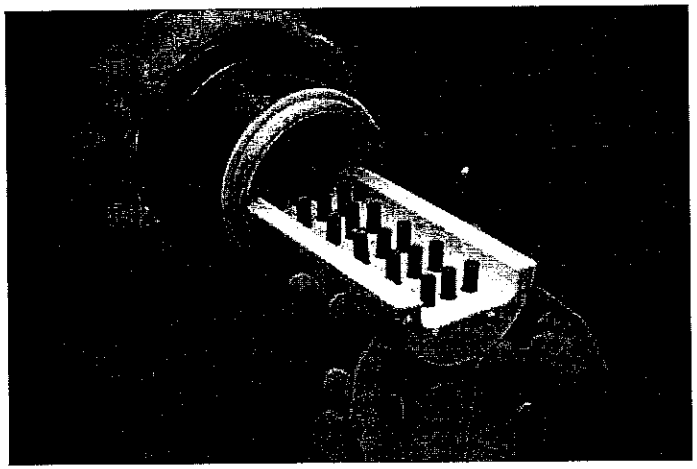
© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.

TTTM – Chattanooga Material's Laboratory

ALSTOM

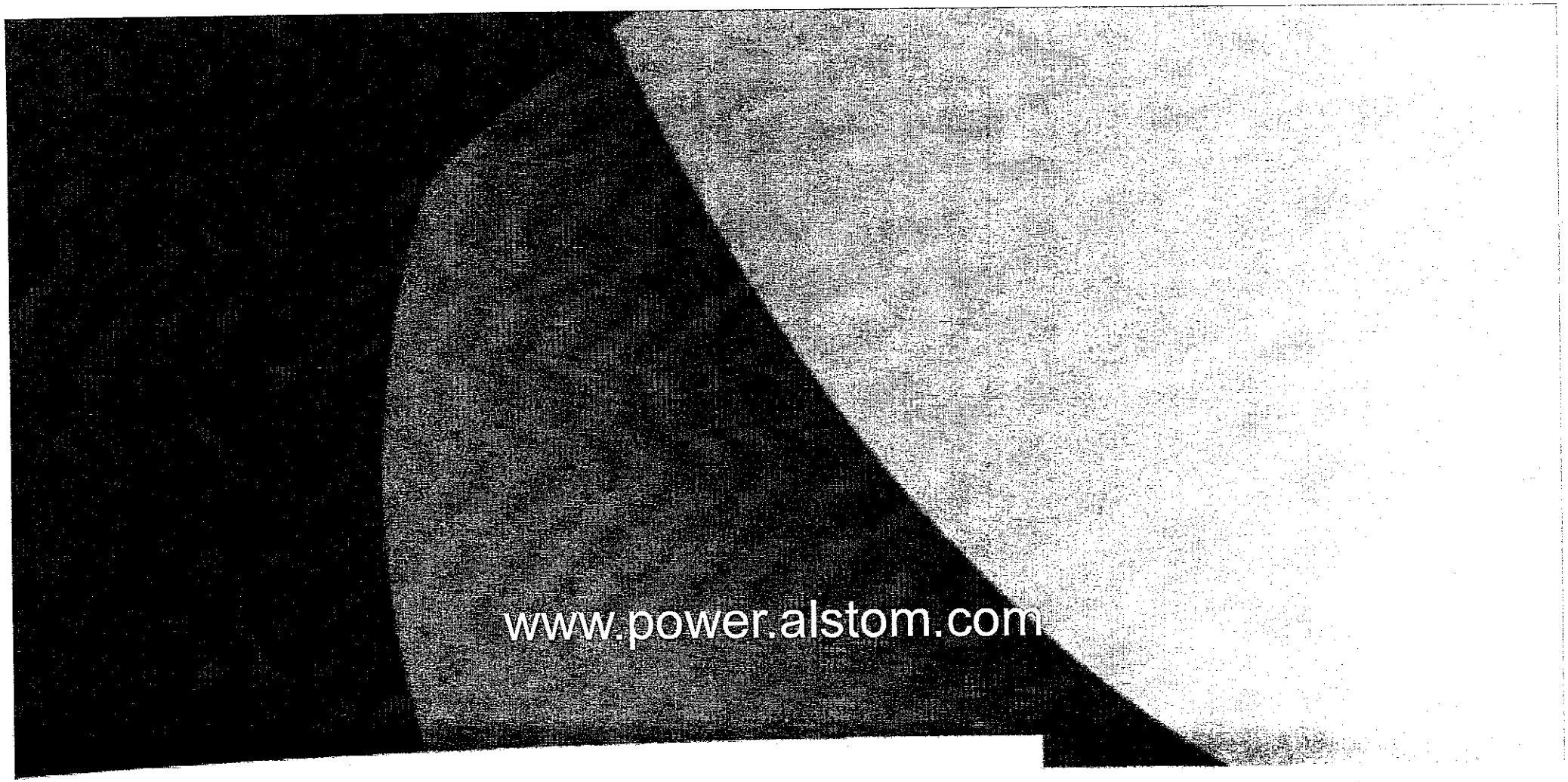
Hot Corrosion and Steam Oxidation Testing

- Laboratory testing of simulated high temperature corrosion environments, 1200°C
- In-situ corrosion probes



- Facilities include:
  - 4 High Temp Corrosion Furnaces
  - 3 Steam Oxidation Test Chambers
  - Thermogravimetric Analyzer, 1000°C max, 100g max, 1,5 cm max width specimen
  - Thermal Cycling Furnace

© ALSTOM 2009. All rights reserved. Information contained in this document is provided without liability for information purposes only and is subject to change without notice. No representation or warranty is given or to be implied as to the completeness of information or fitness for any particular purpose. Reproduction, use or disclosure to third parties, without express written authority, is strictly prohibited.



Alstom Power Turbomachines LLC
1201 Riverfront Parkway
Chattanooga, TN 37402 (USA)

Ann-Mari Stromberg
Senior Chemical Engineer
ann-mari.stromberg@power.alstom.com

February 2013

POWER | ALSTOM