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QUARTERLY REPORT October 1 – December 31, 1999

Project Background

The use of biomass and wood waste solids and sludges as fuel is often hampered by their low heating values and the presence of bound nitrogen that result in inefficient combustion and high NOx emissions. Cofiring supplemental fuel through auxiliary burners helps with improving the combustion effectiveness and NOx reduction, but the benefits are limited to the fractional heat input of the auxiliary fuel.

IGT has developed a process called METHANE de-NOX®, which has shown substantially greater economic, energy and environmental benefits than traditional cofiring methods in demonstrations with both MSW- and coal-fired stoker boilers. In this process, illustrated in Figure 1, auxiliary fuel such as natural gas or oil is injected directly into the lower region if the primary flame zone just above the grate. This increases and stabilizes the average combustion temperature, which improves combustion of high-moisture fuels, provides more uniform temperature profiles and reduced peak temperature, and reduces the availability of oxygen to reduce NOx formation. This is in contrast to conventional reburning, where natural gas is injected above the primary combustion zone after the majority of NOx has already been formed.

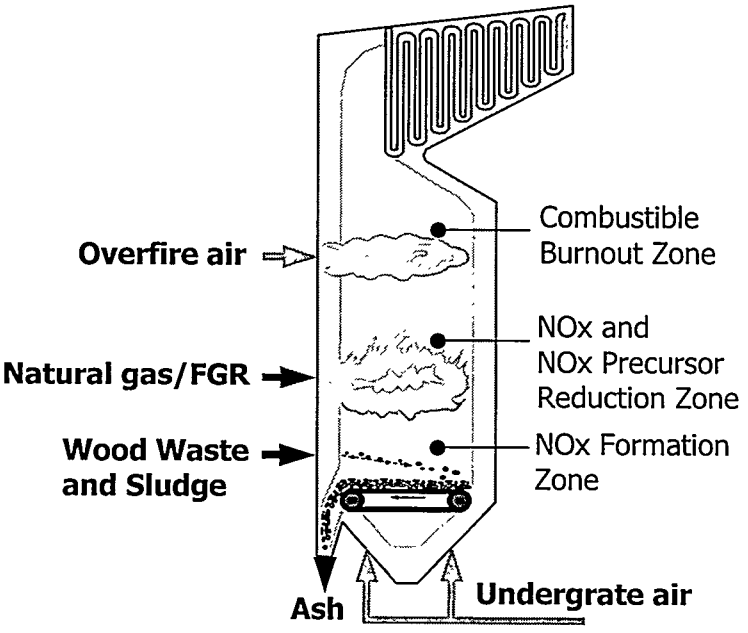

Figure 1. METHANE de-NOX® reburn process for stoker boilers

Demonstration tests carried out with MSW- and coal-fired stoker boilers have shown over 60 % reduction in NOx, CO and VOC emissions, and a 2 % increase in boiler thermal efficiency using only 8 to 13 % natural gas. Since August 1998, METHANE de-NOX® has been in continuous operation on all eight coal-fired boilers in Cogentrix's 240 MWe cogeneration plant in Richmond, Virginia.

Project Objectives

The project team includes the Institute of Gas Technology (IGT), Detroit Stoker Company (DSC), Sargent and Lundy LLC, Boise Cascade Corporation and US EPA. The primary objective of the project is to promote greater and more efficient use of waste wood and sludge for energy generation in the forest products industry while keeping NOx and CO emissions in compliance. Phase 1 of the project will demonstrate the technology on the 300 MMBtu/h waste wood- and sludge-fired Boiler No. 2 at Boise Cascade's plant in International Falls, MN. The specific performance targets for the demonstration are:

- Increased sludge firing from the current 1.2-1.5 tph to 5 tph
- Increased thermal efficiency for 40-100% load of 1 to 2 %
- NOx emissions reduced by over 50%
- Natural Gas input reduced by 25% compared to the current cofiring mode

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In Phase 2 of the project, long-term performance testing of the process will be conducted on Boiler No. 2 to confirm performance, operability and reliability of the system over the full range of boiler operations. A second objective of Phase 2 is development of engineering design protocols for the METHANE de-NOX® reburn system suitable for a variety of boiler and grate types currently used for energy generation in the forest products industry. This will involve the following project tasks:

- Development of a furnace computer model as a design tool
- Pilot-scale testing with wood waste and sludge for model validation
- Baseline performance and emissions field testing on 3 additional wood waste stoker boilers
- Additional field testing on Boise Cascade Unit No. 2 simulating operating conditions found on other boiler types
- Development of a METHANE de-NOX® technology database for wood waste-fired boilers
- Development of design protocols
- Development of a commercialization and technology transfer plan

Project Status and Plans

A detailed schedule for the project is shown in Figure 2. The current status of each project task is discussed below.

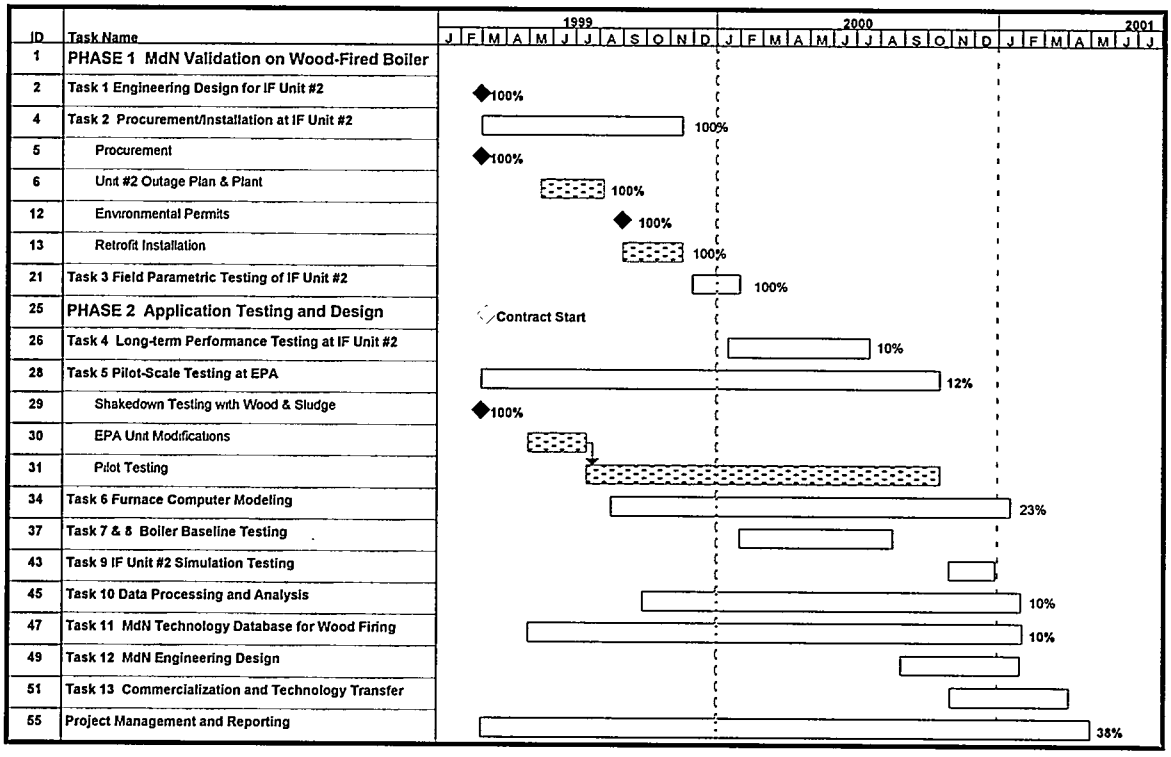

Figure 2. Project Schedule

Task 1 Conceptual & Engineering Design for International Falls Boiler No. 2

All work in this task is complete. As previously reported, baseline testing was conducted on Boiler No. 2 and the results used to generate a conceptual METHANE de-NOX® design. DSC then completed the detailed engineering design based on this information.

Task 2 Reburn Equipment Procurement and Installation

As previously reported, installation was significantly delayed from the original project schedule by delay in acquisition of the necessary Title V permit. This permit was received by Boise in late August, 1999, and retrofit installation begun in early September. Installation of all METHANE de-NOX equipment and controls was completed during the previous reporting period. Electrical installation, insulation of the FGR fan and ductwork, final adjustments and instrument zero checks were completed during the current reporting period. Key elements of the METHANE de-NOX system installed on Boise's Boiler No. 2 are shown in Figures 3 through 7.

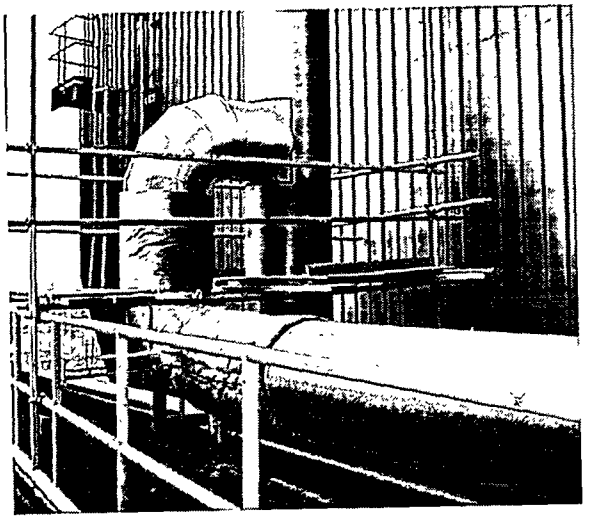

Figure 3. FGR tie-in to Boiler No. 2 exhaust header

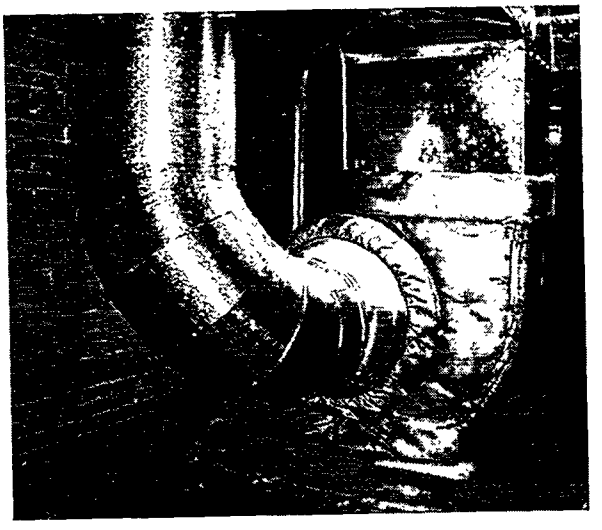

Figure 4. FGR fan

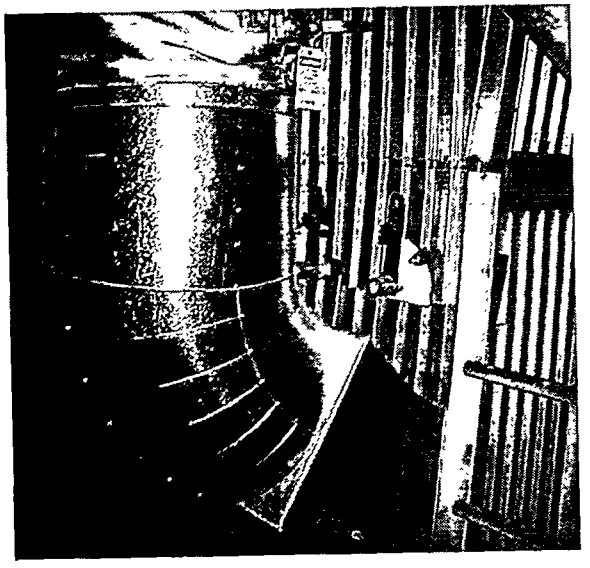

Figure 5. FGR tie-in to overfire air system

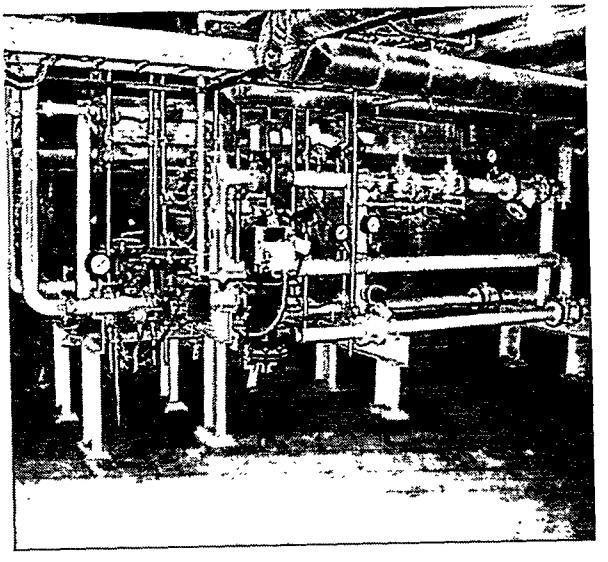

Figure 6. Natural Gas supply train

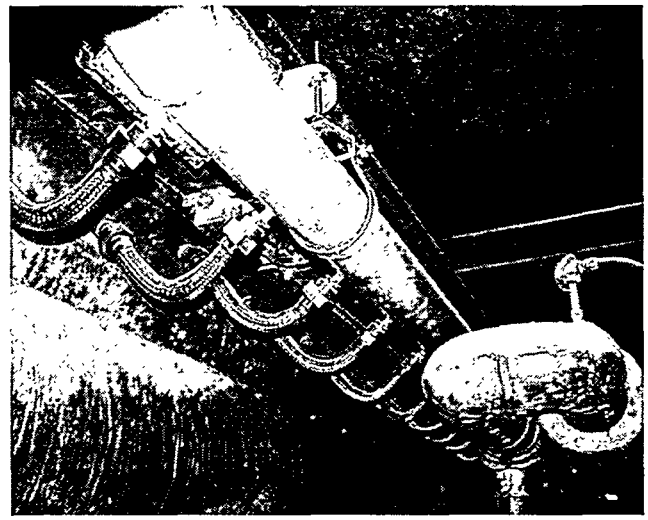

Figure 7. Natural gas distribution header at rear of boiler

Task 3 Field Parametric Testing of the Retrofitted Boiler No. 2

The final parametric test plan was completed by IGT and approved by Boise during the reporting period. The primary control approach for the METHANE de-NOX system was defined based on the relationship of natural gas and flue gas recycle (FGR) flow distribution to boiler steam flow. This formed the basis for a detailed test matrix (Table 1) developed by IGT and approved by Boise at the end of November. The planned test sequence was as follows:

1) Repeat baseline test points at the normal average sludge feeding rate of 1.3 TPH and increased sludge feed rate of 4 TPH to confirm that the basic boiler operating parameters have not changed significantly from the original baseline testing conducted almost 2 years ago.
2) Conduct up to 3 tests at the normal sludge feeding rate with FGR only to determine the effect of FGR distribution to the overfire air vs. undergrate air headers and between the front and rear overfire air headers.
3) Adjust FGR flow distribution based on results of the above testing, and then conduct up to 4 tests with natural gas flow at 5 % and 10% of total thermal input to the front and rear distribution headers.
4) Select FGR and natural gas distribution based on the above testing, then conduct up to 5 tests at 2.5-5 ton/h sludge with boiler loads from 70-100% to optimize FGR and natural gas distribution for minimum natural gas usage.

Summary of Task 3 Results:

IGT and DSC personnel began mobilizing at the site on December 1st, 1999. IGT's specialized sampling and analysis equipment was installed in the boiler house and boiler testing was begun on December 6th. Testing continued for ten days, during which time all equipment and controls were commissioned and put in service, and a total of 15 parametric tests of the system were completed. By December 12th, 1999, the entire METHANE de-NOX system, including flue gas recycle and natural gas injection, were placed in continuous operation under automatic control.

TABLE 1. PARAMETRIC TEST MATRIX FOR METHANE de-NOX SYSTEM ON BOILER No. 2

Test	Test Series	Load	Total EA	UGA/OFA	Sludge	Wood/Sludge/Gas	Flue Gas Recirculation (FGR)			Natural Gas			
No.		%	%O2	%/%	TPH	%/%/%	Total,%	UG FGR,%	OF FGR,%	Total,%	Burners,%	Front Injectors,%	Rear Injectors,%
1	Baseline 1	100	3	55/45	1.3	87/1.5/11.5	0	0	0	11.5	11.5	0	0
2	Baseline 2	100	3	55/45	4	84/4.5/11.5	0	0	0	11.5	11.5	0	0
3	Flue Gas	100	3	55/45	1.3	87/1.5/11.5	6	3	3	11.5	11.5	0	0
4	Recirculation	100	3	55/45	1.3	87/1.5/11.5	10	5	5	11.5	11.5	0	0
5	(FGR)	100	3	55/45	1.3	87/1.5/11.5	8	2	6	11.5	11.5	0	0
6	FGR	100	3	55/45	1.3	89.5/1.5/9	8	2	6	9	4	5	0
7	and	100	3	55/45	1.3	89.5/1.5/9	8	2	6	9	4	0	5
8	Natural Gas	100	3	55/45	1.3	84.5/1.5/14	8	2	6	14	4	5	5
9		100	3	55/45	1.3	79.5/1.5/19				19	4	7.5	7.5
10	FGR, NG	100	3	55/45	4	86.5/4.5/9	8	2	6	9	4	5	0
11	and	100	3	55/45	4	86.5/4.5/9	8	2	6	9	4	0	5
12	Sludge	100	3	55/45	4	83.5/4.5/12	8	2	6	12	4	3	5
13	FGR, NG	70	4	55/45	2.5	85/3/12	8	4	4	12	4	3	5
14	and	70	4	55/45	2.5	85/3/12	8	4	4	12	4	3	5
	Sludge												

During commissioning and shakedown operations, the ash handling performance of the stoker's hydrograte was improved significantly by mechanical repairs and tuning of the shaker mechanisms under the direction of DSC's representative. This was necessary to successfully integrate the METHANE de-NOX system into the existing boiler operations. The increased sludge firing rates result in a large increase in ash on the grate, which might limit the sludge firing rate without improved grate performance.

Parametric testing of the system was completed in accordance with the test plan previously developed. A total of 15 parametric tests were conducted during the period of December 6^{th} – 15^{th}. The major test variables were:

- sludge firing rate — 0 to 5 ton per hour (TPH)
- natural gas (NG) heat input — 0 to 17%
- flue gas recirculation flow rate — 0 to 8%
- boiler load — 80 to 100%

The results of these tests confirm that the performance goals of the project have been successfully met:

- with 8% NG heat input, the sludge firing rate was increased from regular 1.3 TPH to 4 TPH, and NO_x emission was reduced by 35%
- with 17% NG heat input, sludge firing rate was increased to 5 TPH and more than 50% NO_x reduction was achieved (90 ppm NO_x emission was demonstrated)

During the course of the shakedown and testing, all 4 shifts of Boise's boiler operators participated in and received training on the METHANE de-NOX system operation.

An evaluation of the boilers existing flue gas oxygen trim control system performance indicates that significant improvement can be realized by modifying the current system. Preliminary sketches of the modified control scheme were developed for future discussion with Boise. Improvement in this control system will facilitate future optimization of the METHANE de-NOX system and boiler performance in general.

Since December 12, 1999, the METHANE de-NOX system has been in full-scale operation with up to 5 TPH sludge combustion and NO_x emissions significantly lower than required by state regulations. The average sludge firing rate during this period was between 3-4 TPH. The system is now being maintained in continuous operation to collect operating data for long-term performance evaluation and system optimization.

Task 4 Long Term Performance Testing

Task 4 is currently underway. As of the end of the reporting period (12/31/99), the METHANE de-NOX system had logged 19 days of continuous operation on Boiler No. 2 with no major problems reported. IGT continues to monitor boiler operations through regular operating data reviews and teleconferences with Boise's engineering and operating staff.

Task 5 Pilot-Scale Testing

As previously reported, shakedown testing was conducted using wood waste and sludge provided by Boise Cascade in EPA's 2 MMBtu/h multifuel combustor/stoker. It was determined that the existing feeding system on the Pilot unit could not provide reliable and uniform feed rate with these fuels. EPA has modified the feeder to improve reliability and therefore data quality. The physical modeling effort will be resumed once feeder performance is tested and confirmed by EPA and IGT.

Task 6 Furnace Computer Modeling

As previously reported, IGT has acquired FLUENT (Computational Fluid Dynamics modeling and design code) software for the CFD modeling and design effort. The necessary computer hardware and peripherals have also been acquired. A full-time scientist with an extensive modeling background has been added to the project staff, and is supervising the subcontracting of the basic furnace model development effort.

Since the last reporting period, proposals have been received from Reaction Engineering International (REI) and Fluent Incorporated for model development and implementation in FLUENT code, respectively. Contract negotiations are currently underway. A Three-Party Non-Disclosure Agreement has been signed by all parties as the basis for the cooperative modeling effort by REI, FLUENT and IGT.

Tasks 7, 8 and 9 Additional Field Baseline and Simulation Testing

Following the successful conclusion of the parametric testing in Boise Cascades Boiler No. 2, discussions have started with Boise Cascade to determine whether additional sites are available for baseline testing of the METHANE de-NOX process in their other mills.

Task 10 Data Processing

Data processing activities are underway on the data and process samples collected during the Boiler No. 2 parametric testing in December.

Task 11 Development of METHANE de-NOX® Technology Database

As previously reported, an extensive database of stoker boilers compiled by the Gas Research Institute was utilized to identify over 140 stoker boilers over 100MMBtu/h currently in use in the pulp and paper industry. A questionnaire was developed to acquire boiler design and performance information from boiler owner/operators. The questionnaire was submitted to Boise Cascade for review and comment prior to distribution. Distribution of the questionnaire will be coordinated with industry contacts to maximize response.

Tasks 12 and 13 Engineering Design Protocols and Commercialization/Technology Transfer

No activity has taken place to date.

Task 14 Project Management and Reporting

Monthly progress review meetings, attended by the key Boise, IGT and DSC personnel, were held at the Boise Cascade, International Falls plant site throughout the quarter to monitor and assist the METHANE de-NOX retrofit installation and test preparation activities. This was supplemented by weekly conference calls to insure timely response to all questions and concerns among the project team. As a result, the installation and parametric testing were completed on schedule in December.

Weekly conference calls will continue in order to monitor system performance during the long-term performance period. It is expected that one or more site visits will be conducted during the current quarter to assist in modification of the boiler's oxygen trim control system and adjustment of the METHANE de-NOX system based on long-term performance results.

Project Schedule Summary

With successful completion of the METHANE de-NOX installation and parametric testing in December,1999, it is expected that the overall project will be completed as originally scheduled in the 1st quarter of 2001.