Solid Fuel - Oxygen Fired Combustion for Production of Nodular Reduced Iron to Reduce CO_2 Emissions and Improve Energy Efficiencies

November 15, 2011

Award Number: DE - EE0003473

Project Period: August 15, 2010 to August 15, 2011

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This publication is accessible from the home page of the Economic Geology Group of the Center for Applied Research and Technology Development at the Natural Resources Research Institute, University of Minnesota, Duluth (http://www.nrri.umn.edu/egg) as a PDF file readable with Adobe Acrobat 6.0.

Date of release: November 15, 2011

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This report is based upon work supported by the U. S. Department of Energy under Award No. **DE-EE0003473**

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Recommended Citation:
Fosnacht, D.R, Kiesel, R.F., Englund, D.J., Hendrickson, D.W., Iwasaki, I Bleifuss, R.L., and Mlinar, M.A., 2011, Solid Fuel-Oxygen Fired Combustion for Production of Nodular Reduced Iron to Reduce CO2 Emissions and Improve Energy Efficiencies, University of Minnesota, Duluth, MN, Technical Report NRRI/TR-2011/48, 44 pp.

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ACKNOWLEDGEMENTS
The project team gratefully acknowledges the financial contribution of the US Department of Energy for supporting grant **DE-EE0003473**. The team also would like to note the contributions of Dr. Dibyajyoti Aichbhaumik, the DOE Project Manager for his advice and direction during the course of project implementation. Many participated in the execution of this grant. The team would like to acknowledge the work of Dr. Iwao Iwasaki with the assistance of Mr. Andy Lindgren for his diligence in the laboratory development of mix designs. We also acknowledge the work and efforts of the Linear Hearth Team including Jerry Lien, Tim Kemp, Shawn Graham, Steve Zaitz, and Mike Swanson. We would also thank the University for providing financial support to the project from the Permanent University Trust Fund. Next, we would like to thank our corporate sponsor NuIron Technologies, LLC for their support and thoughtful discussions during the course of execution of this project.

Intellectual Property
During the course of this investigation and prior to that, the work conducted under earlier funding, various intellectual properties have been generated. These properties have been assigned by the University to NuIron Technololgies, LLC. A listing of the various patents issued and published applications is given in Section 10 of this report.

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List of Acronyms

BMSS – Bimodal Super Stoichiometry
CMRL – Coleraine Minerals Research Laboratory
EAF – Electric Arc Furnace
GHG – Green House Gas
Hi-QIP – High Quality Iron Pebble
LHF – Linear Hearth Furnace
NRI – Nodular Reduced Iron
NRRI – Natural Resources Research Institute
RHF – Rotary Hearth Furnace

Glossary

Abbreviated notation of lime and fluorspar in slag

In order to simplify the notation of the fluxing additive of lime and fluorspar, the following notation was used in this report. Composition (L) is located in the low fusion temperature trough near (CaO)/(SiO_2) of 1.2 in the CaO-SiO_2-Al_2O_3 phase diagram. The slag compositions were abbreviated by indicating the amounts of additional lime used in percent as a suffix, for example, $L_{0.5}$ and L_1 indicated lime additions of 0.5% and 1%, respectively, over that of Composition (L). The amount of fluorspar (abbreviated to FS) added in percent was also indicated as a suffix, for example, $L_{0.5}FS_{0.25}$, which represented that 0.25% by weight of fluorspar was added to a feed mixture with Slag Composition of $L_{0.5}$.

Atmosphere control

Atmosphere control in the LHF refers to the control of the atmosphere directly above the feed compositions regarding reducing gas composition, (specifically CO and H_2, with the absence of oxygen), and the volumetric turbulence of the combustion products that have an influence on these compositions.

Basicity

$$B_2 = \frac{CaO}{SiO_2} \qquad B_4 = \frac{CaO+MgO}{SiO_2+Al_2O_3}$$

Bimodal Super Stoichiometry

Bimodal Super Stoichiometry or BMSS is a term given to the practice of using a coarse and fine size fraction of carbon reductant in the reaction mixture for production of NRI. The fine fraction provides the reductant source for conversion of iron oxides to reduced iron while the coarser fraction survives the furnace atmosphere to allow the carbon solution reaction to sufficiently reduce the melting temperature to enhance the kinetics for production of metallic iron.

Bio-Coal

Bio-coal is defined as a coal or carbon substitute produced from a biomass resource.

Fusion time

NRI fusion time, also referred to as residence time, is defined as the time required in the box furnace or LHF to fully reduce a composition consisting of iron oxide, carbon reductant and fluxes to metallic iron. Reducing fusion time correlates to an increase in productivity for a given furnace dimension.

Micro NRI

Both in box furnace and LHF tests, NRI with a range of sizes formed depending on the test conditions used. The magnetic products after each test was collected with a hand magnet and screened into +6.35 mm (1/4”), -6.35 mm (1/4”) +20 mesh and -20 mesh. Plus 6.35 mm (1/4”) fractions were fully metallic when the products were judged to be fused. Minus 6.35 mm

(1/4")+20 mesh fractions were essentially all metallic and referred to as "micro NRI." Minus 20 mesh fractions had large amounts of fine carbon particles to which small metallic iron particles were attached. They are generally considered as unacceptable product as they typically contain higher levels of sulfur and their relatively small size can negatively influence EAF productivity.

Stoichiometric amount

In an attempt to quantify the amount of coal, coke or char needed as a reductant in feed mixture, the amount of carbon required to reduce iron oxides to metallic iron with the formation of CO was calculated and termed "stoichiometric amount" according to

$$FeO + C = Fe + CO$$
$$Fe_3O_4 + 4C = 3Fe + 4CO$$
$$Fe_2O_3 + 3C = 2Fe + 3CO$$

Fixed carbon from proximate analysis was used in the calculation.

Torrefaction

Torrefaction is a mild pre-treatment of biomass at a temperature between 200-300°C under low oxygen conditions to remove moisture, light volatiles and accumulate the carbon component. The resulting product is a partially carbonized biomass, essentially moisture-free and friable which allows it to be used similar to coal. Torrefied biomass has the potential to be composed of several biomass sources (ex. wood by-products, agricultural by-products, grasses, energy crops etc.) giving them similar material handling and processing capabilities.

Executive Summary

The current trend in the steel industry is an increase in iron and steel produced in electric arc furnaces (EAF) and a gradual decline in conventional steelmaking from taconite pellets in blast furnaces. In order to expand the opportunities for the existing iron ore mines beyond their blast furnace customer base, a new material is needed to satisfy the market demands of the emerging steel industry while utilizing the existing infrastructure and materials handling capabilities. This demand creates opportunity to convert iron ore or other iron bearing materials to Nodular Reduced Iron (NRI) in a recently designed Linear Hearth Furnace (LHF). NRI is a metallized iron product containing 98.5 to 96.0% iron and 2.5 to 4% C. It is essentially a scrap substitute with little impurity that can be utilized in a variety of steelmaking processes, especially the electric arc furnace.

The objective of this project was to focus on reducing the greenhouse gas emissions (GHG) through reducing the energy intensity using specialized combustion systems, increasing production and the use of biomass derived carbon sources in this process. This research examined the use of a solid fuel-oxygen fired combustion system and compared the results from this system with both oxygen-fuel and air-fuel combustion systems. The solid pulverized fuels tested included various coals and a bio-coal produced from woody biomass in a specially constructed pilot scale torrefaction reactor at the Coleraine Minerals Research Laboratory (CMRL). In addition to combustion, the application of bio-coal was also tested as a means to produce a reducing atmosphere during key points in the fusion process, and as a reducing agent for ore conversion to metallic iron to capture the advantage of its inherent reduced carbon footprint.

<u>Combustion Systems</u>

Each of the combustion systems were compared on a relative basis, using the standard air-natural gas system as the baseline. The results of this comparison show the oxy-gas burner system resulted in a 57% reduction in carbon dioxide emission in the flue gas. Although the use of solid fuels, including the thermally processed bio-coal, was successful for production of NRI, the configuration of the burner system with an air swept eductor to convey the fuel, resulted in air contamination, therefore minimizing the impact on reduced GHG to 12-15%. It is very likely that this technology could be used with a dense phase transfer system. Although the emission analysis for the coal based testing and the bio-based tests were essentially equivalent within the error capabilities of the equipment, the carbon footprint for the bio-based fuel is significantly lower.

<u>Use of Bio-coal in the Reduction/Smelting Process</u>

To evaluate bio-coal application as a carbonaceous reductant, a series of furnace tests were conducted that showed that the fusion behavior using biomass derived carbon reductant resulted in significantly faster fusion time (over 30% faster than base condition) while reducing sulfur content of NRI to 0.028% - 0.031%. This indicates that fully fused metallic NRI can be formed in about 60% of the time when compared to the baseline mix with med volatile bituminous coal as a reductant. Further application of the bio-coal was evaluated as a means to control the reducing atmosphere of the furnace during the important smelting phase of the process. Late stage carbon addition tests demonstrated that effective control of the atmosphere layer over the reaction mixture has the potential to increase productivity by 15% through improved heat transfer.

Use of Bi-modal Carbonaceous Reductant

It was found that for certain conditions, sizing of carbonaceous materials into a coarse and finer fraction helped control final smelting properties for the reduced iron products by aiding carbon transfer after iron oxide reduction had completed and by helping provide a protective atmosphere around the reduced iron to prevent reoxidation. The specific sizing for each of the carbon fractions needs to be closely controlled to minimize the formation of micro iron nodules and maintain high yields of primary NRI.

Concluding Comments

The results from this study indicate that the approaches taken can reduce both greenhouse gas emissions and the associated energy intensity with the Linear Hearth Furnace process for converting iron ore to metallic iron nodules. Various types of coals including a bio-coal produced though torrefaction can result in production of NRI at reduced GHG levels. The process results coupled with earlier already reported developments indicate that this process technique should be evaluated at the next level in order to develop parameter information for full scale process design. Implementation of the process to full commercialization will require a full cost production analysis and comparison to other reduction technologies and iron production alternatives. The technical results verify that high quality NRI can be produced under various operating conditions at the pilot level.

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1 Introduction

The current trend in the steel industry is an increase in iron and steel produced in electric arc furnaces (EAF) and a gradual decline in conventional steelmaking from taconite pellets in blast furnaces. Currently, iron ores from Minnesota and Michigan are pelletized and shipped to the lower Great Lakes ports as blast furnace feed. The existing transportation system and infrastructure is geared to handling these bulk materials. In order to expand the opportunities for the existing iron ore mines beyond their blast furnace customer base, a new material is needed to satisfy the market demands of the emerging steel industry while utilizing the existing infrastructure and materials handling capabilities.

Several processes have been proposed as alternatives and significant activity on a world-wide basis continues in developing these alternative ironmaking processes. Mesabi Nugget LLC recently commercialized Kobe Steel's ITmk3 process by producing "iron nuggets" in a 500,000 mt/yr pilot plant in Hoyt Lakes, Minnesota. A similar pilot plant campaign has also been demonstrated outside of Tokyo, Japan producing using JFE Steel's Hi-QIP process [5,6,7]. As with any new process or technology, much opportunity exists for further cost reduction and continued quality improvement to create added incentive for commercial development.

The University of Minnesota Duluth - Natural Resources Research Institute has been developing an advanced iron making technology in conjunction with one of the leading US EAF steel producers. The development, first funded by the University and the US Economic Development Administration and subsequently by the US DOE, has been summarized in a recently issued technical report entitled "Next Generation Metallic Iron Nodule Technology in Electric Arc Steelmaking – Phase II", DE-FG36-05G015185, US Department of Energy [1]. The process, developed by NRRI, considered for commercial development uses a specialized linear furnace design (LHF) with oxy-fuel combustion that affords several process and environmental advantages. Further expansion of the capabilities of the oxy-fuel combustion to utilize pulverized solid fuels for ironmaking technologies, including carbon char produced from woody biomass or agricultural products affords unique opportunities with respect to carbon neutrality and reduced greenhouse gas (GHG) emissions. The LHF to NRI process uses fine concentrates rather than fired pellets as required in the most prevalent gas-based, shaft DRI (direct reduced iron) systems in use today.

This program focuses on demonstrating the application of oxy-fuel combustion technology to reduce green house gas emissions while utilizing the best technology and processing conditions for converting iron oxide resources to high quality **N**odular **R**educed **I**ron (NRI). The resulting product will; 1) contain less gangue, 2) contain less sulfur, 3) be resistant to reoxidation, 4) cost less to produce and 5) use the existing transportation infrastructure and material handling systems. High quality NRI will be universally acceptable feedstock across the steel industry, electric arc furnace (EAF), submerged arc furnace (SAF), basic oxygen furnace (BOF), iron foundries, or as supplementary iron units to the blast furnace (BF).

2 Background

2.1 The Scientific and Technical Merit of the Technology

Currently, most iron making processes require agglomeration of iron bearing materials prior to processing into an alternative iron product, especially if the iron bearing material is a very fine material. The iron ore materials from the United States fall into this category of iron bearing material. The process of converting iron ore or iron bearing waste oxides to metallic iron containing between 2 and 4% carbon NRI has been developed by others over the course of the last decade. The technology differs from that of Midrex/Kobe or JFE in that a linear furnace concept is considered instead of the rotary hearth technology of the other developers.

For this application, oxygen-fuel burners offer many advantages over air-fuel burners. They are inherently more stable throughout a wide range of operating conditions and excess oxygen ratios. They provide good turndown performance. They can be designed and operated to produce either compact, high velocity, low luminosity flames, or, long, highly luminous, low velocity flames. Oxygen-fuel burners can produce a wide range of oxidizing or reducing products of combustion streams.

Oxygen-enriched combustion can:

- *Increase efficiency*. Flue gas heat losses are reduced because the flue gas mass decrease as it leaves the furnace. There is less nitrogen to carry heat from the furnace.
- *Lower emissions*. Certain burners and oxy-fuel fired systems can achieve lower levels of nitrogen oxide, carbon monoxide, and hydrocarbons.
- *Improve temperature stability and heat transfer*. Increasing the oxygen content allows more stable combustion and higher combustion temperatures that can lead to better heat transfer.
- *Increase productivity.* When a furnace has been converted to be oxygen enriched, throughput can be increased for the same fuel input because of higher flame temperature, increased heat transfer to the load, and reduced flue gas.

One distinct advantage of this technology is that it can utilize solid fuel rather than natural gas where the cost and/or the effect of the combustion products on the furnace gas atmosphere are problematical. The technology development has focused on reducing green house gases when compared to alternative technologies and employs oxy-fuel and oxy-coal combustion as the prime means of providing the necessary endothermic heating requirements to the process. In convective heat-governed furnaces, the furnace gas velocity may drop because the convective heat transfer coefficient may decrease in a larger proportion than the increase in gas temperature. If this happens, the conversion would do little to increase the overall heat transfer, so reducing flue gas temperature to pre-conversion level may not be possible.

The test program was initiated using a laboratory tube furnace with subsequent testing in a slightly larger box furnace. Over 6,000 laboratory, pilot and demonstration scale tests have been conducted over the course of the development, which was initiated in 2001. Major parameters investigated included such raw materials as:

(1) Taconite concentrates with different levels of silica content,
(2) Different carbonaceous reductants including Eastern anthracite, low-, medium- and high-volatile bituminous and Western sub-bituminous coals as well as their carbonized char and coke, and
(3) Different types of additives, such as balling binders and some specific additives for slag fusion temperature reduction and iron nodule sulfur control.

Furnace operating conditions included temperature and residence time, furnace atmosphere, hearth layer materials, iron nodule and slag chemistries as well as iron nodule size. A major difference between the test conditions of the LHF and the box furnace is the high CO_2, low CO concentrations and high turbulence of the burner combustion products. From computational fluid dynamics (CFD) modeling of the LHF, the furnace gas was noted to be circulating vigorously within each zone, and while the temperature at the surfaces of trays in Zone 3 was relatively uniform 1427°C (2600°F), furnace gas velocities approached 1-3m/s (3-10ft/s) in localized regions at tray level. In the box furnace, on the other hand, the furnace gas velocities were estimated at as much as two to three orders of magnitude less, 0.03-0.003 m/s (0.1-0.01 ft/s). Furnace atmosphere profoundly influenced the temperature needed to form fully fused iron nodules. Increasing concentrations of CO_2 required higher temperatures, but the fusion behaviors of iron nodules became less sensitive to the presence of CO_2 above 1400°C. In laboratory tests, fully fused iron nuggets could be formed at as low as 1325°C (2417°F) under a N_2-CO atmosphere, and sulfur in iron nuggets could be lowered to as low as 0.01% or less. Thus, from both a product quality standpoint and from an operating standpoint, furnace atmosphere control becomes a key control variable and must be considered in design of the overall furnace operating conditions.

The choice and amount of addition of carbonaceous reductants was found to be an important factor in iron nodule formation. While anthracite, low- and medium-volatile bituminous coal as well as coke worked well both in dry balled feed and a feed without prior agglomeration, sub-bituminous coal was totally unsatisfactory in balled mixtures, and its char generated inordinately large amounts of micro nodules under similar conditions. The optimum level of carbonaceous reductants was determined to be 75-85% of the stoichiometric requirement for metallization for the reaction mixture, based on Fixed Carbon analyses, when the furnace atmosphere consisted of N_2-CO mixtures.

Certain additives were found to be effective for lowering the fusion temperature of NRI, while some other additives lowered sulfur in iron nodules to as low as less than 0.01%. The generation of micro nodules, which need to be recycled, had been a drawback to the newly developed approach, but methods to control the generation of micro nodules have been developed.

2.2 Innovation, Originality and Feasibility of the Technology

2.2.1 Linear Hearth Furnace Design Considerations

The alternative processes previously described utilize a Rotary Hearth Furnace (RHF) design where the NRI process make use of a Linear Hearth Furnace (LHF) that affords some unique opportunities:

(1) The LHF creates an exit end which provides opportunity to recuperate sensible heat in a heat recuperation zone that cannot be done with an RHF. Combustion gas exhaust temperature in the LHF will be lower (inherent 'self' recuperation) than in the RHF, since the exhaust gas duct will be located away from the hot fusion zone.

(2) The LHF has the advantage of the charging and discharging being accomplished outside of the kiln, in a more accessible location. External charging and discharging has the added advantage of simplified dust control, outside of the kiln. Additionally, under ambient conditions for unloading, the product, slag and hearth layer can be removed magnetically, dumped, scraped, vacuumed or with a non-cooled auger – options not available in the RHF where the only practical discharge mechanism is an expensive water-cooled screw taking all material off at one time.

(3) It is a simple matter to incorporate an in-line drying zone with LHF, utilizing recoup-heat from the process; this cannot be done directly with an RHF.

(4) The LHF affords segregation of combustion gas atmosphere from reducing atmosphere in reduction/fusion zones. This would be very difficult to engineer, build and maintain in an RHF.

(5) For all but very large RHFs, the product is not symmetrically loaded and side to side uniformity is affected. This causes the production tonnage to be greater at the outer diameter than the inner diameter requiring asymmetrical application of heat. Exhaust flow around the RHF tends to follow the inner diameter.

(6) The RHF is less efficient in building space use and therefore more capital intensive. LHF can be constructed on grade, whereas the RHF requires an elevated hearth to allow access to the inner circle of the furnace.

(7) Uniform feeding, product removal and temperature distribution have to be considered in the RHF. Symmetrical loading affects side to side uniformity. Also, exhaust flow around the RHF tends to follow the inner diameter. An LHF is simply more uniform. In addition to the side to side uniformity discussed above, the co-current flow from hottest to coolest product is more easily controlled in an LHF. Since the charge and discharge are adjacent in an RHF, any seal that is less than 100% at this point allows exhaust flow to short circuit between these two points.

(8) A change in length requirements is only applicable to an LHF in order to allow an increase in production.

(9) The LHF design facilitates the creation of side by side batteries of reduction smelting furnaces that allow kiln cars to be shifted to the next furnace in a close and compact manner for processing material in the reverse direction in order to effectively increase facility productivity.

(10) The current LHF burner system employs oxy-fuel burners and allows the off-gas to be

more readily concentrated and treated for CO_2 reduction compared to the air-fuel systems employed by competitor processes.

(11) The use of oxy-fuel systems also reduces the contact of the products with furnace flue gases that potentially cause high slag FeO contents.

When a fuel is burned, oxygen in the combustion air chemically combines with the hydrogen and carbon in the fuel to form water and carbon dioxide, releasing heat in the process. Air is made up of 21% oxygen, 78% nitrogen, and 1% other gases. During air–fuel combustion, the chemically inert nitrogen in the air dilutes the reactive oxygen and carries away significant amounts of the energy in the hot combustion exhaust gas. An increase in oxygen in the combustion air can reduce this energy loss in the exhaust gases and increase heating system efficiency.

2.2.2 Oxy-fuel Combustion Systems

Oxygen-fuel burners can produce a wide range of oxidizing or reducing products of combustion streams. They can be designed and operated to produce either compact, high velocity, low luminosity flames, or, long, highly luminous, low velocity flames. For the LHF, an oxygen-fuel burner capable of producing an optimum atmosphere in the furnace, along with low emissions and a low momentum, highly radiant flame, is the desired goal.

The principle of CO_2 capture by oxy-fuel combustion is to burn fuel with oxygen rather than air so that the flue gas consists mainly of CO_2 and water with little nitrogen. When CO_2 capture is not required, oxy-firing is inherently more expensive than combustion with air using current state-of-the-art technologies. Potential advantages of oxy-firing deriving from smaller equipment size are offset by costs related to cryogenic air separation and flue gas recycle necessary to maintain acceptable temperature levels in the equipment (boiler/heater/gas turbine). When considering CO_2 capture, however, oxy-firing has the unique advantage to generate an effluent stream composed almost exclusively of CO_2 and H_2O. It is very inexpensive and easy to capture CO_2 of the necessary purity for sequestration from this stream, simply by water condensation. Applications in other industries have shown that the major additional capital and operating costs in oxy-fuel combustion for CO_2 capture are those associated with oxygen production when new gas turbine design costs are excluded. New and lower cost oxygen production methods are under active development which means that the overall cost of oxy-fuel concepts, i.e. those using flue gas recycle, should fall significantly. Combustion in pure oxygen or in oxygen enriched air in special high temperature furnaces is widespread in the metallurgical, glass and other industries, and therefore the operational and safety issues of oxygen combustion are well understood [9,10].

2.2.3 Oxy-Coal Combustion

Ordinarily coal combustion results in only about 15% CO_2 in the flue gas. The capture of CO_2 from the flue gas for sequestration is made difficult due to its relatively low concentration and the presence of other gaseous species like sulfur oxides that interfere with its separation. As an alternative, nitrogen can be separated from the air stream prior to combustion. However, combustion with pure oxygen results in very high flame temperatures that the current materials of construction cannot withstand. A method for using enriched oxygen for coal combustion with flue gas recycle to control the adiabatic flame temperature has been investigated so that the new technology can easily be applied as a retrofit to existing boilers. This method may result in more than 90% CO_2 in the flue gas [12].

2.2.4 Oxy-Biomass Combustion

Biomass as an energy source has several important advantages. Renewability and an infinite list of plant, byproducts, and waste materials that can be used as feedstock are very attractive features. Also, biomass consumes atmospheric CO_2 during growth and therefore may have no net generation of CO_2 during use and, therefore no negative impact on green-house gases. Although wood is clean and renewable fuel which, compared to coal, contains little ash, sulfur and nitrogen, it is not an ideal fuel for gasifiers. Its optimum gasification temperature is rather low (below 700°C) due to the high O/C ratio. As a result, wood is generally over-oxidized in gasifiers leading to thermodynamic losses. It is possible to reduce these thermodynamic losses by prior thermal pre-treatment in the range of 250-300°C, i.e. wood torrefaction. If the heat produced in the gasifier is used to drive the wood torrefaction reactions, the chemical energy preserved in the product gas has been shown to increase provided that both torrefied wood and volatiles are introduced into the gasification process [13]. The opportunity exists to utilize the existing technology for oxy-fuel combustion and pulverized coal firing techniques to use torrefied woody biomass or agriculture by-products as a low cost carbon neutral fuel for ironmaking. In addition to the benefits afforded by the concentration of CO_2 gas, the woody biomass products are also relatively free of sulfur oxides, creating more opportunities for CO_2 capture technologies. The LHF technology has the potential to apply these technologies, by taking advantage of the radiant flame of the oxy-fuel combustion, the reduction in NO_x, coupled with the potential for CO_2 enrichment afforded by the carbon source firing, and the carbon footprint benefits associated with the woody biomass fuel.

2.3 Potential Energy, Carbon Emissions Reduction, and Environmental Benefits

2.3.1 Potential Energy Reductions

The total energy requirement for a competitive technology was estimated at 16,282 J/mt (14.0 MM BTU/st). This compares favorably with recently published data of the ITmk3 demonstration project of 15,689 J/mt (13.49 MM BTU/st) [11]. The analysis for the proposed process led to overall energy savings of 3,489 J/mt to 5,815 J/mt (3 to 5 MM BTU/st-MIN), or 23 to 37% reduction over competitive processes. This benefit is in addition to reported energy savings of 30% for similar technologies over the current integrated steelmaking process [2,3]. For a one million st/y plant, therefore, potential energy savings would be 3 to 5 T BTU/y (3 to 5 x 1012 BTU/y). Furthermore, the proposed technology reduces emissions over ITmk3's reported reduction in emissions of more than 40 %[4].

2.3.2 Potential Carbon and Emission Reductions

The principle of CO_2 capture by oxy-fuel combustion is to burn fuel with oxygen rather than air so that the flue gas consists mainly of CO_2 and water with little nitrogen. When considering CO_2 capture, oxy-firing has the unique advantage to generate an effluent stream of the necessary purity for sequestration from this stream by simple water condensation. In addition, replacing air-fuel burners with oxygen-fuel burners is reported to save natural gas by 50 to 60% in a steel reheating furnace [(10)]. This fuel savings can be directly related to reduced CO_2 emissions. Therefore, the principle behind CO_2 reduction is two-fold; (1) reduced products of combustion by reducing fuel requirements by 40-50% and (2) the absence of nitrogen in the combustion system makes the CO_2 more available for capture by containment and reduced separation requirements. Typical oxygen combustion results in very high combustion temperatures without the nitrogen diluent from air. Recent designs of oxygen-fuel burners allow for staging of the combustion oxygen deeper into the flame zone and further out into the fired chamber, reducing flame temperatures. In addition, this oxygen staging capability produces NOx emissions that are **80% lower** than conventional, non-staged designs. In fact, NOX emissions decreased from 5.0 to 0.8 lb/st (84% decrease) in a glass furnace [(9)].

2.4 Previous Laboratory Development

During the course of the laboratory investigation, various combinations of variables were studied in order to determine the best combination of mix chemistry and processing conditions that would result in the production of high quality metallic NRI that contain little residual gangue material, possess low sulfur levels (<0.05%), and contain high amounts of carbon (>2.5%). The reduction of iron ore with coal and fluxes is simple in concept, but various factors must be controlled in order to effectively hit target chemistries and at the same time minimize energy requirements and avoid potentially catastrophic processing problems (e.g., aggressive slag attack on refractories and equipment). Various phenomena occur in the process of carbothermic reduction and these phenomena are summarized in Table I.

Table 1: Sequence of Events

		Mixture Temperature Range	
Event	**Description**	**°C**	**°F**
1	Dehydration of free water	100	212
2	Emission of volatile matter from coal	350 to 500	662 to 932
3	Dehydration of bound water from $Ca(OH)_2$	427	800
4	Calcination of calcium and magnesium carbonates	~727	~1340
5	Reduction of magnetite and hematite to iron	>827	>1521
6	Melting of fayalite ($2FeO.SiO_2$)	1177 to 1204	2150 to 2200
7	Melting of carbon saturated iron	1150	2102
8	Melting of slag	>1311	>2392
9	Melting of wustite (depending on dissolved oxygen content)	1373 through 1426	2503 through 2599
10	Melting of fluorspar	~1418	~2584
11	Melting of pure iron	1538	2800

2.4.1 Laboratory Tube Furnace Tests

The test program was initiated using a tube furnace with a 50.8 mm diameter x 1168 mm long mullite tube, which takes 25.4 mm wide x 101.6 mm long and 25.4 mm high graphite boats, to screen the test conditions for use in laboratory box and pilot plant linear hearth furnaces. To control the furnace atmosphere, N_2 and CO were supplied to the combustion tube via respective rotameters. Tests were carried out with a mixture, consisting of N_2 and CO mixture at 2 and 1 L/min, respectively.

Several major parameters have been investigated including such raw materials as: (1) multiple forms of iron oxide such as different taconite concentrates with different levels of silica content, a natural hematite ore and mill scale from an industrial plant, (2) different carbonaceous reductants including Eastern anthracite, low-, medium- and high-volatile bituminous and Western sub-bituminous coals as well as their carbonized char and coke, and (3) different types of additives, such as balling and briquetting binders and some specific additives for slag fusion temperature reduction and NRI sulfur control.

In addition, furnace operating conditions, such as temperature and time at temperature, furnace atmosphere, hearth layer materials, NRI and slag chemistries as well as NRI size, were varied. Taconite iron ore concentrates with different levels of silica indicated that magnetite concentrates with 6% SiO_2 produced NRI more readily than a more expensively produced flotation concentrate of 4% SiO_2, or super-concentrate of 2% SiO_2. ***All the iron bearing materials tested could be used to produce acceptable NRI.***

The choice and amount of addition of carbonaceous reductant is an important factor in NRI formation. While anthracite, low- and medium-volatile bituminous coal as well as coke worked well both in dry feed and feed without prior agglomeration, Powder River Basin (high-volatile sub-bituminous) subituminous coal was totally unsatisfactory in agglomerated (briquette or pellet) mixtures due to low strength development, and its char generated inordinately large amounts of micro NRI (<2.54 mm + 20 mesh) under similar conditions. The optimum level of carbonaceous reductants was 75-85% of the stoichiometric requirement for NRI formation, based on fixed carbon analyses with minimum generation of micro NRI, when the furnace atmosphere consisted of N2-CO mixtures and a carbon hearth layer was used. Certain additives were found to be effective for lowering the fusion temperature of NRI, while some other additives lowered sulfur in NRI to as low as less than 0.01%. Furnace atmosphere profoundly influenced the temperature needed to form fully fused NRI. Increasing concentrations of CO_2 required higher temperatures, but the fusion behaviors of NRI became less sensitive to the presence of CO_2 over 1400°C. The laboratory apparatus used for the studies are shown in Figure 1 and 2. The tube furnace was used to screen variables and the box furnace was used to confirm test conditions on a larger scale.

Figure 1: Laboratory Tube Furnace

Figure 2: Laboratory Box Furnace

2.4.2 Box Furnace Tests

Laboratory investigations were scaled up from the tube furnace trials using an electrically heated box furnace. This furnace shown in Figure 2 consisted of two 304.8 mm x 304.8 mm x 304.8 mm heating chambers with the two chambers capable of controlling temperatures up to 1450°C independently, and which accepted a 127 mm wide x 152.4 mm long x 38.1 mm high graphite or ceramic fiber board tray. To control furnace atmosphere, N_2, CO and CO_2 were supplied to the furnace in different combinations via respective rotameters. Total gas flow could be adjusted in the range of 10 to 50 L/min. In most tests, graphite trays were used, but in some tests, trays made of fiber board with a thickness of 12.7 mm were used. After introducing a tray into the cooling chamber, the furnace was purged with a gas, typically a mixture of N_2 and CO at 18 and 2 L/min, respectively, for 15 minutes to expel the air when a tray was introduced into the cooling chamber. Initially, the tray was pushed just inside of the flip-up door, held there for 3 minutes for preheating, then into the first chamber, held at 1149°C, for 5 minutes, and then into the second chamber, held at 1400°C for certain periods of time. After the test, the tray was pushed to the back of the flip-up door and held there for 3 minutes, and then into the cooling chamber. After cooling for 10 minutes, the tray was removed from the cooling chamber for visual inspection to see if NRI was formed. A major emphasis was placed in developing methods to produce larger-sized NRI by feeding mounded raw material mixtures in an attempt to circumvent costly agglomeration and drying steps. It was found that various sizes of NRI could be routinely produced, ranging from 8.38 mm to 63.5 mm. Box furnace tests provided an opportunity to further develop methods which showed promise in controlling the generation of micro NRI and for achieving desired sulfur levels in the metallized product. Modifications of hearth materials as well as proper selection of additives to feed mixtures were studied. It was found that high quality NRI could be produced using non-agglomerated mounds, and various agglomerated mixtures (pellets or briquettes) at smelting temperatures < 1450°C. During the course of the laboratory investigation, it was also found that control of slag chemistry and the atmosphere above the reduction mixtures was essential to allow complete smelting of the iron oxides to metallic iron and for separation of the gangue components to an easily removable slag phase. The atmosphere within the tube furnace and box furnace was much less turbulent than that encountered during pilot scale testing in the larger linear hearth furnace that will be discussed later. In addition, the degree of mixing of the off-gas from the reduction process was very low relative to a gas fired furnace. These differences proved to be very significant in evaluating the actual performance. The laboratory tests were extremely useful for developing mix compositions and hearth carbon and cover compositions that could be employed at the next scale, but these furnaces could not duplicate the conditions that actually occurred in the larger gas fired linear hearth furnace.

2.4.3 Findings from Laboratory Tests

The optimum size of coal added as a reductant was determined to be -65 to +100 mesh. Finer mesh-of-grind of coal formed NRI just as effectively, but the amount of micro NRI increased somewhat. The use of coarser coal required increased amounts of coal for forming fully fused NRI, suggesting that a certain amount of fine coal was necessary. Optimal size of coke or anthracite char used as hearth materials was found to be less than 10 mesh. Effective fluxing of the feed mixtures could be achieved using manganese oxide and fluorspar with a lime to silica ratio (1.5 to 1.7) that produced a fusion temperature of the slag under 1400°C. Other fluxes such as borax were investigated, but fluorspar was found to be most effective. It was also found that the height of a reaction mound or the size of the agglomerate was a very significant factor in controlling total process time. This indicates that the time needed for radiant heat transfer was significantly impacted by the surface area exposure to the radiant heat source. The mechanism for NRI formation was also investigated in some detail in the laboratory studies. Formation of fully-fused NRI depends not only on the effectiveness of the radiant and conductive heat transfer, but also on the rate of carburizing of the sponge iron with carbon coming from the hearth layer and also perhaps from the cover layer. Briquettes heated at 1400°C for different periods of time showed that slag was observed to form initially at the bottom of the briquettes.

2.5 Linear Hearth Furnace

2.5.1 Description

The Linear Hearth Furnace (LHF) can be best described as a moving hearth iron reduction furnace simulator. The furnace is 12.2 m long, consisting of three individual heating zones and a final cooling section (Figure 3). The LHF has undergone several stages of development, transitioning from a walking beam, natural gas-air fired furnace to one with a continuous moving car system and three distinct combustion systems that can be used individually or in combination. It has routinely been used to test a variety of the variables shown to be important from tube and box furnace tests. The primary goal of the program was to develop sufficient understanding of the controlling variables associated with iron oxide reduction and smelting using coal based reductant materials. The research has allowed sufficient knowledge to be developed so that nodular reduced iron (NRI) can be routinely produced with low levels of tramp impurities using various carbonaceous reduction materials. The laboratory furnaces allow very precise manipulation of key variables under very controlled experimental conditions. The LHF facility allows these basic studies to be expanded to a significantly larger scale and to create bulk samples of product for further testing. The conditions studied in the course of this project have shown that nodules of iron can be produced with various additives and operating conditions by manipulating the correct variables.

Figure 3: Pilot-Scale Linear Hearth Furnace

Atmosphere and Combustion - A major difference between laboratory electric furnaces and the LHF is the high turbulence associated with the natural gas – air burner combustion products. In the natural gas-fired LHF, operating under sub-stoichiometric gas and air mixtures simulates the required reducing conditions for reduction and smelting. The resulting furnace gas atmosphere contains a relatively low ratio of CO:CO_2 (approximately 1:5). Partially metallized iron ore from the reduction zone directly contacts the high CO_2, low CO, further enhanced by the highly turbulent furnace gas at high temperature as they enter the melting zone. Exposure of the partially metallized feed mixtures to this atmosphere causes rapid loss of added reductant carbon and formation of high FeO slag. The FeO content in the slag controls the oxidation state, and consequently, makes sulfur removal to the slag less favorable. The furnace atmosphere and the high FeO content of the slag coupled with the operating temperature typically 1450-1550°C as claimed in previous patents, appears to lead to some difficulty in lowering sulfur in iron nodules to below 0.1%S. Processing of high sulfur nodules in the EAF would lead to higher steelmaking costs and extra energy use as more slag forming compounds would be needed to purify the steel.

A simple Computational Fluid Dynamic (CFD) model of the furnace was built and used to demonstrate the impact of nitrogen introduced via burners firing with air, on turbulence in the furnace. Output from the CFD model using air fired burners shows the velocity scale ranges from 0 to 2.5 m/s. With the same level of energy input, using oxygen at 90% purity the velocity range is decreased to 0 to 0.8 m/s. This reduction of turbulence reduces the interaction of high CO_2 containing furnace gases and aids the metallization process efficiency. As a result, the LHF furnace has been equipped with three distinct combustion systems that can be operated separately or in combination:

- Natural Gas – Air Fuel Combustion System
- Oxygen - Natural Gas Combustion System
- Dilute Phase Pulverized Coal – Oxygen Combustion System

Thus, from both a product quality standpoint and from an operating standpoint, furnace atmosphere control is a key control variable and must be a key parameter in design of the overall furnace operating conditions. Various concepts for atmosphere control were tested. One method that was found to be very useful was to use a carbonaceous cover on top of the reaction mixture. This effectively shielded the reaction mixtures from the highly turbulent and oxidizing gas atmospheres. Other control methods included use of various reducing gas mixtures during the reduction stage of the process (>1093^{o}C to ~1250^{o}C). Finally, the use of oxygen-fuel burners reduces the volume of flue gas, thereby alleviating the turbulence within the furnace and conserving the energy associated with heating chemically inert nitrogen [(8)]. Turbulence may also be further reduced through flame shape characteristics.

Oxygen-Fuel Burners - Natural gas-air fired linear hearth furnace (LHF) tests generated high CO_2 (10%CO_2, 2-4%CO) and highly turbulent furnace gas as compared to the electrically-heated box furnace. This difference made it difficult in the LHF to produce satisfactory iron nodules consistently and the nodules produced often had sulfur contents that were undesirably high (0.1-0.3%S). The LHF remodeled with an oxy-fuel combustion system was tested initially by comparing the effect of oxy-fuel and air fuel burners on fusion time using bituminous coal-added briquettes. The results show fusion time was shorter by 10 to 30% when oxy-fuel burners were used as compared to air-fuel burners. This difference was related to the high turbulence of the furnace gas with air-fuel burners and their effect on the endothermic carbon solution reaction. NRI quality at fusion time analyzed 3.0 to 3.6 %C and 0.04 to 0.05 %S under the conditions tested.

Oxy-Coal Combustion - A 590,343 kJ/hr oxy-coal burner was positioned to fire horizontally from the end of the furnace, down the length of the LHF. The coal is fed by a variable feed Acrison screw conveyor/hopper through an eductor system for dilute phase coal injection into the burner. Oxygen is then monitored through the Programmable Logic Control (PLC) system to match coal addition and adjust stoichiometry. Atmosphere control was investigated while simultaneously controlling temperature by minimizing airflow, operating the burner in a sub-stoichiometric manner and controlling furnace zone pressure to prevent heat transfer into adjacent zones. The installation resulted in the LHF operating successfully on the coal-oxygen burner system, controlling both atmosphere and temperature. This was accomplished by reducing the ratio of conveying air to coal with increased fuel flow rates and using sub-stoichiometric oxy-gas burners to control oxygen content. The coal-oxygen burner system was capable of controlling the set point temperature of 1413 ^{o}C in zone 3 while maintaining good atmosphere control for production of NRI. The coal type used was a low volatile bituminous coal. A maximum loading of 0.27 kg/min of coal or an equivalent of 507,063 kJ/hr was used as a base energy load while the gas – oxy system was used to trim and control the temperature. While the coal system was in operation, the natural gas system was operating at less than 10% of full fire, and frequently less than1% on a single burner.

Recent testing in the LHF resulted in a failure of the firebrick refractory on the sidewalls of zones two and three. For this project the furnace was relined with new firebrick refractories. In addition, the exhaust ducts from two zones (zones 2 and 3) were removed to isolate the exhaust gases to a single duct. This allowed process gases to be directed co-current to the flow of the LHF and the gas analysis to be concentrated to a single stream for evaluation of the process emissions under each of the combustion systems. Figure 4 shows the finished refractory lining just prior to staged curing.

Figure 4: Refractory Reline in Zones 2-3 of the LHF

3 Production of Bio-coal from Biomass

3.1 Torrefaction

Torrefaction is a relatively new technology that partially carbonizes biomass, making it moisture-free and friable. Torrefaction is a mild pre-treatment of biomass at a temperature between 200-300°C under low oxygen conditions to remove moisture, light volatiles and accumulate the carbon component. Torrefied biomass has the potential to be composed of several biomass sources (ex. wood by-products, agricultural by-products, grasses, energy crops etc.) by giving them essentially all the same material handling and processing capabilities. During torrefaction the biomass properties are changed to obtain an enhanced fuel quality for combustion applications. Torrefaction of biomass is an effective method to improve the grindability of biomass to enable more efficient co-firing with fossil based fuels. It can then be used as a complete, or more likely partial, replacement for coal in pulverized coal facilities.

The feedstock utilized for the creation of a torrefied solid fuel consisted of mixed hardwood biomass donated by Sylva Corporation of Princeton, Minnesota. Woody biomass was chosen as the research feedstock due to its relatively low ash content and high availability in Northern Minnesota. The feedstock was chipped and screened to minus three-eighths of an inch before arriving at the Natural Resources Research Institute (NRRI). The raw woodchip moisture content was typically 7-10% with a bulk density of approximately 200 kg/m^3 (12.5 pounds per cubic foot). Hardgrove Grindability Index for the raw wood chips was approximately 10-15 and calorimetry on the dried wood chips was 19.05 MJ/kg (8,192 BTUs per pound). Table 2 displays a screen analysis for the Sylva wood chips.

Table 2: Sylva -3/8" Wood Chip Screen Structure

Mesh (Tyler)	Weight %	Passing Retained Cumulative %
+8	22.5%	77.5%
+10	6.7%	70.8%
+14	17.1%	53.8%
+20	12.1%	41.7%
+28	12.5%	29.2%
+100	26.3%	2.9%
+200	2.1%	0.8%
-200	0.8%	0.0%
Total	100.0%	-

Ash chemistry for the woodchip feedstock can be viewed in Table 3 below.

Table 3: Sylva -9.53 mm (-3/8") Ash Chemistry

Compound	Weight %
SiO_2	5.54
Al_2O_3	0.88
CaO	51.67
MgO	5.59
Total C	0.89
Fe^{++}	1.65

The raw woodchip feedstock was fed into the torrefier apparatus to create the solid fuel used in the LHF.

3.2 Calciner Torrefier Apparatus and Testing Conditions

The continuous process consisted of a retrofitted Calciner unit on the NRRI-CMRL campus. Dimensions of the reactor tube were 178 mm (seven inches) in diameter by 9.53 mm (3/8") wall thickness by 2,134 mm (seven feet) in length. The unit was fed through a variable frequency screw auger and was electrically heated by three heating elements, each 2.5 kW. The reactor tube could be rotated between 1.5 and 10 rpm. Torrefaction gases were taken away via an air blower and either condensed or flared. Figures 5, 6 and 7 display the torrefier diagram, a photo of the device, and the feeder/temperature controller, respectively.

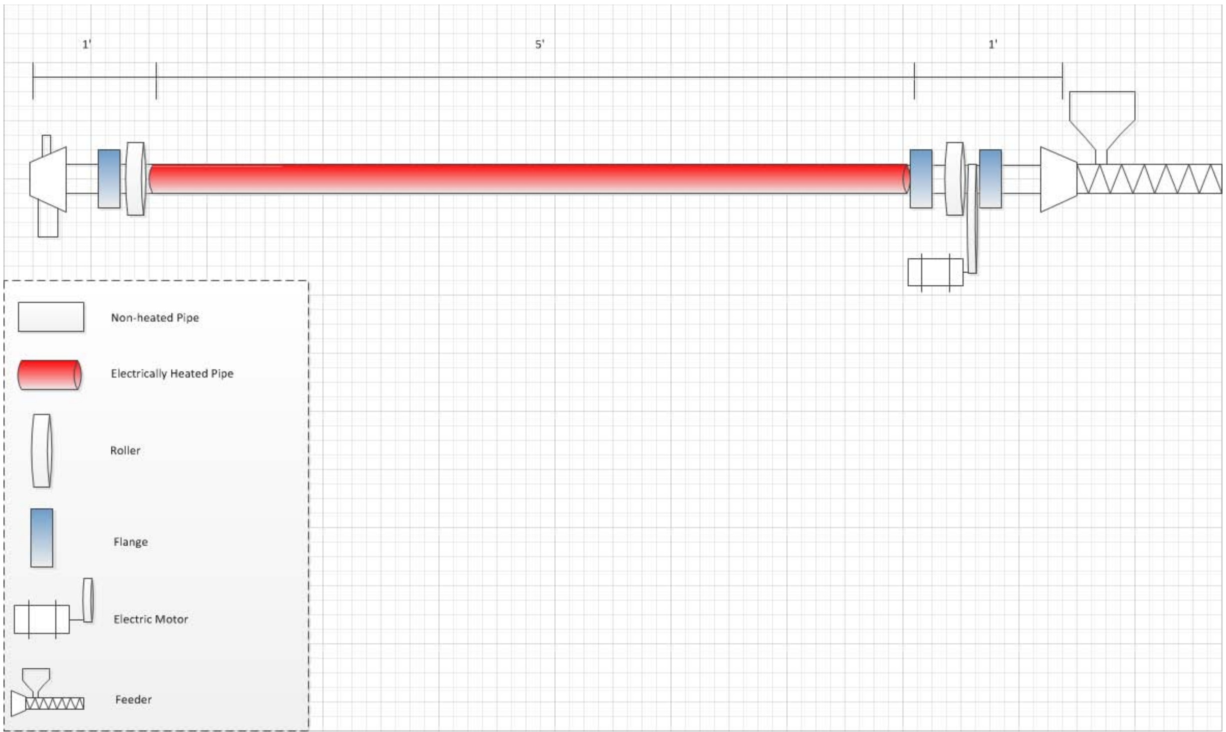

Figure 5: Calciner Torrefier Device Diagram

Figure 6: Completed Rotary Calciner Torrefier at NRRI

Figure 7: VFD Feeder and Temperature Controller for Calciner Torrefier

The torrefier operating parameters included feed rate, feedstock preprocessing, internal reactor temperature, and reactor rotational speed and angle. Feedstock sizing and moisture content, along with the other operating parameters, were held constant throughout each run with the exception of the reactor temperature. The baseline operating conditions were as follows:

- Feeder setting: Variable frequency drive setting of 50%
- Raw material throughput: ~10.9 kg (~24 pounds) per hour (0.18 kg (0.4 pounds) per minute)
- Feedstock moisture content: ~7-9%
- Drum rotational speed: 9 rpm
- Device alignment: 0.5° decline from feeder to discharge end

Almost the entirety of the sample was processed between 250°C and 300°C, with approximately 50% or more being thermally treated at 275°C in steady state. Figures 8 and 9 below show the biomass before and after roasting to produce the bio-coal.

Figure 8: Raw Feedstock -3/8" Wood Chips

Figure 9: Thermally Processed Bio-coal (275° C)

3.3 LHF Application and Testing Conditions

After thermally processing approximately 385.9 kg (850 pounds) of raw feedstock, the entire sample was ground via an Allis Chalmers vibrating ball mill (Figure 10). Fineness was judged upon a plus/minus sieve analysis. After thermally processing and grinding the sample was greater than 60% passing a 100 mesh sieve.

Figure 10: Vibrating Ball Mill

A sample was cut and sent to Standard Labs, Inc. for a chemical analysis. Table 4 displays the proximate and ultimate analyses of the ground torrefied biomass.

Table 4: Bio-coal Proximate and Ultimate Analyses

	As Received	Dry Basis
Moisture Content	4.52%	-
Volatile Content	68.54%	71.79%
Fixed Carbon	23.73%	24.85%
Ash	3.21%	3.36%
Sulfur	0.10%	0.10%
Carbon	53.55%	56.09%
Hydrogen	5.26%	5.51%
Nitrogen	0.17%	0.18%
Oxygen	33.19%	34.76%
BTU/LB	9,150	9,583
MJ/kg	21.283	22.290

The ground torrefied biomass was fed into the linear hearth furnace (LHF) via a coal feeder, a feed hopper, and an air conveyance system. The coal feeder and conveyor air control system can be seen in Figure 11 and Figure 12, respectively.

Figure 11: Coal Feeder and Feed Hopper

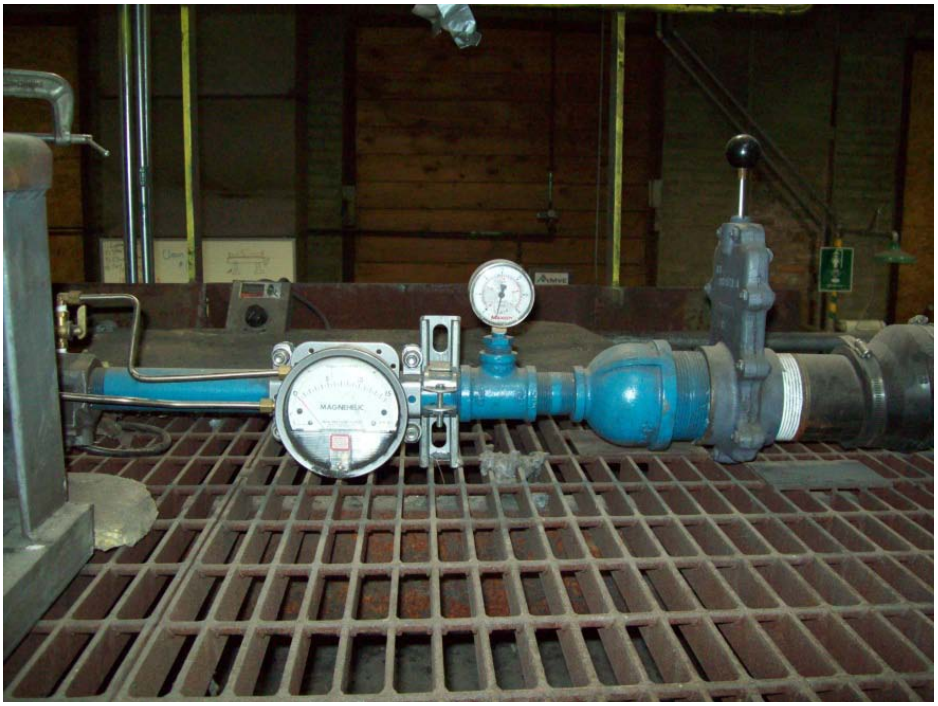

Figure 12: Conveying Air Flow Measurement

4 Results

This program compares the energy intensity and greenhouse gas emissions in a linear hearth furnace (LHF) using a solid fuel - oxygen fired combustion system. The solid pulverized fuels are identified as coals, and torrefied woody biomass char materials. The successful production of high quality NRI provides opportunities for recycling steelmaking waste products, diversification of iron ore processing and a new pure iron feedstock for the electric arc furnace steelmaking industry, while affording unique opportunities with respect to reducing greenhouse gas emissions (GHG) while providing process advantages. Research objectives are described below:

1. Establish the baseline energy and GHG intensity of the nodular reduced ironmaking process using standard air-fired natural gas burners
2. Establish the energy and GHG intensity of the nodular reduced iron making process using oxygen fired natural gas burners
3. Measure the energy and the GHG intensity of the nodular reduced iron making process using oxygen fired solid fuel burners and a variety of solid fuel types
4. Determine the feasibility of using thermally processed biomass as a reductant carbon source for advanced ironmaking
5. Evaluate the feasibility of using thermally processed biomass as a fuel for oxygen fired solid fuel burners in the nodular reduced ironmaking process

All combustion systems, fuel types (natural gas, coal and bio-coal) and conditions were tested. GHG were recorded during production of quality NRI from the baseline briquette chemistry (P-269), with a full furnace of anthracite char to simulate a true representation for the performance.

4.1 LHF Operation with Alternative Solid Fuel Combustion

Coal types tested were an eastern medium volatile bituminous coal, a southern high volatile bituminous coal, and western high volatile sub-bituminous coal. The bio-coal solid fuel was prepared using the torrefaction system previously described to a dry solid weight loss (DSL) of 30%. All baseline tests were conducted on briquettes (Mix ID# P-269) consisting of 73.5% magnetite concentrate, 18.0% med. volatile bituminous coal and fluxing components consisting of 6.5% hydrated lime and 2.0% fluorspar. The raw material chemistry for all components used in this study can be found in Appendix A and individual mix compositions in Appendix B. Results showed that residence time increased slightly by approximately 15%. This result was attributed to the loss of radiant energy from the idled oxy-gas burners and difficulty in controlling atmosphere due to the generation of CO_2 and water vapor from the conveying airflow.

The use of thermally processed bio-coal was successful for production of NRI, however, the steady-state operation of the solid fuel - oxygen burner system in the LHF required the bio-coal to be processed prior to use. The successful use of the fuel was found to be dependent on reducing the moisture content to less than a few percent, and sizing the bio-coal to a size distribution of – 20 Mesh. The present solid fuel combustion system uses an eductor to convey the solid fuel, and with the current configuration this system was prone to plugging. The relatively small size of the pilot LHF prevents the use of a larger diameter pipe to control the solid fuel addition and minimize air contamination within the furnace. It is believed that a larger system on a more industrial scale would not exhibit this phenomenon; however a dense phase conveyance system is desired to eliminate air contamination. The trends for comparison of CO_2 emissions by individual zone in the LHF are shown in Figures 13-16. In each case the trend is representative of the full furnace cycle, including the feed vestibule and the cooling section of the LHF.

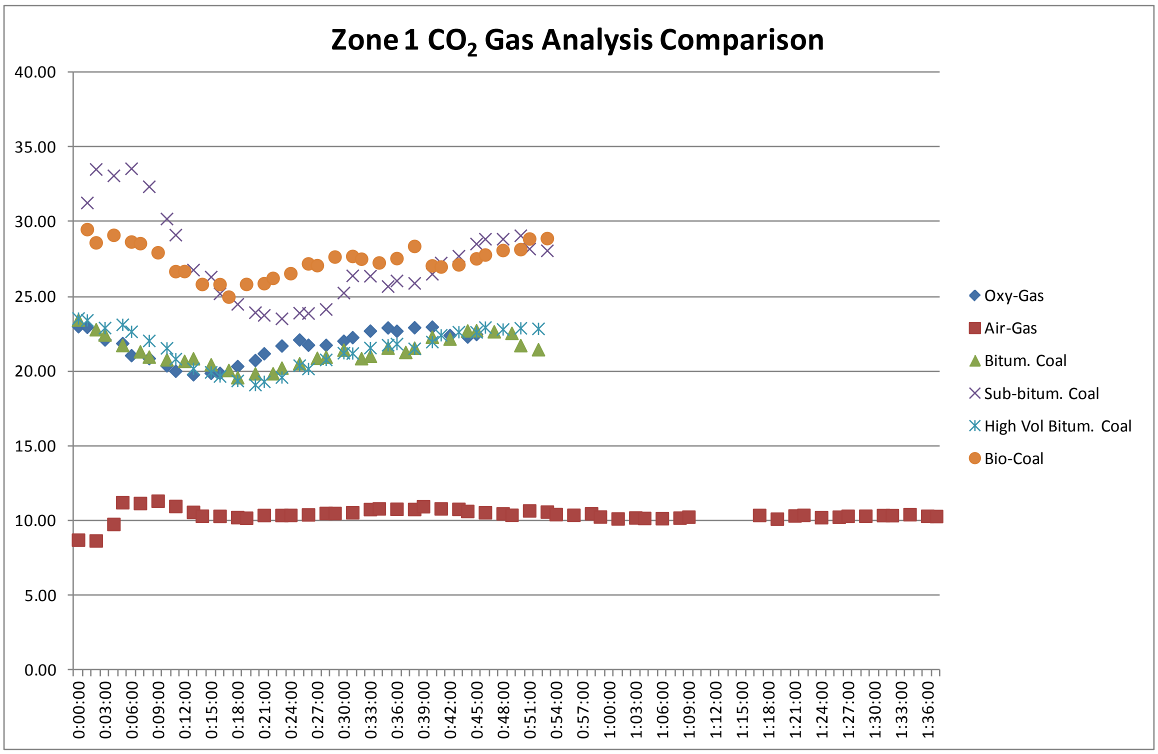

Figure 13: LHF Zone 1 CO_2 Measurements

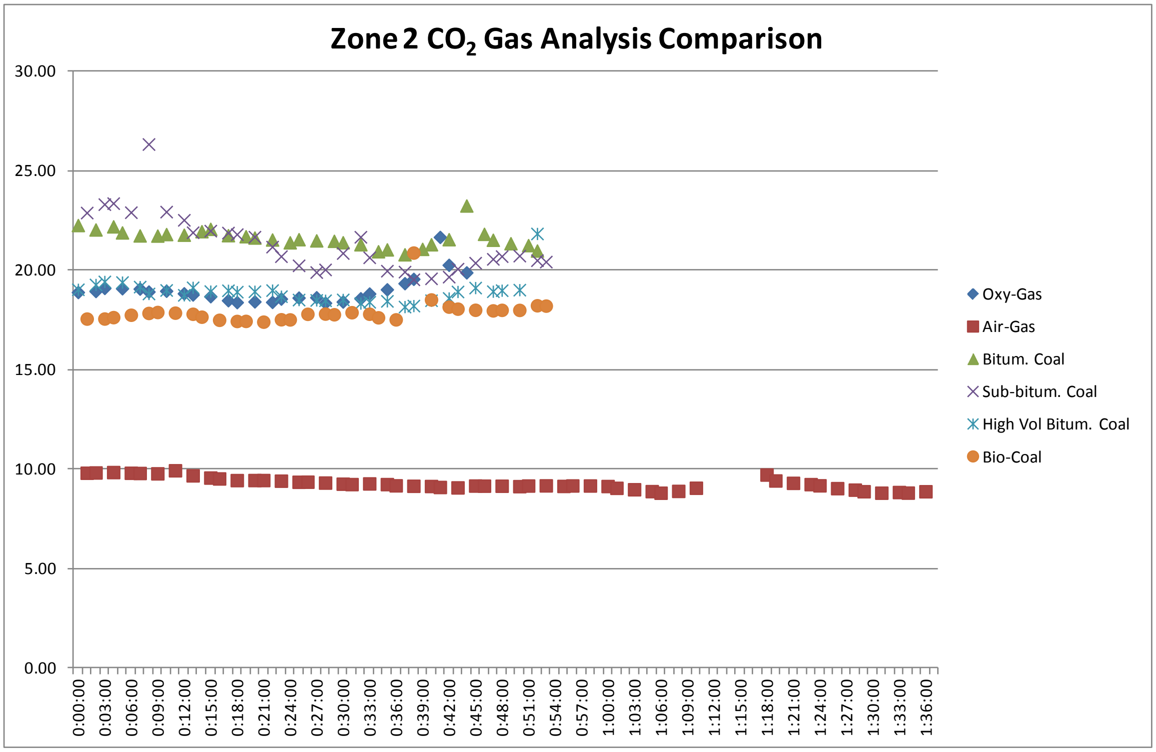

Figure 14: LHF Zone 2 CO_2 Measurements

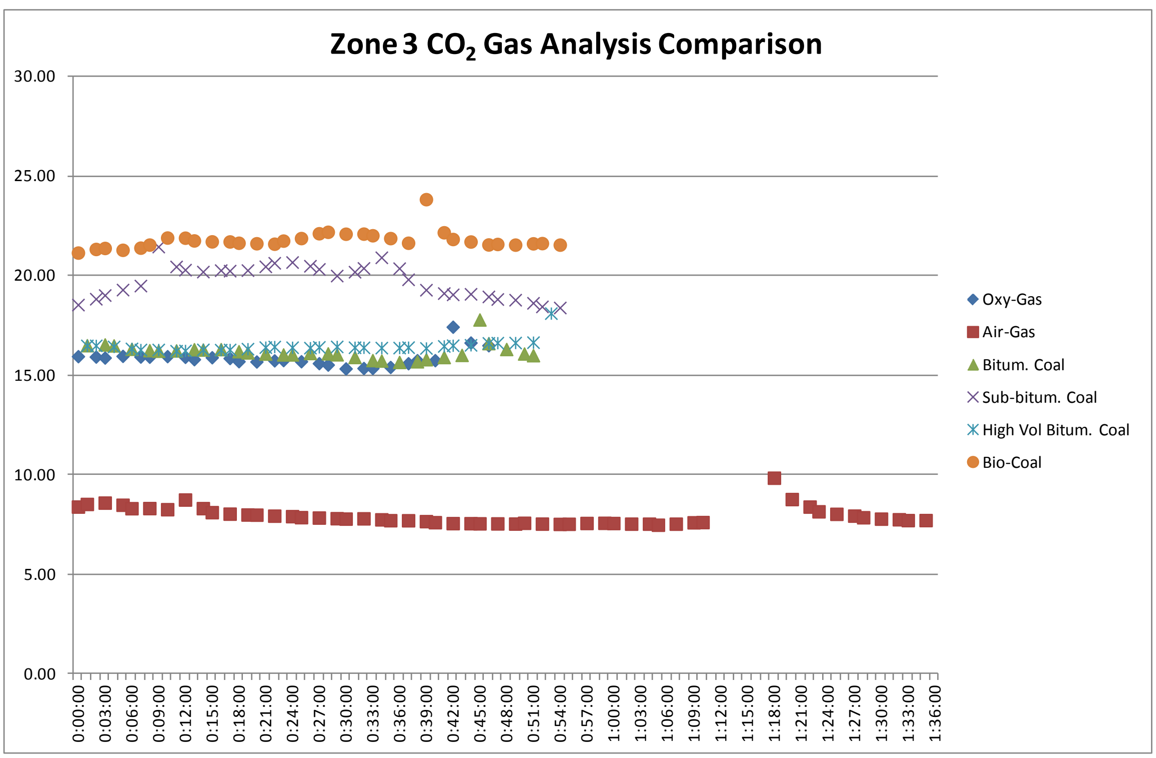

Figure 15: LHF Zone 3 CO_2 Measurements

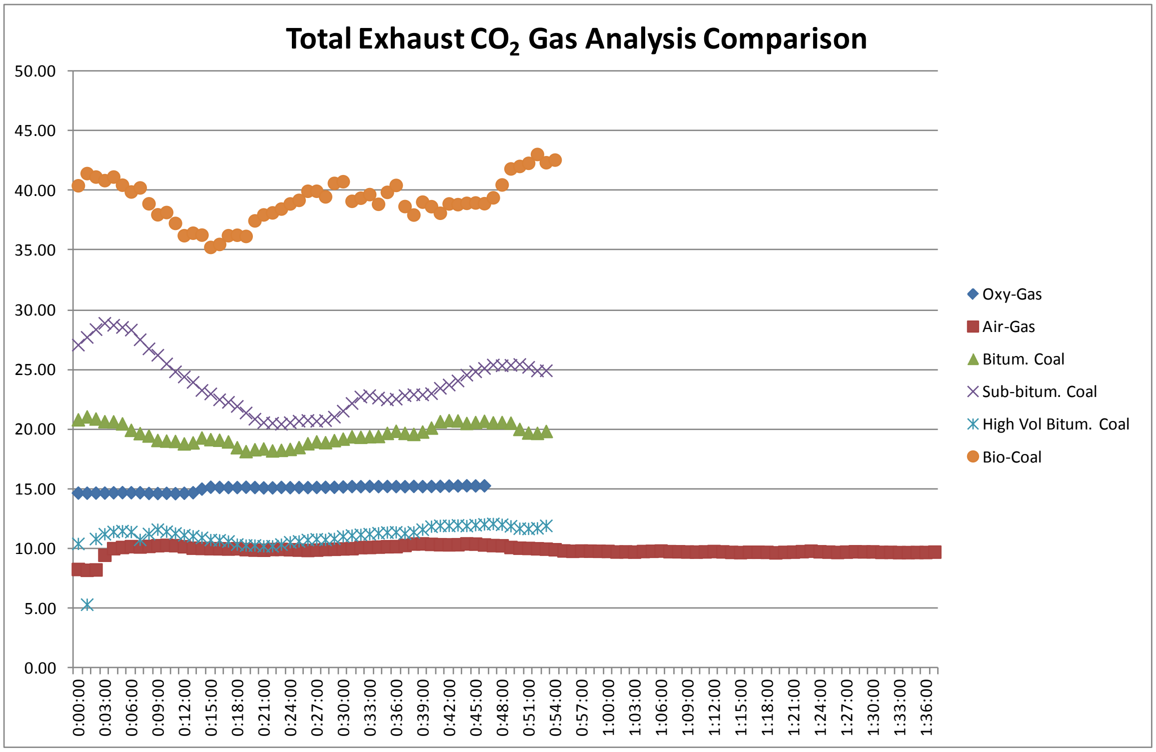

Figure 16: LHF Combined Total Flue Gas CO_2 Measurements

These trends show the increased concentration of CO_2 in the off gases when firing the solid fuels over the conventional air fired system. In addition, the emissions analysis shows a 57% reduced CO_2 reduction from the oxygen fired fuel options versus the air based system, on the basis of kg CO_2/mt of iron. The balances of the gases are primarily CO, nitrogen and water vapor. It should be noted that the nitrogen and water vapor content are estimated on the basis of a dew point calculation with the balance assumed to be N_2. Complete gas analysis data and LHF operating data can be found in Appendix C. For the intent of this study, N_2 and water vapor were assumed constant and comparisons were made on a relative basis. Although the use of solid fuels, including the thermally processed bio-coal was successful for production of NRI, the configuration of the burner system resulted in air contamination, therefore minimizing the impact on reduced GHG (kg CO_2/mt) to 12-15%. The oxy-solid fuel combustion system uses an air swept eductor to convey the fuel. Although the emission analysis for the coal based testing and the bio-based tests were essentially equivalent within the error capabilities of the equipment, the carbon footprint for the bio-based fuel is significantly lower. Figure 17 shows a comparison of the average CO_2 production based on per metric ton of NRI produced in the LHF.

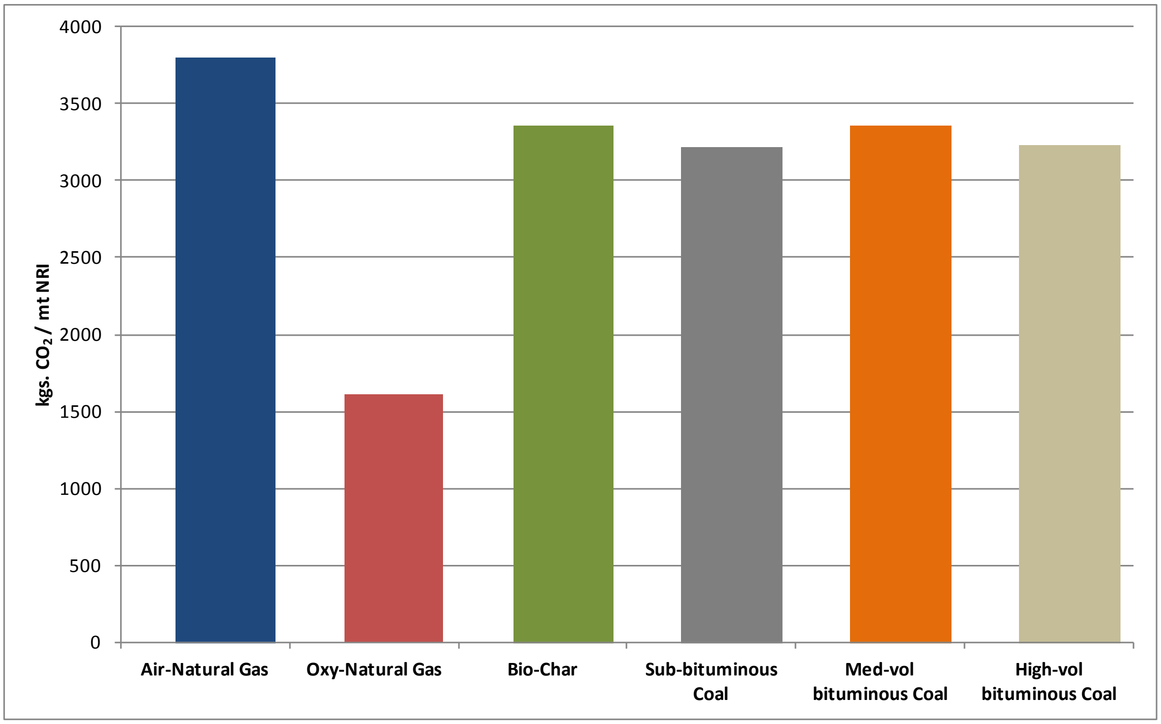

Figure 17: Greenhouse gas emissions comparison by fuel type

4.2 Atmosphere Control using Late Stage Bio-coal Addition

Tests were conducted to evaluate the feasibility of late stage addition of a coarse bio-coal cover layer (+16 mm) at a relatively high temperature ~1260°C (2300°F) to modify the atmosphere in the LHF during critical stages of fusion to increase productivity. The objective was to determine if waiting until the briquettes had reached a relatively high temperature, and metallization of the iron was essentially complete, would improve productivity on the LHF. Previous testing determined that direct exposure of the briquettes to radiant and convective heating without the cover layer will accelerate both heat up and reduction. The addition of the cover layer at this point has several advantages.

1. The briquettes are less than 150°C (300°F) below the temperature needed for fusion.
2. The reduction has been completed therefore the endothermic reduction reaction is not absorbing energy.
3. Hot briquettes will accelerate the heating of the cover layer and promote the Boudouard reaction necessary to provide the high CO levels needed to prevent back oxidation of the iron.
4. The gases from the reduced mass have greatly subsided and a protective atmosphere is now needed to prevent reoxidation of the reduced iron

The object of the tests was to determine if char could be substituted for coke or anthracite as a cover layer. The feeder system delivered a uniform char layer. It was observed that the char contained a high amount of volatiles, about the same, or perhaps a bit more, than we observed when western US sub-bituminous coal was used as a cover layer in prior studies (not publically reported). ***The tests demonstrated that the wood char is an effective atmosphere cover layer and has the potential to increase productivity by 15%.***

4.3 Bio-coal as a Reductant

The tube and box furnace tests were used to identify the benefits of using bio-coals in the agglomeration mixture as a reductant. Results are compared to a residence time of 5 minutes at 1400 ^oC for a baseline briquette composition (P-269). Briquettes were prepared using a common molasses binder (4%). Each of the tests conducted for comparison of the bio-coal addition as reductant were done using the designated $L_{1.5}$ FS_2 fluxing system described in the glossary in the preface to this report.

4.3.1 100% Bio-coal Reductant

Box furnace tests indicated that the fusion behavior using biomass derived carbon reductant resulted in ***significantly reducing fusion time over 30% while reducing sulfur content of NRI to 0.028% - 0.031%***. Prior results showed that a stoichiometric ratio of 85-95% fixed C:Fe, was optimal for production of quality NRI at low sulfur concentration. Using biomass prepared reductant at comparable stoichiometric ratios increased the volume of reductant carbon in the mix, as a result of the decreased fixed carbon and lower bulk density. Coupled with the relatively high volatile matter in the bio-coal resulted in increasing the generation of micro NRI (-6 Mesh +20 Mesh fraction). Reducing the ratio to 75% resulted in decreasing the amount of micro NRI. The results of these tests are shown in Table 5. This is consistent with a study conducted for DOE, for biomass application to the RHF, where replacing coal with wood charcoal as reductant can provide significant productivity gains, from 33 to 46%, a carbon source virtually free of net CO2 emissions [15].

Table 5: 100% Bio-coal Test Results

Mix No.	Test No.	Bio-coal % stoich.	B_2	Time at 1400°C min	Micro NRI (%)	% C	% S
P-1202	B-2231	65	1.85	5.5	0	2.93	0.031
P-1203	B-2235	75	1.87	5	7.3	2.83	0.028
P-1199	B-2222	85	1.89	3	43.5	NA	NA
P-1200	B-2224	100	1.92	3	96.7	NA	NA

This shows that 100% fused metallics can be formed in about 60% of the time when compared to the baseline P-269 mix of 5 min to fusion at 1400^{o}C. However, these were primarily micro NRI. Carbon and sulfur analyses were not conducted on sample mix # P-1199 and P-1200 due to an insufficient quantity of NRI produced. In addition, due to the relatively low fixed carbon level (25-30%) in bio-coal, significant quantities were required to achieve the stoichiometric levels required. This reduced the density of briquettes by 30%, and therefore reduced productivity of NRI.

4.3.2 Bio-coal and Coal Reductant Blends

In an effort to reduce micro NRI, while attaining the benefit observed with the bio-coal reductant, blends of bio-coal with both medium and high volatile bituminous coal at 10%, 30% and 50% were conducted. Two series of box furnace tests were carried out at 75% and 85% stoichiometric ratios of fixed carbon to iron. Table 6 shows the results of these tests.

Table 6: Blending Bio-coal with Medium-Volatile Coal Test Results

Mix No.	Test No	Char %	Coal %	Stoich %	B_2	Time at 1400°C min	Micro NRI (%)	% C	% S
P-1207	B-2237	10	90	75	1.54	10	0	3.34	0.030
P-1208	B-2241	30	70	75	1.58	7	0.2	3.20	0.030
P-1209	B-2245	50	50	75	1.63	6	0.7	2.95	0.029
P-1204	B-2249	10	90	85	1.53	5.5	0	3.21	0.025
P-1205	B-2251	30	70	85	1.57	4.5	0	2.81	0.025
P-1206	B-2253	50	50	85	1.62	3.5	0	2.66	0.024

This shows that 100% fused metallics can be formed with the same 85% stoichiometric ratio determined in previous testing, reducing residence time requirements by 30%, reducing sulfur content while increasing briquette density proportionately with the amount of bio-coal and coal addition.

For comparison, blends were also made from the bio-coal with high volatile bituminous coals. Briquettes were prepared with the same proportions of bio-coal to coal at 10%, 30% and 50% bio-coal and were tested in the box furnace with both 75% and 85% stoichiometric ratios. Table 7 shows the test results of these blends.

Table 7: Blending Bio-coal with High-Volatile Coal Test Results

Mix No.	Test No	Char %	Coal %	stoich %	B_2	Time at 1400°C min	Micro NRI (%)	% C	% S
P-1216	B-2281	10	90	75	1.57	6.5	0	2.82	0.047
P-1217	B-2275	30	70	75	1.61	6	0	2.93	0.042
P-1218	B-2282	50	50	75	1.65	5	0	2.94	0.034
P-1219	B-2285	10	90	85	1.56	4	2.6	2.78	0.029
P-1220	B-2278	30	70	85	1.60	3.5	7.8	2.48	0.027
P-1221	B-2288	50	50	85	1.65	3.5	13.2	2.61	0.029

Again, **this shows that 100% fused metallics can be formed with 85% stoichiometric ratio, while also reducing residence time requirements by 30%**. The amount of micro NRI generated at this ration increased slightly over the medium-volatile coal, indicating that the generation of micro-NRI is proportional to the amount of volatile contained within the reductant. This is also consistent with previous study using high-volatile sub-bituminous coals as reductant.

4.3.3 Micro-Nodule Generation

To further investigate the generation of micro NRI, a sequence of box furnace tests was conducted at timed intervals with blends of bio-coal and medium-volatile bituminous coal. Briquettes prepared for previous tests ranging from 50-100% bio-coal were heated at 1400 ^{o}C in a 10% CO atmosphere (balance N_2) at 1 minute intervals up to 6 minutes. Four samples of briquettes were placed in each crucible as shown in Figure 18. The six samples after reduction are shown in Figure 19.

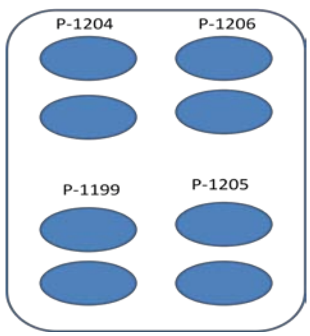

Figure 18: Briquette Test Schematic

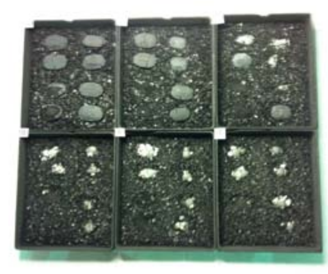

Figure 19: Pictorial presentation of interval reduced briquettes:

a) 1 min. b) 2 min. c) 3 min. d) 4 min. e) 5 min. f) 6 min.

The samples were then magnetically separated and screened on the standard 6.3 mm, -6.3 mm + 20 Mesh, and – 20 Mesh. The non-magnetic portion is reported as slag. Table 8 shows the results of the interval testing.

Table 8: Sequence of Micro Nodule Generation for Various Blends

				Magnetics (%)			Non-Mag (%)	
Mix #	% Bit. Coal	% Bio-Char	Time	+6.3mm"	-6.3mm + 20M	-20M	Slag	Observation
1199	0	100	1 min.	29.3	16.0	54.7	0.0	not fused
1199	0	100	2 min.	16.3	35.1	48.6	0.0	primarily fused, partial reduced iron
1199	0	100	3 min.	13.2	38.5	36.9	11.4	all fused
1199	0	100	4 min.	27.2	32.6	30.9	9.4	all fused
1199	0	100	5 min.	16.5	50.2	22.1	11.3	all fused
1199	0	100	6 min.	11.6	49.3	27.4	11.6	all fused
1204	90	10	1 min.	100.0	0.0	0.0	0.0	not fused
1204	90	10	2 min.	100.0	0.0	0.0	0.0	not fused
1204	90	10	3 min.	89.4	10.6	0.0	0.0	not fused
1204	90	10	4 min.	82.4	0.0	0.0	17.6	all fused
1204	90	10	5 min.	82.7	0.0	0.0	17.3	all fused
1204	90	10	6 min.	85.3	0.0	0.0	14.7	all fused
1205	70	30	1 min.	100.0	0.0	0.0	0.0	not fused
1205	70	30	2 min.	100.0	0.0	0.0	0.0	starting to show fusion, primarily DRI
1205	70	30	3 min.	90.2	3.4	0.0	6.4	some fusion, primarily DRI
1205	70	30	4 min.	81.5	0.0	0.0	18.5	all fused
1205	70	30	5 min.	81.8	0.0	0.0	18.2	all fused
1205	70	30	6 min.	82.7	0.0	0.0	17.3	all fused
1206	50	50	1 min.	100.0	0.0	0.0	0.0	not fused
1206	50	50	2 min.	100.0	0.0	0.0	0.0	approx. 1/2 fused
1206	50	50	3 min.	75.7	9.6	1.4	13.2	partially fused, partial reduced iron
1206	50	50	4 min.	82.4	0.0	0.0	17.6	all fused
1206	50	50	5 min.	80.2	1.9	0.6	17.3	all fused
1206	50	50	6 min.	81.3	0.0	0.0	18.7	all fused

The data show that the generation of micro NRI, defined as the % - 6.3mm + 20M, occurs very early on in the process. At the 2 minute interval, with 100% bio-coal, (Mix #1199), micro NRI accounts for 35% of the metallic portion of the sample. It's reasonable to assume that a portion of these micro NRI will reform into the metallic NRI sample since, at the 3 minute interval, all samples showed some signs of micro NRI, however decreased in subsequent intervals. It's also important to note that the 100% bio-coal sample was near full fusion at the 2 minute time interval.

4.4 Bimodal Super Stoichiometric Reduction (BMSS)

Because of the high CO_2, high H_2O atmosphere in LHF, fine size reductant coal was lost and became less than the optimum amount as determined in the box furnace, which led to increased fusion time and higher NRI sulfur. Preliminary LHF tests indicated that fusion time could be significantly decreased by increasing the size of a portion of the reductant coal, thereby, reducing the reaction rate of a portion of the coal used in the reaction mixture. The resulting reductant carbon blend consists of two fractions (bimodal size distribution), 1) a nominal 80% passing 150μm coal and 2) a coarser -1.2mm +0.3mm fraction, in this case recycled anthracite hearth layer, necessary to survive the atmosphere and finalize the reduction step. Bimodal Super-Stoichiometric (BMSS) briquettes after they were fully reduced (metallized) had residual carbon of 8-9%C, which suggested that coarse recycled anthracite could be lowered to below 40% of the stoichiometric amount. Various teat were conducted to examine the bi-modal carbon concept and these are summarized in the next sections

4.4.1 Medium Volatile Bituminous Coal / Anthracite Char

In these briquettes, the amounts of -100 mesh medium-volatile bituminous coal was varied from 85% to 105% of the stoichiometric amount and 14/48 mesh recycled anthracite hearth layer from 40% to 20%, thereby keeping the total carbon to 125% of the stoichiometric amount, in order to examine the effect of increasing coal to correct for the oxidizing atmosphere in the LHF. Test samples were obtained from the batches used in the LHF tests, and box furnace tests were carried out using the standardized procedure. The box furnace test results are given in Table 9. For comparison, the LHF test results are presented in Table 10.

Table 9: Medium Volatile Bituminous coal and coarse recycled anthracite on fusion behavior

medium-volatile bituminous Coal: Recy anthracite % stoich	B_2	Mix No.	Time at 1400°C, min	% micro NRI	NRI %S
85:40	2.3	P-1171	3	12.4	0.016
	2.1	P-1172	3	4.9	0.016
	1.9	P-1173	3	4.0	0.018
95:30	2.3	P-1165	3	20.9	0.016
	2.1	P-1166	3	16.8	0.021
	1.9	P-1167	2	14.3	0.018
105:20	2.3	P-1168	2	28.3	0.016
	2.1	P-1169	2	52.1	0.020
	1.9	P-1170	2	34.9	0.018

(Magnetite concentrate, different amounts of -100 mesh med.-volatile coal and 14/48 mesh recycled anthracite, but keeping the total carbon addition to 125% of the stoichiometric amount, 2% fluorspar, bauxite added to produce 15% Al_2O_3 in slag, and slag basicity B_2 of 2.3 to 1.9. 4% molasses was used as a binder)

Table 10: LHF tests with medium volatile bituminous coal and coarse recycled anthracite on fusion behavior

medium-volatile bituminous coal: Recy anthracite % stoich	B_2	Mix No.	LHF test No.	Car speed "/min	Fusion time, min	% micro NRI	NRI %S
85:40	2.3	P-1171	1098	>16	<19.5	10.9	0.056
	2.1	P-1172	1099	>16	<19.0	10.1	0.056
	1.9	P-1173	1097	14	21.0	5.5	0.073
95:30	2.3	P-1165	1098	>16	<19.5	22.3	0.052
	2.1	P-1166	1099	>16	<19.0	13.8	0.061
	1.9	P-1167	1101	15	20.5	12.5	0.071
105:20	2.3	P-1168	1098	>16	<19.5	27.1	0.040
	2.1	P-1169	1099	>16	<19.0	24.9	0.054
	1.9	P-1170	1100	>16	<18.5	30.8	0.099

Major findings of this investigation were as follows:

1. Fusion time decreased from 3 to 2 minutes when medium-volatile bituminous coal increased from 85 to 105 % of the stoichiometric amount. The fusion time was in the same range as BMSS briquettes using other reductant carbon.
2. Fusion time in the box furnace of 2-3 minutes indicated that fusion time in the LHF was less than 19 minutes, as sample trays could not be moved fast enough to determine the fusion time with the currently-installed system.
3. Micro NRI was high in the range of 4-12% even when medium-volatile bituminous coal was 85% stoichiometric, and increased to 28-52% as medium-volatile bituminous coal increased to 105% stoichiometric.
4. In the absence of recycled anthracite, micro NRI was minimal (0.2-0.3%) when medium-volatile bituminous coal was 85% stoichiometric. The increase in micro NRI by the addition of recycled anthracite suggested that the small-size end of 14/48 mesh recycled anthracite acted as reductant carbon along with medium-volatile bituminous coal, and, in effect, the amount of combined reductant carbon became high beyond the optimum amount of 85% stoichiometric.
5. Micro NRI was lower in the LHF as the oxidizing atmosphere must have consumed some medium-volatile bituminous coal. The size of recycled anthracite needs to be made coarser in order to control the generation of micro NRI.
6. NRI sulfur in the box furnace remained 0.02%S or less regardless of the amount of medium-volatile bituminous coal or slag basicity. In the LHF, NRI sulfur was 0.05%S or somewhat higher due presumably to the oxidizing atmosphere.

4.4.2 High-Volatile Bituminous Coal as a Reductant

Earlier, it was established that medium-volatile bituminous coal worked the best as a reductant from a suite of coals ranging from lignite to anthracite, coke and char. medium-volatile coal has been used as a reference coal in our laboratory. However, medium-volatile coal, being coking coal, is appreciably more expensive than non-coking high-volatile bituminous coal. In this investigation, a comparison was made between medium-volatile bituminous coal and high-volatile bituminous coal for their fusion behavior. The results using high-volatile bituminous coal are summarized in Table 11.

Table 11: High-volatile bituminous coal in briquettes on fusion behavior

B_2	Recycle anthracite % stoich.	Mix No.	Time at 1400°C, min	% micro NRI	NRI %S
1.5	---	P-1160	7	0.2	0.042
1.7	---	P-1161	9	0.3	0.036
1.9	---	P-1162	6	0.0	0.029
2.1	---	P-1163	5.5	0.2	0.031
2.3	---	P-1164	6	0.2	0.029
1.5	40	P-1155	3	1.5	0.033
1.7	40	P-1156	3	1.6	0.031
1.9	40	P-1157	3	4.0	0.027
2.1	40	P-1158	3.5	9.9	0.019
2.3	40	P-1159	4	14.8	0.016

(Magnetite concentrate, 85% stoichiometric high-volatile bituminous coal, 2% fluorspar, bauxite to 15% Al_2O_3, and slag basicity B_2 of 2.3 to 1.5. 4% molasses was used as a binder.)

Major findings of this investigation were as follows:

1. Box furnace tests indicated that the fusion behavior using high-volatile bituminous coal was essentially identical to when medium-volatile bituminous coal was used. Therefore, less expensive high-volatile bituminous coal can replace more expensive medium-volatile bituminous coal.
2. The addition of 40% stoichiometric 14/48 mesh recycled anthracite (BMSS) to briquettes decreased the fusion time by 30-60%. NRI sulfur also decreased somewhat by the addition of recycled anthracite.
3. Increased micro NRI with BMSS briquettes suggested that the fine limit of the recycled anthracite of 48 mesh was too fine. The fine fraction together with high-volatile bituminous coal, in effect, increased reductant carbon, thereby increasing the generation of micro NRI.
4. Although the BMSS briquettes gave satisfactory results in the box furnace regardless of B_2, the oxidizing atmosphere in the LHF made their fusion time and NRI sulfur highly sensitive to B_2. In addition, an indication was given that recycled anthracite needed to be coarser than 14/48 mesh in order to minimize the generation of micro NRI

A comparison of results for the medium-volatile and high volatile bituminous coals is shown in Table 12.

Table 12: Summary of test results using medium-volatile bituminous coal and high-volatile bituminous coal

B_2	Recycled anthracite % stoich	Med-vol. coal			High-Vol. coal		
		Time at 1400°C, min	% micro NRI	NRI %S	Time at 1400°C, min	% micro NRI	NRI %S
1.5	---	6	0.2	0.034	7	0.2	0.042
1.7	---	5.5	0.3	0.027	9	0.3	0.036
1.9	---	5	0.3	0.027	6	0.0	0.029
2.1	---	5	0.3	0.025	5.5	0.2	0.031
2.3	---	5	0.2	0.027	6	0.2	0.029
1.5	40	3	2.3	0.029	3	1.5	0.033
1.7	40	3	2.7	0.022	3	1.6	0.031
1.9	40	3	3.0	0.024	3	4.0	0.027
2.1	40	3	5.9	0.017	3.5	9.9	0.019
2.3	40	3.5	12.9	0.020	4	14.8	0.016

Briquettes were placed on 6/100 mesh recycled anthracite.

This shows that the high volatile coal increases residence time slightly without the addition of the coarse fraction, with essentially equivalent amounts of micro NRI. The addition of the coarse fraction significantly reduces time to fusion, however slightly increases the micro NRI fraction. With the BMSS addition of anthracite char, increasing basicity results in increased residence times with increased micro NRI generation. **The optimal conditions as a result of this comparison show that BMSS addition of recycled anthracite with a basicity of 1.5 results in minimal residence time and micro NRI production.** Confirmation of these results is necessary in subsequent LHF testing in the presence of products of combustion.

4.4.3 Sub-Bituminous Coal Char as a Reductant

In earlier studies, it was established that with high-volatile sub-bituminous coal as reductant carbon, briquettes could not maintain integrity during reduction, while satisfactory briquettes could be prepared when high-volatile sub-bituminous coal was carbonized at 1000° and 1400°C.

In the present investigation, preliminary box furnace tests were carried out by using high-volatile sub-bituminous char, generated in previous LHF tests. This material was screened at -100 mesh in order to remove -100 mesh fraction with high ash content. The 6/100 mesh high-volatile sub-bituminous char was ground to -14 mesh, and was screened into 14/48 mesh and -100 mesh fractions for box furnace tests.

Two series of box furnace tests were carried out on briquettes, prepared by using 85% stoichiometric -100 mesh fraction as reductant carbon by itself, and then in combination with

40% stoichiometric 14/48 mesh fraction (BMSS), both at slag basicity, B_2, of 1.9, 2.1 and 2.3. The briquettes were placed on the hearth layer of 6/100 mesh high-volatile sub-bituminous char. The results are summarized in Table 13.

Table 13: High-volatile sub-bituminous char in briquettes

B_2	Recycled high-vol sub-bit. Char % stoich	Mix No.	Time at 1400°C, min	% micro NRI	NRI %S
1.5	---	P-1174	8	0.7	0.023
1.7	---	P-1175	7	0.6	0.020
1.9	---	P-1176	6	1.5	0.018
2.1	---	P-1177	7	1.5	0.017
2.3	---	P-1178	7	2.0	0.016
1.5	40	P-1179	4	46.7	0.022
1.7	40	P-1180	3	38.2	0.052
1.9	40	P-1181	3	46.5	0.024
2.1	40	P-1182	3	38.2	0.022
2.3	40	P-1183	3	37.2	0.020

(magnetite concentrate, high-volatile sub-bituminous char carbonized in LHF, 2% fluorspar, bauxite added to mix to have 15% Al_2O_3 in slag, and slag basicity B_2 of 2.3 to 1.5. 4% molasses was used as a binder.)

Briquettes were placed on 6/100 mesh high-volatile sub-bituminous char hearth layer.)

Major findings of this investigation were as follows:

1. Briquettes, prepared only with -100 mesh high-volatile sub-bituminous char, showed that fusion behavior was essentially identical to that when either medium-volatile bituminous coal or high-volatile bituminous coal was used. Therefore, high-volatile sub-bituminous coal can replace more expensive bituminous coals, such as high-volatile bituminous coal and medium-volatile bituminous coal, if the coal is processed to char before use.
2. Because of its high moisture and high volatiles, raw high-volatile sub-bituminous coal cannot be used as reductant carbon effectively. However, by removing the moisture and volatiles by carbonizing, high-volatile sub-bituminous char can be used satisfactorily as reductant carbon.
3. As high-volatile sub-bituminous coal does not cake, high-volatile sub-bituminous coal can be used in hearth layer, and high-volatile sub-bituminous char can be produced in the process. Therefore, it is not necessary to provide a separate carbonizing furnace for producing high-volatile sub-bituminous char.
4. In practice, a part of hearth layer char may be used as internal carbon. Then, fresh high-volatile sub-bituminous coal may be added to the remaining high-volatile sub-

bituminous char for use in hearth layer. In this manner, the volatiles in high-volatile sub-bituminous coal can be utilized in heating the furnace as well as in accelerating the reduction reaction.

5. BMSS briquettes, however, generated excessive amounts of micro NRI regardless of B_2 indicating that the 14/48 mesh fraction also acted as a reductant. This would mean that together with -100 mesh fraction, total carbon for reduction, in effect, increased to in excess of 100% stoichiometric.
6. Due presumably to the high reactivity, the 14/48 mesh high-volatile sub-bituminous char likely acted more as reductant rather than as carburizing agent. In order to confine the role played by the coarse fraction to carburizing, its size range needs to be much coarser than 14/48 mesh. It will be necessary to re-examine the size and amount of high-volatile sub-bituminous char not only in the coarse fraction, but also in the fine fraction in order to minimize micro NRI generation because of its high reactivity.

5 Mass Balances on LHF Furnace Tests

Six mass balances were developed for furnace fuel tests. The mass balances were based on inlet feed streams and as such, serve mainly for relative comparison. Solid feed (briquettes) loading and briquette composition were fixed, furnace speed (residence time) changed as required to yield complete NRI conversion.

Table 14 provides a summary of loading conditions and components in the briquettes. Feed rates to furnace were determined from mass of briquettes per square inch and tray speed through the furnace. For these balances the feed was assumed constant during the tests.

Table 14: Baseline Feeding and Raw Materials

Briquette Loading Conditions	
Kg/tray	1.85
Kg by component	
Fe	0.89
SiO_2	0.61
Al_2O_3	0.01
CaO	0.1
MgO	0.005
H_2O Hydrate	0.028
CaF_2	0.034
Molasses	0.07
Fixed C	0.22
Coal Volatile and Free Water	0.07
Oxygen in Solid Iron Oxide	0.34
Totals	1.84
Briquette Bed Width (mm)	460
Briquette Bed Area (mm^2)	209,012

Table 15 provides composition information for the molasses binder, on a dry basis and on a partially dried basis. Molasses was added with nominal 25% water. The briquettes were dried, but in some cases may have absorbed moisture during storage. The mass balance assumptions included 5% moisture remaining in the molasses as fed to the furnace plus 1.2% moisture in the briquette reductant coal. On a total mass basis these assumptions result in 0.4% moisture in the briquettes as fed to the furnace.

Table 15: Binder Components and Addition

Molasses Binder Compostion			
	Dry % wt.	By Component in Briquette	
Dextrose	9.45	Sugar % C	33.94
Glucose	5.36	Sugar % H_2O	50.49
Sucrose	65.18	%Ash (slag)	10.57
Fructose	8.88	Free Water (final after drying)	5.00
Ash	11.13		100.00
Totals	100.00		
Mass Wt'd Free Water in Briquette, % wt	0.41		

Anthracite coal was used for hearth and cover layers with a combined loading of 10.84 kg/m^2 (0.0154 lbs/in^2).

Oxygen and natural gas flow rates were measured directly for all tests except the Air-Natural gas test. In the air-natural gas baseline burner, percent of full fire was recorded, and airflow was determined using the same ratio of oxygen to natural gas as found in the oxy-natural gas conditions. Natural gas and air flow were back calculated from the percent full fire values for each burner. Coal mass flow rates were measured, and carrier air flow was determined by an orifice pressure drop measurement. Mass flows were determined from these measurements to complete the inlet flow into the furnace. Inlet feeds were broken down into elemental components, C, H, O etc. from which a total elemental composition was determined and used in an equilibrium calculation to determine flue gas composition. All reductant carbon was assumed to gasify, except for 3% remaining in the briquettes. No hearth carbon was assumed to gasify as there were no measurements taken to indicate hearth carbon losses to furnace atmosphere. Table 16 gives an example for the Bio-coal test.

Table 16: Bio-Coal Mass Balance on Inlet Feeds

	Furnace Feed, kgs/min					Volatiles					
		Fe	**Slag(Ash)**	**Fix C**	**Water**	**C**	**H2**	**N2**	**O2**	**S**	**Row Totals**
Zone 1	N. Gas	---	---	---	---	0.04669	0.01466	0.00446	0.00035	---	0.06616
	Oxygen	---	---	---	---	---	---	0.00076	0.17384	---	0.17460
Zone 2	N. Gas	---	---	---	---	0.07427	0.02332	0.00709	0.00055	---	0.10523
	Oxygen	---	---	---	---	---	---	0.00121	0.27516	---	0.27637
Zone 3	N. Gas	---	---	---	---	0.06606	0.02074	0.00630	0.00049	---	0.09360
	Oxygen	---	---	---	---	---	---	0.00107	0.24254	---	0.24361
	Bio Char Burner Fuel		0.00380	see vol C		0.06414	0.00583	0.00019	0.03680	0.00011	0.11088
	Air							0.18683	0.05676		0.24358
	Oxygen							0.00227	0.51689		0.51916
	Briquettes	0.30041	0.07188	0.08263	0.02276	0.01284	0.00487	0.00179	0.11703	0.00060	0.61481
	Cover & Hearth	---	0.13982	0.57882	0.00000	0.00743	0.01308	0.00781	0.00171	0.00588	0.75455
											3.20256
	Column totals	0.30041	0.21550	0.66145	0.02276	0.27144	0.08251	0.21977	1.42212	0.00659	3.20256

Solids Fixed C to Gases via Reduction 0.07361731 (assumed no carbon solution loss)

Equilbrium inputs kgs						
Water	C	H2	N2	O2	S	kgs/min
0.0228	0.3451	0.0825	0.2198	1.4221	0.0066	2.0988

Equilibrium inputs shown were used in FactSage software [14] to determine an equilibrium gas composition at 1093°C (2000°F). Table 17 contains a summary of these compositions. The carbon dioxide emission was determined from these compositions. An estimated energy content in the flue gas based on hydrogen and carbon monoxide is found at the bottom of the table. The Testo measurements for CO_2 were also be compared, and plotted in Figure 20.

Table 17: Mass Balance and Gas Composition Summary

	Air-Natural Gas	Oxy-Nat Gas	Bio-Char	Sub-bit. Coal	med-vol bit. Coal	High-vol bit. Coal
Natural Gas MJ/mt NRI	137,899	60,011	115,268	42,095	52,313	52,276
Reductant Coal MJ/Mt NRI	11,244	11,244	24,794	11,244	11,244	11,244
Solid Carbon Fuel MJ/Mt NRI			18,308	2,822	20,333	14,713
Total Fuel Consumed, MJ/Mt NRI	149,144	71,255	158,370	56,162	83,891	78,233
% Deviation from Air N. Gas Baseline	0.00	-52.22	6.19	-62.34	-43.75	-47.54
kgs CO_2/Mt NRI	3,788	1,605	3,347	3,215	3,348	3,221
% Deviation from N. Gas Fuel Rate	0.00	-57.63	-11.64	-15.12	-11.61	-14.97
Inlet Mass, kgs/min						
Briquettes	0.3074	0.7173	0.6148	0.6148	0.6148	0.6148
Hearth & Cover C	0.3773	0.8803	0.7546	0.7546	0.7546	0.7546
Natural Gas	0.4361	0.4428	0.2663	0.2663	0.3309	0.2663
Oxygen	4.8819	1.1535	0.6946	0.6946	0.8604	0.6946
Solid Carbon Burner Fuel			0.1109	0.0365	0.1928	0.1438
Oxygen			0.5192	0.5192	0.5192	0.5192
Air			0.2436	0.3294	0.4601	0.4026
Totals	6.0026	3.1940	3.2038	3.2152	3.7328	3.3958
Outlet Mass, kgs/min						
NRI	0.1547	0.3610	0.3094	0.3094	0.3094	0.3094
Slag	0.0359	0.0839	0.0719	0.0719	0.0719	0.0719
Hearth C	0.2894	0.6753	0.5788	0.5788	0.5788	0.5788
Burner Coal and Hearth Ash	0.0699	0.1631	0.1436	0.1422	0.1588	0.1501
Flue Gas	5.4506	1.9086	2.0988	2.1116	2.6123	2.2843
Totals	6.0005	3.1918	3.2026	3.2139	3.7312	3.3946
			Equlibrium Gas Composition at 2000 F Vol %			
H_2O	15.14	33.66	48.02	48.18	35.40	39.52
H_2	9.14	27.97	5.2965	3.28	12.54	8.85
CO	7.42	22.43	6.5991	3.93	15.86	11.51
CO_2	6.13	13.48	29.867	28.87	22.34	25.65
N_2	62.13	2.23	9.9573	15.48	13.64	14.20
H_2S	0.05	0.24	0.22552	0.16	0.22	0.26
HS	1.82E-04	5.52E-04	1.19E-03	1.07E-03	7.59E-04	1.05E-03
NH_3	2.15E-04	2.18E-04	3.79E-05	2.30E-05	1.62E-04	9.78E-05
SO_2	1.30E-04	1.19E-04	3.36E-02	1.01E-01	1.35E-03	5.53E-03
Totals	100.00	100.00	100.00	100.00	100.00	100.00
Calc. m^3 15.5 C	5.14	2.31	0.85	1.85	2.49	2.09
Measured m^3 at 15.5 CF	1.94	3.74	4.45	5.05	4.48	4.79
Measured (Testo Data) % CO2	9.92	15.06	39.21	23.92	19.61	11.13
Ave. LGA N2 Ports 1-4, % N2	71.61	21.48	37.13	42.49	28.43	25.37
Flue Gas Energy Content, MJ/min						
H2	4.81	6.62	0.46	0.62	3.21	1.90
CO	4.56	6.20	0.67	0.87	4.73	2.88
MJ/Mt NRI						
H2	31,113	18,351	1,484	2,010	10,358	6,128
CO	29,467	17,181	2,159	2,817	15,284	9,298
Totals	60,579	35,532	3,643	4,827	25,642	15,426

Note: 1 BTU=1.055 kJ

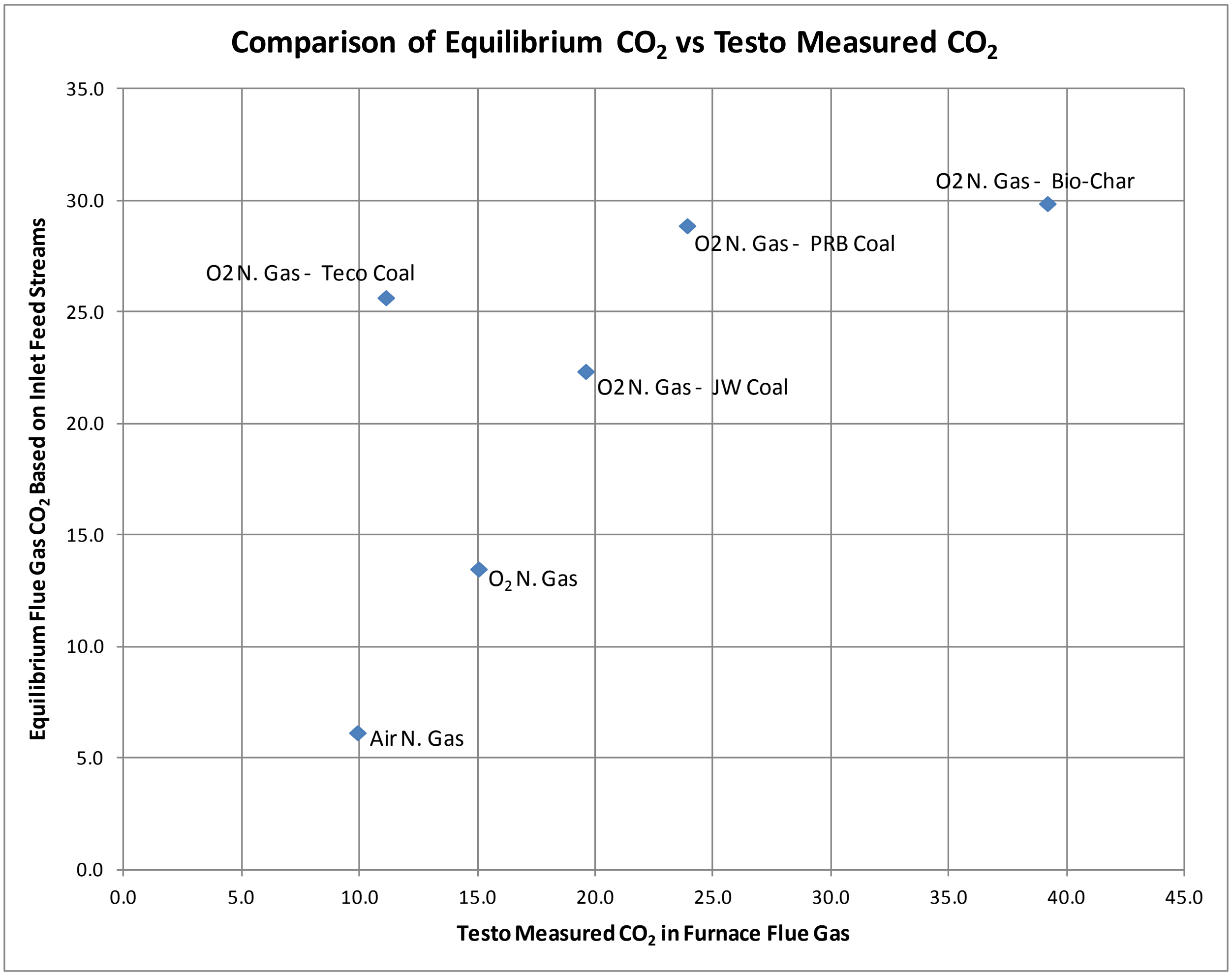

Figure 20: Equilibrium Comparison of CO_2 vs. Measured

On a relative basis, using the Air-Natural Gas as the baseline, the following observations are made:

a) Oxygen-Natural Gas burners resulted in a 57% reduction in carbon dioxide emission in the flue gas.
b) Oxygen-Natural Gas in combination with solid fuels yielded a carbon dioxide reduction of 10-15% relative to Air-Natural Gas.
c) The greatest reduction in fuel consumed occurred for Oxygen-Natural Gas – high-volatile sub-bituminous Coal at 62% of the Air-Natural Gas baseline.
d) Oxygen-Natural Gas condition demonstrated a 52% reduction in fuel relative to the air baseline; similarly using Bio-Coal reduce fuel by 51%, High-volatile bituminous Coal reduced fuel by 47% and J W Coal reduced fuel consumed by 43%, all relative to air.

6 Commercialization and Market Acceptance

6.1 Value in Use

The products from this process development are targeted to provide high quality, low impurity iron units to electric arc furnace (EAF) steel manufacturers, but can also be used to enhance blast furnace productivity, basic oxygen furnace coolant and scrap requirements, and can be used in various iron foundry applications. The material consists of approximately 96.5% to 97% metallic iron, 2.5 to 3% carbon and minimal tramp impurities. The material can be handled using conventional material handling techniques and is very dense and can easily penetrate steel slag. It is anticipated that the material will be used at rates up to 30% of the metallic charge into a high powered electric furnace and can be added to the furnace on either an intermittent basis or using continuous charging practices. The contained carbon provides valuable chemical energy to displace electrical power requirements during steel processing when oxygen blowing practices are employed in the EAF operation. The product quality from pilot plant operations at the Coleraine Minerals Research Laboratory was evaluated by a leading electric furnace based steel company in the USA. They indicated that the material would be equivalent or better to the purchased pig iron that is routinely purchased and used in their various plants today. As a consequence of their evaluation of the product and their due diligence of the process development, they formed a joint venture development company with the University of Minnesota to support continued development and they have been our industrial partner on our current DOE funded project for Development of Advanced Iron Metallization Concepts. The joint development company is NuIron Technologies, LLC. The development company is governed by a joint management board made up of key personnel from the parent company and the University. This venture continues to examine the use of this technology as one option in providing clean iron metallics for use in steel operations. This technology must be compared to other viable technologies such as natural gas based DRI production to determine the best overall fit for the future in producing iron from iron ore or other iron bearing feedstocks. The availability of merchant natural gas and coals will play a key role in determining the best path forward.

6.2 Economic Analysis

Depending on the cost of the incoming iron oxide materials, a preliminary economic analysis of the cost of iron nodule production by the development team indicates that iron nodule production costs can range from $190 to $250 per tonne using the data generated from the pilot scale testing. The biggest cost items are the cost of iron ore and coal required for the process. These items have escalated in price rapidly due to the world-wide expansion in steel production. A key need for the process demonstration is to refine the economic analysis of the process using a facility design that is much closer to commercial size compared to the pilot furnace at the Coleraine Minerals Research Laboratory.

6.3 Market Share

The amount of steel produced by electric arc furnaces on a world-wide basis is enormous. Over 393,000,000 tonnes of crude steel was produced in 2007 from steel manufacturers using this type of steel melting facilities. In the United States, over 56% of all crude steel was made using this steel processing method. Europe, the Middle East, North America, India and Africa also utilize this steel production method extensively. The volume of electric arc steel manufactured in Asia is also very high even though the blast furnace/basic oxygen converter process is the predominant steel manufacturing technology employed. The key iron raw materials used in electric furnace steelmaking are scrap and purchased pig iron. Based on discussions with our steel partner, a reasonable target for iron nodule use in the metallic charge to an electric arc furnace is estimated to be approximately 30% of the total metallics. If this technology were widely adopted on a world-wide basis, approximately 118 million metric tonnes of iron nodule product could be utilized based on 2007 production levels and a 30% market penetration using the proposed technology. This would amount to 236 iron nodule production modules with each module sized at 500,000 metric tonnes of production.

6.4 Barriers to Commercialization

The chief barriers to commercialization are: 1) Confirmation of the technical feasibility of the pilot scale test results on a prototype level. This includes establishment of a cost-effective operating regime that will simultaneously achieves the desired yield of high metallurgically acceptable grades of iron nodules and the product size characteristics desired for electric arc furnace consumers. 2) The desired level of engineering detail must be developed as well so that commercialization issues can be minimized when full scale modules are constructed. 3) The reliability of the various sub-processes including material preparation, exhaust gas handling, and product removal also need to be established so that working ratios for system availability are well understood. 4) The costs of the raw materials for the process are within control levels of the original assumptions so that the attractiveness of the new pig iron process remains favorable compared to alternative technology options for pig iron including conventional blast furnace iron production, charcoal mini-blast furnace iron production, or direct reduced iron based on natural gas systems or iron smelting processes.

7 Conclusions

The objective of this project was to focus on reducing the greenhouse gas emissions (GHG) in a newly designed linear hearth furnace (LHF) for converting iron ore or other iron bearing materials to nodular reduced iron (NRI). NRI is described as a metallized iron product containing 96 to 98.5% Fe with 2.5 to 4% C. It is essentially a scrap substitute with little impurity that can be utilized in a variety of steelmaking processes, especially the electrical arc furnace. The research examined the use of solid fuel-oxygen fired combustion system and compared the results for this system with both oxygen-fuel and air-fuel combustion systems. The solid pulverized fuels tested included various coals and a newly created bio-coal produced through torrefaction of woody biomass in a specially constructed pilot scale torrefaction reactor at the Coleraine Minerals Laboratory. The various fuels were tested to determine if high quality NRI could be produced under varying operating conditions. In addition, the properties of bio-coal were evaluated both as combustion fuel and as a metallurgical agent used for atmosphere control or as a reducing agent for iron ore conversion to metallic iron. The results are discussed in summary form in the paragraphs that follow and in detail in the main sections of this report.

Alternative Fuels and Greenhouse Gas Emissions

It was previously determined that the production of NRI using oxygen-natural gas combustion reduces residence time by 30% over the conventional air-fuel system(1). In addition, the application of the oxygen-natural gas burners resulted in a 57% reduction in carbon dioxide emission in the flue gas, on the basis of kg CO_2/mt of iron. When considering CO_2 capture, oxy-firing has the advantage to generate an effluent stream composed almost exclusively of CO_2 and H_2O with little nitrogen. It is very inexpensive and easy to capture CO_2 of the necessary purity for sequestration from this stream, simply by water condensation. The results show that the CO_2 emissions were significantly more concentrated when compared to the air-natural gas combustion system, creating opportunity for application of CO_2 capture and sequestration technologies.

Biomass as an energy source has several important advantages. Renewability and an infinite list of plant, byproducts, and waste materials that can be used as feedstock are very attractive features. Wood is clean and renewable fuel which, compared to coal, contains little ash, sulfur, mercury and nitrogen. Also, biomass consumes atmospheric CO_2 during growth, and therefore, has no net generation of CO_2 during use and, consequently, no negative impact on green-house gases. The bio-coal solid fuel used in this study was prepared using a process known as torrefaction. For this process, a blend of mixed hardwood was partially carbonized at 250-300 ^oC where moisture and light weight volatiles were driven off. The remaining product has a concentrated energy content, is friable, and can be processed and used similarly to coals. Utilizing the oxy-fuel combustion with pulverized coal firing techniques on torrefied woody biomass results in low cost carbon neutral fuel for ironmaking. In addition to the benefits afforded by the concentration of CO_2 gas, the bio-coal products are also relatively free of sulfur oxides, creating more opportunities for CO_2 capture technologies and the carbon footprint benefits associated with the woody biomass fuel.

In this investigation, the solid fuel - oxygen burner system in the Coleraine LHF was used to test several types and grades of solid carbon fuels. Several coals and bio-coal were evaluated to determine if they could produce beneficial impact on greenhouse gas emissions during the production of NRI. This potential was compared to the air-natural gas and oxygen-natural gas baselines. The coal types tested were an eastern medium volatile bituminous coal, a southern high volatile bituminous coal, and western high volatile sub-bituminous coal. The bio-coal was prepared using torrefaction from a mix of northern Minnesota hardwoods. The results show that the use of this burner system was successful for production of quality NRI, however, the conveying air required for the solid-fuel delivery system resulted in an increased residence time of approximately 15%. This result can be attributed to the loss of radiant energy from the idled oxy-gas burners and the atmosphere contamination of CO_2 and water vapor from the airflow required to convey the coal through the eductor. The impact on GHG (kg CO_2/mt) was reduced to 12-15% due to air contamination, as a result of the functionality of the combustion design. The results show that the dilute mass transfer system used for solids injection to the combustor is not the right system to reach the desired efficiencies. A dense phase mass transfer technology that would reduce the amount of transfer gas medium is needed for this type of combustion system to reach maximum efficiency.

In addition to GHG, the fuels comparison showed the use of high-volatile bituminous coal reduced total fuel consumed by 62% from the air-gas baseline. The oxy-fuel condition demonstrated a 52% reduction in fuel relative to the air baseline. Similarly, bio-coal reduces fuel consumption by 51%, with high-volatile and medium-volatile bituminous coal reducing total fuel by 47% and 43% respectively, all relative to air-gas combustion. Aside from the oxy-gas system, the volatile content of the solid fuel is directly proportional to the amount of natural gas displaced.

Late Stage Carbon Addition

The object of the tests was to determine if bio-coal could be substituted for more expensive coke or anthracite as a cover layer, to generate a reducing atmosphere and reduce residence time due to the inherently improved heat transfer. The addition of a cover layer of carbon in-situ during the NRI fusion (melting) step, and following the reduction of iron oxide to metallic iron has several advantages; 1) the briquette mix is near fusion temperature, and minimal energy is required to finalize the melting, 2) the reduction has been completed, and therefore, the endothermic reduction reaction is not absorbing energy and 3) reduced briquettes will accelerate the heating of the cover layer and promote the CO levels needed to prevent back oxidation of the iron. The tests demonstrated that the bio-coal produces an effective atmosphere cover layer and has the potential to increase productivity by 15%.

Bio-coal as a Reductant

A series of box furnace tests showed that the fusion behavior using biomass derived carbon reductant resulted in significantly faster fusion time (over 30% faster than base condition) while reducing sulfur content of NRI to 0.028% - 0.031%. Fully fused metallic NRI can be formed in about 60% of the time when compared to the baseline mix with med volatile bituminous coal as a reductant. Prior results showed that a stoichiometric ratio of 85-95%, fixed C:Fe, was optimal for production of quality NRI at low sulfur concentration, however using this same ratio with bio-coal resulted in the generation of significant micro NRI. Decreasing the stoichiometric ratio to 75% results in generation of less micro NRI, however the benefit of residence time is lost. Also, due to the relatively low fixed carbon level and lower bulk density of the bio-coal, a large volume was required to achieve the stoichiometric level. This reduced the density of briquettes by 30%, and subsequently reduced productivity of NRI.

To further investigate the generation of micro NRI, a sequence of tests were conducted where blends of bio-coal with medium volatile bituminous coal were quenched at 1 minute intervals and examined by screen analysis. The data shows that the generation of micro NRI occurs very early in the reduction process. With 100% bio-coal, micro NRI accounts for 35% of the metallic portion of the sample at the 2 minute interval. Since all samples showed some signs of micro

NRI generation at the 3 minute interval, then subsequently decreased, it's reasonable to assume that a portion of the micro NRI will coagulate into the metallic NRI sample. It's also important to note that the 100% bio-coal sample was near full fusion at the 2 minute time interval and opportunity exists to reduce fusion time further.

Bio-coal as a Partial Reductant

To reduce micro NRI, and realize the benefits previously described with 100% bio-coal reductant, box furnace tests were carried out at 75% and 85% stoichiometric ratios with blends of bio-coal and medium volatile bituminous coal. Briquettes were prepared using the same conditions as previous using carbonaceous reductant blends of 10%, 30% and 50%, bio-coal to coal on weight basis. The results show that 100% fused NRI can be formed in 3.5 minutes with the blend of 50% bio-coal reductant. This was done with the same 85% stoichiometric ratio determined in previous testing and produced 0% micro NRI. This equates to a reduction in residence time by 30%, also reducing sulfur content and increasing briquette density proportionately with the amount of bio-coal and coal addition.

For comparison, blends were also made from the bio-coal with high volatile bituminous coals with the same proportions of 10%, 30% and 50%. Both 75% and 85% stoichiometric ratios were tested as previous. The results show that 100% fused NRI can be formed with 85% stoichiometric ratio, while also reducing residence time requirements by 30%. The amount of micro NRI generated at this ratio increased slightly over the medium-volatile coal, indicating that the generation of micro-NRI is proportional to the amount of volatile contained within the reductant. This is also consistent with previous study using high-volatile sub-bituminous coals as reductant.

Overall, the results described above indicate that the bio-coal produced using the torrefaction process is a potential direct substitute for coal in both furnace atmosphere control and as a metallurgical reductant coal in the production of quality NRI.

Bimodal Super-Stoichiometric Reduction (BMSS)

Box furnace and LHF testing were conducted to evaluate the opportunity to add residual carbon to the briquette mix to compensate for the amount of carbon reductant lost as a result of the oxidizing atmosphere of the combustions systems. These tests indicated that fusion time could be significantly decreased by increasing the portion of this reductant coal with a coarser size fraction and subsequently extend its existence. The resulting reductant carbon blend consists of two fractions (bimodal size distribution), 1) a nominal 80% passing 150μm coal and 2) a coarser -1.2mm +0.3mm fraction, in this case recycled anthracite hearth layer, necessary to survive the atmosphere and finalize the reduction step. Tests conducted with BMSS briquettes under these conditions showed that 8-9% of the residual carbon remained after full metallization of the NRI. Fusion time for briquettes, prepared only with high-volatile sub-bituminous char, was essentially identical to that when either medium-volatile bituminous coal or high-volatile bituminous coal was used. Therefore, high-volatile sub-bituminous coal can replace more expensive bituminous coals, such as high-volatile bituminous coal and medium-volatile bituminous coal with the addition of BMSS. With each of the coal types tested, residence time decreased by 30-60%. However, increases in micro NRI were obtained proportional to the amount of added coarse carbon. The LHF tests resulted in lowering the amount of micro NRI, presumably due to the influence of the combustion products on the formation of NRI. Although the BMSS briquettes gave satisfactory results in the box furnace regardless of basicity employed (B_2), the oxidizing atmosphere in the LHF made their fusion time and NRI sulfur highly sensitive to B_2. Additional testing is required to fully understand the effect of carburizing carbon versus the fine reductant coals and their relationship to basicity.

Concluding Comments

The results from this study indicate that the approaches taken can reduce both energy intensity and greenhouse gas emissions associated with the Linear Hearth Furnace process for converting iron ore to metallic iron nodules. Various types of coals including a bio-coal produced though torrefaction can result in production of NRI at reduced GHG levels. The process results coupled with earlier already reported developments indicate that this process technique should be evaluated at the next level in order to develop parameter information for full scale process design. Implementation of the process to full commercialization will require a full cost production analysis and comparison to other reduction technologies and iron production alternatives. The technical results verify that high quality NRI can be produced under various operating conditions at the pilot level.

8 Recommendations

The results show that the reduction and smelting process can be used to produce high quality NRI under a variety of conditions and that oxy-fuel systems can result in reduced energy requirements for the production process. In addition, torrefaction can be used to produce an interesting bio-coal product that has very useful metallurgical properties. The results of the program were conducted using laboratory and pilot scale equipment. The results need to be brought to the next level of scale so that detailed engineering can be based on a process demonstration closer to that required for commercialization. This would be the next logical step for continued development of this technology. The results from this test program coupled with previous results from our laboratory and from process modeling can facilitate the next level of scale development for this process.

9 References

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10 Intellectual Property and Patents Relating to NRI Development

In the course of the development program supported by the US Department of Energy and prior to that by the US Economic Development Agency the following patent portfolio has been developed.

Title	Grant Reference	Status
High Luminosity Burner	DOE S-111,957 & DE-FG36-05GO15185	Abandoned
Linear Hearth Furnace	DOC/EDA 06-69-04501	US 7,413,592; US 7,666,249; US 7,875,236
Magnetic Removal System used with Linear Hearth System	DOE DE-FG36-05GO15185	Disclosure
Method and System for Producing Metallic Iron Nuggets (coarse Coal Cover)	DOD/EDA 06-69-04501 & DE FG36-05GO15185	PCT/US07/74471; CA2,658,897; US 12/359,729
Method and System for Producing Metallic Iron Nuggets (late Stage Addition of Coarse Cover)	DOE DE FG36-05GO15185	US 8,021,460
Method and System for Producing Metallic Iron Nuggets	DOC/EDA 06-69-04501	US60/633,886
Method and System for Producing Metallic Iron Nuggets (Domes, Cones and Mounds)	DOC/EDA 06-69-04501	US 7,695,544; AU 2005313001; Multiple applications PCT/IB05/054110
Method and System for Producing Metallic Iron Nuggets (70-90 Stoichiometric Carbon)	DOC/EDA 06-69-04501	US 7,628,839; AU 2005312999;Multiple Applications PCT/IB05/054108
Method and System for Producing Metallic Iron Nuggets (stoichiometric carbon with additives)	DOC/EDA 06-69-04501	US 7,641,712
Method and System for Producing Metallic Iron Nuggets (micro-agglomerates)	DOC/EDA 06-69-04501	US 7,632,335
Method and System for Producing Metallic iron nuggets (multiple layer and sub-bituminous material)	DOC/EDA 06-69-04501 & DE FG36-05GO15185	PCT/US09/032519; US 12/847,591
Production of Iron from Metallurgical Waste(recovery of Metallurgical Waste)	DOC/EDA 06-69-04501 & DE-FG36-05GO15185	PCT/US10/21790; US 13/187,937; AU 2010 206718

Refractory Coating for Hearth	DOE DE FG36-05GO15185	Disclosure
System and Method for Cooling and removing iron from a hearth	DOC/EDA 06-69-04501 & DE-FG36-05GO15185	PCT/US08/50855; US 12/522,867; CA 2,675,311;
System and Method for Making Iron with reduced CO_2 emissions (shrouded LHF with CO_2 control)	DOE DE FG36-05GO15185	US 61/246,817; PCT/US10/50547
System and Method for Producing Metallic Iron (O_2 Plus Coal Consumption Including Flue Gas Recirculation)	DOE DE-FG36-05GO15185	PCT/US10/50743;US 61/246,739
System and Method for Producing Metallic Iron (injection Under the hood in conversion zone)	DOC/EDA 06-69-04501	US 60/828,171; PCT/US07/80364
System and Method for Producing Iron (Wedge Linear Hearth Furnace)	DOE DE FG36-05GO15185	PCT/US10/507 30; US 61/246,787
Use of Bimodal Carbon Distribution in Compacts for Producing Metallic Iron Nodules	DOE DE FG36-05GO15185	US 12/977,035
Use of Manganese Oxide with Fluorspar	DOE 117,356 & DE FG36-05GO15185	Disclosure

11 APPENDIX A – Raw Materials Chemistry

Description	Moisture	Volatile	BTU/lb	Sulfur	Fixed C	Ash	Fe	FeO	SiO2	Al2O3	CaO	MgO
							Chemistry, %					
Magnetite Concentrate							68.43		3.54	0.06	0.70	0.36
Medium Volatile Bituminous Coal	1.25	20.82	13,993	0.67	69.34	8.59		6.10	50.60	27.44	5.54	1.26
Red Pine Char (25% DSL)	0.00		9,975	0.00	58.8	0.70			14.50	1.98	26.59	8.10
High-Volatile Bituminous Coal (1)	2.47	32.54	13,484	0.73	57.46	7.53			50.73	28.93	2.91	1.32
High-Volatile Bituminous Coal (2)	1.43	36.17	13,605	0.93	55.36	7.04		6.20	44.72	24.00	4.11	1.14
Sub-Bituminous Char	3.23	6.01	11,175	0.46	73.88	16.88			44.39	10.89	18.36	4.81
Sub-Bituminous Coal	8.53	40.11	10,516	0.33	45.27	6.09		4.70	31.97	14.98	21.44	4.04
Sub-Bituminous Char	2.03	7.75	11,261	0.44	73.49	16.73		5.80	32.99	13.70	22.50	4.56
Recycled Anthracite (Char -1)	0.94	1.71	11,889	0.55	80.93	16.42			52.31	28.73	2.95	0.91
Recycled Anthracite (Char -2)	0.22	1.18	12,112	0.57	83.02	15.58		5.11	56.53	30.18	4.54	0.87
CMRL Torrefied Wood (DOE-14)	2.73	63.71	9,687	0.18	27.26	6.30		2.12	5.54	0.88	51.67	5.59
Jim Walter Coal / Char (DOE-14) Blend - 90:10	1.40	25.11	13562	0.62	65.13	8.36		5.70	46.09	24.78	10.15	1.69
Jim Walter Coal / Char (DOE-14) Blend - 70:30	1.69	33.69	12701	0.52	56.72	7.90		4.91	37.08	19.47	19.38	2.56
Jim Walter Coal / Char (DOE-14) Blend - 50:50	1.99	42.27	11840	0.43	48.30	7.45		4.11	28.07	14.16	28.61	3.43
High-Vol Bit. Coal / Car (DOE-14) Blend - 90:10	1.56	38.92	13213	0.86	52.55	6.97		5.79	40.80	21.69	8.87	1.59
High-Vol Bit. Coal / Car (DOE-14) Blend - 70:30	1.82	44.43	12430	0.71	46.93	6.82		4.98	32.97	17.06	18.38	2.48
High-Vol Bit. Coal / Car (DOE-14) Blend - 50:50	2.08	49.94	11646	0.56	41.31	6.67		4.16	25.13	12.44	27.89	3.37
Torrefied Wood Char DOE-16	3.32	62.56	9,907	0.20	30.62	6.82		38.48	28.34	4.37	21.49	1.66
Torrefied Wood Char DOE-22	3.62	68.61	9,575	0.09	25.87	5.52		23.36	38.07	7.79	22.65	2.40
Med. Vol Bit. Coal / Char (DOE-22) Blend - 90:10	1.49	25.60	13551	0.61	64.99	8.28		7.83	49.35	25.48	7.25	1.37
Med. Vol Bit. Coal / Char (DOE-22) Blend - 70:30	1.96	35.16	12668	0.50	56.30	7.67		11.28	46.84	21.55	10.67	1.60
Med. Vol Bit. Coal / Char (DOE-22) Blend - 50:50	2.44	44.72	11784	0.38	47.61	7.06		14.73	44.34	17.62	14.10	1.83
Hydrated Lime (1)									0.31	0.05	72.12	0.39
Hydrated Lime (2)				0.450			0.05		0.43	0.10	68.80	0.32
Fluorspar				0.440			0.05		1.87	0.12		0.00
Bauxite							6.31		2.58	57.62	0.01	0.00

12 APPENDIX B – Mix Compositions

TEST ID#					Carbon, %							Lime, %	Fluorspar, %	Bauxite, %
	C:Fe	Recyc. Anthracite % Stoich	B/A	Magnetite Iron Ore Concentrate	Bituminous Coal	Anthracite Char	Red Pine Char	High-Vol. Bituminous	Sub-bituminous	Sub-bit Char (ground)	Sub-bit Char (as-is)	Bio-Coal			
P-269	85		1.51	73.5	18.0								6.5	2.0	
1155	85	40	1.50	64.8		6.3		18.8					6.6	2.0	1.60
1156	85	40	1.70	64.0		6.2		18.6					7.5	2.0	1.81
1157	85	40	1.90	63.2		6.1		18.3					8.4	2.0	2.02
1158	85	40	2.10	62.4		6.1		18.1					9.2	2.0	2.22
1159	85	40	2.30	61.7		6.0		17.9					10.1	2.0	2.42
1160	85		1.50	69.9				20.3					6.0	2.0	1.82
1161	85		1.70	69.1				20.1					6.8	2.0	2.02
1162	85		1.90	68.3				19.8					7.6	2.0	2.21
1163	85		2.10	67.6				19.6					8.5	2.0	2.40
1164	85		2.30	66.8				19.4					9.3	2.0	2.48
1165	85	30	2.30	64.0	16.6	4.7							10.3	2.0	2.48
1166	85	30	2.10	64.8	16.8	4.7							9.4	2.0	2.27
1167	85	30	1.90	65.6	17.1	4.8							8.5	2.0	2.07
1168	85	20	2.30	64.0	18.4	3.1							10.1	2.0	2.47
1169	85	20	2.10	64.8	18.6	3.1							9.2	2.0	2.27
1170	85	20	1.90	65.6	18.8	3.2							8.3	2.0	2.06
1171	85	40	2.30	64.0	14.9	6.2							10.4	2.0	2.49
1172	85	40	2.10	64.9	15.1	6.3							9.5	2.0	2.28
1173	85	40	1.90	65.7	15.3	6.4							8.6	2.0	2.07
1174	85			71.9					17.2				6.5	2.0	2.53
1175	85			70.9					16.9				7.4	2.0	2.74
1176	85			70.0					16.7				8.4	2.0	2.95
1177	85			69.1					16.5				9.3	2.0	3.16
1178	85			68.2					16.3				10.2	2.0	3.36
1179	85	40		66.0		7.0			15.8				6.7	2.0	2.53
1180	85	40		65.1		6.9			15.6				7.7	2.0	2.75
1181	85	40		64.2		6.8			15.3				8.7	2.0	2.97
1182	85	40		63.3		6.7			15.1				9.7	2.0	3.19
1183	85	40		62.4		6.6			14.9				10.7	2.0	3.40
1184	85	40		73.2			17.4						7.4	2.0	
1185	85		1.79	71.8			20.4						5.8	2.0	
1186	90		2.03	70.3			21.1						6.6	2.0	
1187	100		1.80	69.3			23.1						5.6	2.0	
1188	85		1.54	70.0				21.1					6.9	2.0	
1189	100		1.52	67.3				23.8					6.9	2.0	
1190	85		1.54	74.3						16.8	16.8		6.9	2.0	
1191	85		1.64	67.2					24.8				6.0	2.0	
1192	100		1.63	64.3					27.8				5.9	2.0	

APPENDIX B – Mix Compositions – continue

TEST ID#	C:Fe	Recyc. Anthracite % Stoich	B/A	Magnetite Iron Ore Concentrate	Carbon, % Bituminous Coal	Anthracite Char	Red Pine Char	High-Vol. Bituminous	Sub-bituminous	Sub-bit Char (ground)	Sub-bit Char (as-is)	Bio-Coal	Lime, %	Fluorspar, %	Bauxite, %
1193	100		1.52	72.0						19.2	19.2		6.8	2.0	
1194	85		1.54	74.3						16.8	16.8		6.9	2.0	
1195	100		1.52	72.0						19.2	19.2		6.8	2.0	
1196	41			71.2								21.1	5.7	2.0	
1197	48			68.6								23.9	5.5	2.0	
1198	55			66.1								26.5	5.3	2.0	
1199	85		1.89	58.6								35.8	3.6	2.0	
1200	100		1.92	55.1								39.7	3.2	2.0	
1201	115		1.94	52.1								43.1	2.9	2.0	
1202	65		1.85	64.0								29.9	4.1	2.0	
1203	75		1.87	61.2								33.0	3.9	2.0	
1204	85		1.53	72.5	16.7							1.9	7.0	2.0	
1205	85		1.57	70.7	14.6							6.2	6.5	2.0	
1206	85		1.62	68.5	11.8							11.8	5.9	2.0	
1207	75		1.54	74.2	15.1							1.7	7.0	2.0	
1208	75		1.58	72.7	13.2							5.6	6.5	2.0	
1209	75		1.63	70.6	10.8							10.8	6.0	2.0	
1216	75		1.57	71.3				18.0				2.0	6.7	2.0	
1217	75		1.61	69.9				15.3				6.6	6.3	2.0	
1218	75		1.65	68.1				12.1				12.1	5.7	2.0	
1219	85		1.56	69.3				19.8				2.2	6.7	2.0	
1220	85		1.60	67.8				16.9				7.2	6.2	2.0	
1221	85		1.65	65.8				13.3				13.3	5.6	2.0	

13 APPENDIX C - LHF Operating and Gas Analysis Data

Single Briquette Layer with Air Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
10/19/2011	1152	3.0	2000 g	1850 g	1530 g	3	1:07 PM	2:44 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
1:26 PM	55	156.3	Zone 1
1:55 PM	61	155.4	Zone 2
2:22 PM	58	155	Zone 3

LHF Data	Cart Pressure	Entrance Exhaust Output	Entrance Pressure	Exhaust Pressure	Exit Exhaust Output	OI Inches per Minute	Zone 1 Exhaust Output	Zone 1 Gas Flow	Zone 1 Oxygen Flow
1:07 PM	-0.05	100.00	0.15	0.00	100.00	3.00	0.00	-0.57	-1.63
1:08 PM	-0.05	100.00	0.13	0.00	100.00	3.00	0.00	-0.57	-1.63
1:09 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
1:10 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:11 PM	-0.06	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:12 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:13 PM	-0.06	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:14 PM	-0.06	100.00	0.09	0.00	100.00	3.00	0.00	-0.57	-1.63
1:15 PM	-0.06	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:16 PM	-0.06	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:17 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.63
1:18 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.63
1:19 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.50
1:20 PM	-0.06	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:21 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
1:22 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.50
1:23 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:24 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
1:25 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.50
1:26 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
1:27 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.75
1:28 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.50
1:29 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
1:30 PM	-0.06	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
1:31 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
1:32 PM	-0.06	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:33 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:34 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:35 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:36 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.75
1:37 PM	-0.06	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:38 PM	-0.05	100.00	0.08	0.00	100.00	3.00	0.00	-0.57	-1.63
1:39 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.50
1:40 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:41 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.50
1:42 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.75
1:43 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
1:44 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.75
1:45 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:46 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:47 PM	-0.05	100.00	0.08	0.00	100.00	3.00	0.00	-0.57	-1.63
1:48 PM	-0.05	100.00	0.08	0.00	100.00	3.00	0.00	-0.57	-1.63
1:49 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
1:50 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:51 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.50
1:52 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
1:53 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63

	LHF Data								
	Cart Pressure	Entrance Exhaust Output	Entrance Pressure	Exhaust Pressure	Exit Exhaust Output	OI Inches per Minute	Zone 1 Exhaust Output	Zone 1 Gas Flow	Zone 1 Oxygen Flow
1:54 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.62	-1.63
1:55 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.62	-1.63
1:56 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.63
1:57 PM	-0.05	100.00	0.02	0.00	100.00	3.00	0.00	-0.62	-1.63
1:58 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.63
1:59 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.62	-1.63
2:00 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
2:01 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.62	-1.63
2:02 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.62	-1.63
2:03 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.62	-1.63
2:04 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.62	-1.63
2:05 PM	-0.05	100.00	0.08	0.00	100.00	3.00	0.00	-0.62	-1.75
2:06 PM	-0.05	100.00	0.08	0.00	100.00	3.00	0.00	-0.57	-1.63
2:07 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.62	-1.63
2:08 PM	-0.05	100.00	0.10	0.00	100.00	3.00	0.00	-0.57	-1.63
2:09 PM	-0.05	100.00	0.09	0.00	100.00	3.00	0.00	-0.62	-1.63
2:10 PM	-0.05	100.00	0.10	0.00	100.00	3.00	0.00	-0.57	-1.63
2:11 PM	-0.05	100.00	0.15	0.00	100.00	3.00	0.00	-0.57	-1.63
2:12 PM	-0.05	100.00	0.14	0.00	100.00	3.00	0.00	-0.57	-1.63
2:13 PM	-0.05	100.00	0.14	0.00	100.00	3.00	0.00	-0.57	-1.63
2:14 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
2:15 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
2:16 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
2:17 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.50
2:18 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
2:19 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
2:20 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.63
2:21 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
2:22 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
2:23 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
2:24 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
2:25 PM	-0.05	100.00	0.07	0.00	100.00	3.00	0.00	-0.57	-1.63
2:26 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
2:27 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
2:28 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
2:29 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
2:30 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
2:31 PM	-0.05	100.00	0.06	0.00	100.00	3.00	0.00	-0.57	-1.63
2:32 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
2:33 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
2:34 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
2:35 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
2:36 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.63
2:37 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
2:38 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.57	-1.63
2:39 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.63
2:40 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.63
2:41 PM	-0.05	100.00	0.03	0.00	100.00	3.00	0.00	-0.57	-1.63
2:42 PM	-0.05	100.00	0.04	0.00	100.00	3.00	0.00	-0.62	-1.50
2:43 PM	-0.05	100.00	0.05	0.00	100.00	3.00	0.00	-0.57	-1.75
2:44 PM	-0.05	100.00	0.05	0.00	100.00	12.00	0.00	-0.57	-1.63

Single Briquette Layer with Air Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
10/19/2011	1152	3.0	2000 g	1850 g	1530 g	3	1:07 PM	2:44 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
1:26 PM	55	156.3	Zone 1
1:55 PM	61	155.4	Zone 2
2:22 PM	58	155	Zone 3

LHF Data	Zone 1 PID CV	Zone 1 Pressure	Zone 1 Temp A	Zone 1 Temp B	Zone 2 Exhaust Output	Zone 2 Gas Flow	Zone 2 Oxygen Flow	Zone 2 PID CV	Zone 2 Pressure
1:07 PM	10.35	1.13	1,973.50	1,935.90	0.00	0.10	0.25	100.00	0.06
1:08 PM	11.37	1.13	1,965.10	1,936.20	0.00	0.16	0.25	100.00	0.07
1:09 PM	10.15	1.13	1,961.60	1,926.70	0.00	0.10	0.37	100.00	0.06
1:10 PM	7.92	1.13	1,958.20	1,925.80	0.00	0.16	0.37	100.00	0.06
1:11 PM	6.53	1.13	1,954.60	1,928.40	0.00	0.10	0.37	100.00	0.06
1:12 PM	6.15	1.13	1,949.50	1,927.60	0.00	0.16	0.25	100.00	0.05
1:13 PM	2.38	1.13	1,949.00	1,929.90	0.00	0.16	0.25	100.00	0.05
1:14 PM	1.12	1.13	1,945.00	1,926.30	0.00	0.16	0.25	100.00	0.05
1:15 PM	3.27	1.13	1,935.90	1,915.20	0.00	0.16	0.25	100.00	0.05
1:16 PM	1.85	1.13	1,932.30	1,911.20	0.00	0.16	0.37	100.00	0.05
1:17 PM	0.00	1.13	1,931.60	1,911.30	0.00	0.10	0.37	100.00	0.04
1:18 PM	0.00	1.13	1,930.00	1,908.50	0.00	0.16	0.25	100.00	0.05
1:19 PM	0.00	1.13	1,931.70	1,911.10	0.00	0.10	0.25	100.00	0.05
1:20 PM	0.00	1.13	1,933.70	1,911.00	0.00	0.10	0.25	100.00	0.05
1:21 PM	0.00	1.13	1,924.30	1,897.00	0.00	0.10	0.37	100.00	0.05
1:22 PM	0.00	1.13	1,920.80	1,894.00	0.00	0.10	0.37	100.00	0.05
1:23 PM	0.00	1.13	1,920.20	1,893.60	0.00	0.10	0.25	100.00	0.05
1:24 PM	0.00	1.13	1,916.60	1,891.70	0.00	0.10	0.25	100.00	0.05
1:25 PM	0.00	1.13	1,918.10	1,895.50	0.00	0.10	0.25	100.00	0.05
1:26 PM	0.00	1.13	1,917.60	1,895.70	0.00	0.10	0.25	100.00	0.05
1:27 PM	0.00	1.13	1,906.80	1,882.80	0.00	0.10	0.25	100.00	0.05
1:28 PM	0.00	1.13	1,903.40	1,881.00	0.00	0.10	0.25	100.00	0.05
1:29 PM	0.00	1.13	1,902.30	1,881.60	0.00	0.10	0.37	100.00	0.05
1:30 PM	0.00	1.13	1,901.10	1,881.60	0.00	0.10	0.37	100.00	0.04
1:31 PM	0.00	1.13	1,903.90	1,886.90	0.00	0.10	0.37	100.00	0.05
1:32 PM	0.00	1.13	1,904.70	1,887.40	0.00	0.10	0.25	100.00	0.05
1:33 PM	0.00	1.13	1,896.10	1,877.50	0.00	0.10	0.25	100.00	0.05
1:34 PM	0.00	1.13	1,892.10	1,873.60	0.00	0.10	0.25	100.00	0.05
1:35 PM	0.00	1.13	1,892.40	1,874.10	0.00	0.10	0.25	100.00	0.04
1:36 PM	0.00	1.13	1,893.70	1,875.60	0.00	0.10	0.25	100.00	0.04
1:37 PM	0.00	1.13	1,896.90	1,881.00	0.00	0.10	0.25	100.00	0.04
1:38 PM	0.00	1.13	1,900.10	1,881.80	0.00	0.10	0.37	100.00	0.04
1:39 PM	0.00	1.13	1,893.90	1,874.50	0.00	0.10	0.25	100.00	0.04
1:40 PM	0.00	1.13	1,891.90	1,872.90	0.00	0.10	0.25	100.00	0.04
1:41 PM	0.00	1.13	1,891.80	1,872.60	0.00	0.10	0.25	100.00	0.04
1:42 PM	0.00	1.13	1,893.50	1,874.40	0.00	0.10	0.25	100.00	0.04
1:43 PM	0.00	1.13	1,898.90	1,882.00	0.00	0.10	0.12	100.00	0.04
1:44 PM	0.00	1.13	1,900.00	1,880.30	0.00	0.10	0.25	100.00	0.04
1:45 PM	0.00	1.13	1,890.10	1,870.00	0.00	0.10	0.25	100.00	0.05
1:46 PM	0.00	1.13	1,886.20	1,866.60	0.00	0.10	0.25	100.00	0.05
1:47 PM	0.00	1.13	1,885.90	1,866.60	0.00	0.10	0.37	100.00	0.05
1:48 PM	0.00	1.13	1,888.10	1,872.00	0.00	0.10	0.25	100.00	0.05
1:49 PM	0.00	1.13	1,892.90	1,876.40	0.00	0.10	0.25	100.00	0.05
1:50 PM	0.00	1.13	1,893.50	1,876.20	0.00	0.10	0.25	100.00	0.05
1:51 PM	0.00	1.13	1,885.90	1,868.00	0.00	0.10	0.25	100.00	0.05
1:52 PM	0.00	1.13	1,883.90	1,866.30	0.00	0.10	0.25	100.00	0.05
1:53 PM	0.00	1.13	1,885.00	1,867.30	0.00	0.10	0.37	100.00	0.05

LHF Data

	Zone 1 PID CV	Zone 1 Pressure	Zone 1 Temp A	Zone 1 Temp B	Zone 2 Exhaust Output	Zone 2 Gas Flow	Zone 2 Oxygen Flow	Zone 2 PID CV	Zone 2 Pressure
1:54 PM	0.00	1.13	1,886.70	1,867.80	0.00	0.10	0.37	100.00	0.05
1:55 PM	0.00	1.13	1,892.50	1,874.70	0.00	0.10	0.25	100.00	0.05
1:56 PM	0.00	1.13	1,896.60	1,879.80	0.00	0.10	0.37	100.00	0.05
1:57 PM	0.00	1.13	1,892.00	1,871.50	0.00	0.10	0.25	100.00	0.05
1:58 PM	0.00	1.13	1,891.40	1,870.70	0.00	0.10	0.25	100.00	0.05
1:59 PM	0.00	1.13	1,894.30	1,875.20	0.00	0.10	0.25	100.00	0.05
2:00 PM	0.00	1.13	1,895.00	1,875.80	0.00	0.10	0.25	100.00	0.05
2:01 PM	0.00	1.13	1,898.40	1,878.90	0.00	0.10	0.37	100.00	0.04
2:02 PM	0.00	1.13	1,898.80	1,878.10	0.00	0.10	0.25	100.00	0.04
2:03 PM	0.00	1.13	1,890.10	1,866.80	0.00	0.10	0.25	100.00	0.04
2:04 PM	0.00	1.13	1,886.00	1,861.70	0.00	0.10	0.25	100.00	0.04
2:05 PM	0.00	1.13	1,887.20	1,863.00	0.00	0.10	0.25	100.00	0.04
2:06 PM	0.00	1.13	1,887.30	1,862.70	0.00	0.10	0.37	100.00	0.04
2:07 PM	0.00	1.13	1,891.40	1,867.90	0.00	0.10	0.25	100.00	0.04
2:08 PM	0.00	1.13	1,893.10	1,869.40	0.00	0.10	0.37	100.00	0.04
2:09 PM	0.00	1.13	1,882.10	1,855.60	0.00	0.10	0.25	100.00	0.05
2:10 PM	0.00	1.13	1,876.40	1,850.80	0.00	0.10	0.25	100.00	0.05
2:11 PM	0.00	1.13	1,876.00	1,851.20	0.00	0.10	0.25	100.00	0.05
2:12 PM	0.00	1.13	1,875.80	1,852.10	0.00	0.10	0.25	100.00	0.05
2:13 PM	0.00	1.13	1,880.20	1,858.40	0.00	0.10	0.37	100.00	0.05
2:14 PM	0.00	1.13	1,880.60	1,856.20	0.00	0.10	0.37	100.00	0.05
2:15 PM	0.00	1.13	1,870.20	1,845.40	0.00	0.10	0.25	100.00	0.05
2:16 PM	0.00	1.13	1,864.40	1,839.60	0.00	0.10	0.37	100.00	0.05
2:17 PM	0.00	1.13	1,862.30	1,838.40	0.00	0.10	0.25	100.00	0.05
2:18 PM	0.00	1.13	1,861.20	1,837.80	0.00	0.10	0.25	100.00	0.05
2:19 PM	0.00	1.13	1,864.00	1,844.30	0.00	0.10	0.25	100.00	0.05
2:20 PM	0.00	1.13	1,864.70	1,844.90	0.00	0.10	0.25	100.00	0.05
2:21 PM	0.00	1.13	1,859.00	1,838.30	0.00	0.10	0.25	100.00	0.05
2:22 PM	0.00	1.13	1,856.90	1,836.90	0.00	0.10	0.25	100.00	0.05
2:23 PM	0.00	1.13	1,858.00	1,838.50	0.00	0.10	0.25	100.00	0.04
2:24 PM	0.00	1.13	1,861.00	1,842.60	0.00	0.10	0.37	100.00	0.04
2:25 PM	0.00	1.13	1,865.80	1,848.60	0.00	0.10	0.25	100.00	0.04
2:26 PM	0.00	1.13	1,871.20	1,854.00	0.00	0.10	0.25	100.00	0.04
2:27 PM	0.00	1.13	1,873.70	1,855.80	0.00	0.10	0.37	100.00	0.04
2:28 PM	0.00	1.13	1,879.00	1,863.80	0.00	0.10	0.25	100.00	0.04
2:29 PM	0.00	1.13	1,884.10	1,868.50	0.00	0.10	0.25	100.00	0.04
2:30 PM	0.00	1.13	1,885.90	1,868.30	0.00	0.10	0.25	100.00	0.04
2:31 PM	0.00	1.13	1,889.60	1,871.40	0.00	0.10	0.25	100.00	0.04
2:32 PM	0.00	1.13	1,890.50	1,872.70	0.00	0.10	0.25	100.00	0.04
2:33 PM	0.00	1.13	1,886.20	1,868.60	0.00	0.10	0.25	100.00	0.04
2:34 PM	0.00	1.13	1,885.40	1,868.50	0.00	0.10	0.37	100.00	0.04
2:35 PM	0.00	1.13	1,888.90	1,871.10	0.00	0.10	0.25	100.00	0.04
2:36 PM	0.00	1.13	1,891.70	1,870.80	0.00	0.10	0.25	100.00	0.04
2:37 PM	0.00	1.13	1,895.50	1,874.40	0.00	0.10	0.25	100.00	0.04
2:38 PM	0.00	1.13	1,895.80	1,875.40	0.00	0.10	0.25	100.00	0.04
2:39 PM	0.00	1.13	1,885.80	1,859.40	0.00	0.10	0.25	100.00	0.04
2:40 PM	0.00	1.13	1,881.80	1,852.30	0.00	0.10	0.37	100.00	0.04
2:41 PM	0.00	1.13	1,878.90	1,851.00	0.00	0.10	0.37	100.00	0.04
2:42 PM	0.00	1.13	1,873.20	1,850.10	0.00	0.10	0.25	100.00	0.04
2:43 PM	0.00	1.13	1,872.90	1,851.70	0.00	0.10	0.12	100.00	0.04
2:44 PM	0.00	1.13	1,870.40	1,849.00	0.00	0.10	0.25	100.00	0.04

Single Briquette Layer with Air Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
10/19/2011	1152	3.0	2000 g	1850 g	1530 g	3	1:07 PM	2:44 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
1:26 PM	55	156.3	Zone 1
1:55 PM	61	155.4	Zone 2
2:22 PM	58	155	Zone 3

LHF Data	Zone 2 Temp A	Zone 2 Temp B	Zone 2 Temp C	Zone 3 Exhaust Output	Zone 3 Gas Flow	Zone 3 Oxygen Flow	Zone 3 PID CV	Zone 3 Pressure	Zone 3 Temp A
1:07 PM	2,327.60	2,304.00	2,498.00	0.00	-1.14	0.31	32.90	0.04	2,574.20
1:08 PM	2,335.90	2,307.10	2,498.00	0.00	35.02	0.47	31.19	0.05	2,578.00
1:09 PM	2,341.10	2,309.60	2,498.00	0.00	-1.14	0.47	28.64	0.05	2,583.50
1:10 PM	2,346.00	2,313.40	2,498.00	0.00	-1.14	0.31	29.04	0.04	2,581.60
1:11 PM	2,349.90	2,316.20	2,498.00	0.00	-1.14	0.31	25.72	0.04	2,587.70
1:12 PM	2,353.50	2,319.80	2,498.00	0.00	-1.14	0.31	23.45	0.04	2,590.70
1:13 PM	2,357.70	2,324.00	2,498.00	0.00	-1.14	0.31	23.38	0.03	2,588.50
1:14 PM	2,356.60	2,322.20	2,498.00	0.00	-1.14	0.47	24.00	0.03	2,585.30
1:15 PM	2,353.30	2,320.10	2,498.00	0.00	-1.14	0.47	22.42	0.03	2,587.40
1:16 PM	2,355.90	2,322.20	2,498.00	0.00	-1.14	0.31	21.52	0.03	2,587.90
1:17 PM	2,356.00	2,323.60	2,498.00	0.00	-1.14	0.31	24.45	0.03	2,579.60
1:18 PM	2,355.60	2,324.20	2,498.00	0.00	-1.14	0.31	26.16	0.03	2,575.50
1:19 PM	2,358.20	2,326.40	2,498.00	0.00	-1.14	0.47	28.53	0.03	2,570.40
1:20 PM	2,358.20	2,325.90	2,498.00	0.00	-1.14	0.31	26.66	0.03	2,575.20
1:21 PM	2,357.00	2,325.00	2,498.00	0.00	43.63	0.47	26.57	0.03	2,575.70
1:22 PM	2,360.20	2,327.10	2,498.00	0.00	-1.14	0.31	27.64	0.03	2,573.30
1:23 PM	2,360.40	2,327.10	2,498.00	0.00	-1.14	0.31	25.48	0.03	2,578.00
1:24 PM	2,361.50	2,328.60	2,498.00	0.00	-1.14	0.31	25.53	0.03	2,577.40
1:25 PM	2,365.30	2,330.80	2,498.00	0.00	-1.14	0.31	24.26	0.03	2,579.80
1:26 PM	2,365.70	2,330.90	2,498.00	0.00	-1.14	0.31	23.43	0.03	2,581.20
1:27 PM	2,364.00	2,332.50	2,498.00	0.00	-1.14	0.47	25.65	0.03	2,575.60
1:28 PM	2,366.60	2,332.60	2,498.00	0.00	-1.14	0.47	21.99	0.03	2,583.40
1:29 PM	2,366.20	2,333.10	2,498.00	0.00	-1.14	0.31	22.38	0.03	2,581.80
1:30 PM	2,366.70	2,334.10	2,498.00	0.00	-1.14	0.31	21.77	0.03	2,582.50
1:31 PM	2,370.00	2,337.60	2,498.00	0.00	-1.14	0.31	23.20	0.03	2,578.50
1:32 PM	2,369.80	2,336.00	2,498.00	0.00	-1.14	0.47	24.48	0.03	2,575.00
1:33 PM	2,369.00	2,334.30	2,498.00	0.00	75.32	0.31	21.71	0.03	2,582.80
1:34 PM	2,370.80	2,335.60	2,498.00	0.00	-1.14	0.31	24.10	0.03	2,574.60
1:35 PM	2,368.60	2,335.20	2,498.00	0.00	-1.14	0.31	21.64	0.03	2,579.40
1:36 PM	2,368.80	2,335.70	2,498.00	0.00	-1.14	0.31	20.36	0.03	2,583.50
1:37 PM	2,371.50	2,338.20	2,498.00	0.00	-1.14	0.31	19.69	0.03	2,582.10
1:38 PM	2,371.40	2,334.70	2,498.00	0.00	-1.14	0.31	22.60	0.03	2,574.80
1:39 PM	2,367.00	2,330.70	2,498.00	0.00	-1.14	0.31	20.05	0.03	2,580.30
1:40 PM	2,367.70	2,330.30	2,498.00	0.00	-1.14	0.47	21.57	0.03	2,576.20
1:41 PM	2,364.60	2,329.00	2,498.00	0.00	-1.14	0.31	20.41	0.03	2,578.30
1:42 PM	2,363.80	2,329.10	2,498.00	0.00	-1.14	0.31	19.35	0.03	2,580.10
1:43 PM	2,365.90	2,330.90	2,498.00	0.00	-1.14	0.31	17.78	0.03	2,579.10
1:44 PM	2,366.60	2,328.90	2,498.00	0.00	-1.14	0.31	19.57	0.03	2,578.40
1:45 PM	2,363.00	2,326.20	2,498.00	0.00	-1.14	0.31	20.41	0.03	2,576.50
1:46 PM	2,364.10	2,324.50	2,498.00	0.00	49.73	0.47	19.08	0.03	2,576.80
1:47 PM	2,361.00	2,324.80	2,498.00	0.00	-1.14	0.31	18.92	0.03	2,579.70
1:48 PM	2,360.60	2,326.30	2,498.00	0.00	-1.14	0.31	18.62	0.03	2,580.10
1:49 PM	2,363.50	2,328.80	2,498.00	0.00	-1.14	0.31	17.92	0.03	2,581.20
1:50 PM	2,361.50	2,326.80	2,498.00	0.00	-1.14	0.31	20.62	0.03	2,575.40
1:51 PM	2,361.10	2,326.60	2,498.00	0.00	-1.14	0.47	19.02	0.03	2,578.60
1:52 PM	2,362.70	2,327.90	2,498.00	0.00	-1.14	0.47	17.39	0.04	2,582.10
1:53 PM	2,361.90	2,327.80	2,498.00	0.00	-1.14	0.31	17.77	0.03	2,580.80

LHF Data

	Zone 2 Temp A	Zone 2 Temp B	Zone 2 Temp C	Zone 3 Exhaust Output	Zone 3 Gas Flow	Zone 3 Oxygen Flow	Zone 3 PID CV	Zone 3 Pressure	Zone 3 Temp A
1:54 PM	2,360.70	2,330.30	2,498.00	0.00	-1.14	0.31	18.82	0.03	2,578.10
1:55 PM	2,365.30	2,333.00	2,498.00	0.00	-1.14	0.47	18.49	0.03	2,578.40
1:56 PM	2,363.90	2,332.00	2,498.00	0.00	-1.14	0.31	21.00	0.03	2,572.30
1:57 PM	2,362.50	2,329.20	2,498.00	0.00	53.30	0.31	20.62	0.03	2,573.50
1:58 PM	2,365.20	2,331.10	2,498.00	0.00	-1.14	0.31	19.66	0.03	2,575.80
1:59 PM	2,366.40	2,331.10	2,498.00	0.00	-1.14	0.31	20.97	0.03	2,572.70
2:00 PM	2,367.90	2,332.20	2,498.00	0.00	-1.14	0.47	20.39	0.03	2,574.10
2:01 PM	2,370.10	2,334.80	2,498.00	0.00	-1.14	0.47	20.32	0.03	2,576.10
2:02 PM	2,368.60	2,334.00	2,498.00	0.00	-1.14	0.47	22.54	0.03	2,569.20
2:03 PM	2,366.60	2,332.50	2,498.00	0.00	-1.14	0.31	20.90	0.03	2,570.30
2:04 PM	2,367.60	2,332.50	2,498.00	0.00	-1.14	0.31	22.41	0.03	2,570.20
2:05 PM	2,366.20	2,332.50	2,498.00	0.00	-1.14	0.47	21.70	0.03	2,572.10
2:06 PM	2,366.30	2,333.50	2,498.00	0.00	27.46	0.31	20.06	0.03	2,575.80
2:07 PM	2,367.90	2,335.40	2,498.00	0.00	-1.14	0.47	18.78	0.03	2,578.60
2:08 PM	2,367.60	2,333.50	2,498.00	0.00	-1.14	0.47	20.08	0.03	2,575.60
2:09 PM	2,363.50	2,331.30	2,498.00	0.00	-1.14	0.31	21.16	0.03	2,573.30
2:10 PM	2,364.50	2,331.40	2,498.00	0.00	-1.14	0.31	21.53	0.03	2,572.50
2:11 PM	2,363.00	2,331.10	2,498.00	0.00	-1.14	0.47	20.71	0.04	2,574.30
2:12 PM	2,363.70	2,334.10	2,498.00	0.00	-1.14	0.31	20.17	0.04	2,575.30
2:13 PM	2,366.00	2,336.30	2,498.00	0.00	-1.14	0.31	18.79	0.04	2,578.10
2:14 PM	2,365.90	2,335.60	2,498.00	0.00	39.24	0.31	19.44	0.03	2,576.50
2:15 PM	2,364.20	2,333.90	2,498.00	0.00	54.11	0.31	20.11	0.04	2,575.20
2:16 PM	2,366.70	2,334.30	2,498.00	0.00	62.16	0.31	20.12	0.04	2,575.10
2:17 PM	2,366.70	2,336.40	2,498.00	0.00	-1.14	0.31	18.89	0.03	2,577.80
2:18 PM	2,366.90	2,337.60	2,498.00	0.00	48.26	0.47	17.60	0.03	2,580.30
2:19 PM	2,370.30	2,340.50	2,498.00	0.00	28.11	0.31	18.97	0.03	2,576.60
2:20 PM	2,369.20	2,339.20	2,498.00	0.00	32.09	0.47	19.89	0.03	2,574.20
2:21 PM	2,368.20	2,336.60	2,498.00	0.00	-1.14	0.31	21.82	0.04	2,570.10
2:22 PM	2,369.60	2,337.50	2,498.00	0.00	-1.14	0.47	20.51	0.04	2,573.20
2:23 PM	2,369.80	2,338.60	2,498.00	0.00	-1.14	0.31	19.49	0.03	2,575.50
2:24 PM	2,370.00	2,339.20	2,498.00	0.00	29.09	0.31	18.44	0.03	2,578.00
2:25 PM	2,372.40	2,340.50	2,498.00	0.00	-1.14	0.31	18.91	0.03	2,576.20
2:26 PM	2,371.00	2,337.70	2,498.00	0.00	-1.14	0.31	20.18	0.02	2,573.10
2:27 PM	2,365.20	2,334.00	2,498.00	0.00	-1.14	0.47	19.40	0.02	2,575.10
2:28 PM	2,366.30	2,334.30	2,498.00	0.00	42.66	0.47	18.76	0.02	2,576.80
2:29 PM	2,364.60	2,334.00	2,498.00	0.00	-1.14	0.31	19.95	0.02	2,574.10
2:30 PM	2,363.20	2,332.20	2,498.00	0.00	-1.14	0.47	18.98	0.02	2,576.30
2:31 PM	2,364.20	2,333.10	2,498.00	0.00	-1.14	0.47	18.10	0.02	2,578.10
2:32 PM	2,362.60	2,331.00	2,498.00	0.00	-1.14	0.31	21.12	0.02	2,571.10
2:33 PM	2,356.40	2,327.60	2,498.00	0.00	-1.14	0.31	21.37	0.02	2,572.50
2:34 PM	2,356.10	2,327.50	2,498.00	0.00	-1.14	0.47	20.01	0.02	2,574.40
2:35 PM	2,355.30	2,325.90	2,498.00	0.00	-1.14	0.31	22.47	0.02	2,568.90
2:36 PM	2,354.90	2,325.90	2,498.00	0.00	-1.14	0.31	20.96	0.02	2,572.60
2:37 PM	2,357.70	2,328.10	2,498.00	0.00	-1.14	0.31	20.14	0.02	2,574.60
2:38 PM	2,354.30	2,325.70	2,498.00	0.00	-1.14	0.47	22.65	0.02	2,569.10
2:39 PM	2,349.10	2,322.80	2,498.00	0.00	-1.14	0.31	22.51	0.03	2,570.00
2:40 PM	2,350.70	2,322.60	2,498.00	0.00	-1.22	0.31	20.27	0.03	2,575.40
2:41 PM	2,348.90	2,321.90	2,498.00	0.00	-1.14	0.31	22.04	0.03	2,571.50
2:42 PM	2,348.80	2,322.80	2,498.00	0.00	-1.14	0.31	21.85	0.03	2,572.10
2:43 PM	2,350.70	2,324.40	2,498.00	0.00	-1.14	0.16	19.77	0.03	2,576.90
2:44 PM	2,349.10	2,323.40	2,498.00	0.00	-1.14	0.31	21.99	0.03	2,571.90

Single Briquette Layer with Air Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
10/19/2011	1152	3.0	2000 g	1850 g	1530 g	3	1:07 PM	2:44 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
1:26 PM	55	156.3	Zone 1
1:55 PM	61	155.4	Zone 2
2:22 PM	58	155	Zone 3

LHF Data			LGA Data								
			Port 1								Port 2
	Zone 3 Temp B	Zone 3 Temp C	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi
1:07 PM	2,463.80	2,498.00	4.57	0.00	0.00	0.00	5.51	8.74	78.09	0.43	
1:08 PM	2,467.90	2,498.00									2.51
1:09 PM	2,466.70	2,498.00	4.64	0.00	0.00	0.00	5.58	8.68	77.72	0.45	2.52
1:10 PM	2,470.20	2,498.00									
1:11 PM	2,470.50	2,498.00	0.34	0.00	0.00	0.00	2.46	9.78	86.49	0.00	2.39
1:12 PM	2,474.80	2,498.00	0.35	0.00	0.00	0.00	1.71	11.24	85.96	0.00	
1:13 PM	2,474.30	2,498.00									2.19
1:14 PM	2,470.90	2,498.00	0.77	0.00	0.00	0.00	1.85	11.18	85.41	0.00	2.26
1:15 PM	2,471.40	2,498.00									
1:16 PM	2,471.20	2,498.00	0.41	0.00	0.00	0.00	1.72	11.34	85.82	0.00	2.26
1:17 PM	2,468.70	2,498.00									
1:18 PM	2,466.30	2,498.00	1.44	0.00	0.00	0.00	2.56	10.99	84.07	0.00	2.32
1:19 PM	2,467.60	2,498.00									
1:20 PM	2,465.20	2,498.00	2.03	0.00	0.00	0.00	2.98	10.59	83.00	0.00	2.19
1:21 PM	2,468.40	2,498.00	2.53	0.00	0.00	0.00	3.49	10.33	82.10	0.00	
1:22 PM	2,472.00	2,498.00									2.22
1:23 PM	2,471.10	2,498.00	2.53	0.00	0.00	0.00	3.56	10.33	81.96	0.00	2.24
1:24 PM	2,471.90	2,498.00									
1:25 PM	2,472.30	2,498.00	2.68	0.00	0.00	0.00	3.73	10.24	81.69	0.00	2.24
1:26 PM	2,473.70	2,498.00	2.72	0.00	0.00	0.00	3.75	10.20	81.42	0.00	
1:27 PM	2,470.70	2,498.00									2.35
1:28 PM	2,470.60	2,498.00	2.41	0.00	0.00	0.00	3.53	10.38	82.04	0.00	2.38
1:29 PM	2,472.50	2,498.00									
1:30 PM	2,470.90	2,498.00	2.46	0.00	0.00	0.00	3.56	10.38	82.11	0.00	2.39
1:31 PM	2,474.30	2,498.00	2.53	0.00	0.00	0.00	3.65	10.39	81.94	0.00	
1:32 PM	2,473.30	2,498.00									2.40
1:33 PM	2,473.60	2,498.00	2.56	0.00	0.00	0.00	3.66	10.42	81.74	0.00	2.47
1:34 PM	2,476.00	2,498.00									
1:35 PM	2,474.00	2,498.00	2.49	0.00	0.00	0.00	3.59	10.52	81.98	0.00	2.52
1:36 PM	2,475.60	2,498.00	2.61	0.00	0.00	0.00	3.71	10.52	81.57	0.00	
1:37 PM	2,474.60	2,498.00									2.50
1:38 PM	2,471.00	2,498.00	2.68	0.00	0.00	0.00	3.70	10.57	81.66	0.00	2.56
1:39 PM	2,471.00	2,498.00									
1:40 PM	2,467.70	2,498.00	2.80	0.00	0.00	0.00	3.70	10.78	81.08	0.00	2.61
1:41 PM	2,469.20	2,498.00	2.94	0.00	0.00	0.00	3.75	10.82	80.86	0.00	
1:42 PM	2,469.00	2,498.00									2.60
1:43 PM	2,469.00	2,498.00	3.14	0.00	0.00	0.00	3.91	10.80	80.37	0.00	2.61
1:44 PM	2,467.20	2,498.00									
1:45 PM	2,465.00	2,498.00	3.22	0.00	0.00	0.00	4.01	10.79	80.17	0.00	2.65
1:46 PM	2,467.10	2,498.00	3.35	0.00	0.00	0.00	4.02	10.97	79.75	0.00	
1:47 PM	2,465.20	2,498.00									2.68
1:48 PM	2,468.70	2,498.00	3.72	0.00	0.00	0.00	4.20	10.82	79.22	0.00	2.63
1:49 PM	2,465.60	2,498.00									
1:50 PM	2,467.80	2,498.00	3.69	0.00	0.00	0.00	4.26	10.79	79.13	0.00	2.66
1:51 PM	2,468.40	2,498.00	4.18	0.00	0.00	0.00	4.57	10.65	78.48	0.00	
1:52 PM	2,467.30	2,498.00									2.77
1:53 PM	2,466.10	2,498.00	0.00	0.00	0.00	0.00	4.64	10.57	78.19	0.00	2.85

LHF Data			LGA Data								
			Port 1								Port 2
	Zone 3 Temp B	Zone 3 Temp C	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi
1:54 PM	2,466.10	2,498.00									
1:55 PM	2,469.20	2,498.00	0.00	0.00	0.00	0.00	4.62	10.49	78.38	0.00	2.89
1:56 PM	2,469.50	2,498.00	0.00	0.00	0.00	0.00	4.59	10.40	78.47	0.00	
1:57 PM	2,467.80	2,498.00									2.90
1:58 PM	2,468.50	2,498.00	0.00	0.00	0.00	0.00	3.91	10.69	80.49	0.00	2.93
1:59 PM	2,466.80	2,498.00									
2:00 PM	2,465.40	2,498.00	0.00	0.00	0.00	0.00	3.84	10.61	80.71	0.00	2.90
2:01 PM	2,469.10	2,498.00	0.00	0.00	0.00	0.00	3.97	10.44	80.47	0.00	
2:02 PM	2,469.10	2,498.00									2.93
2:03 PM	2,468.00	2,498.00	0.00	0.00	0.00	0.00	3.97	10.40	80.98	0.00	2.96
2:04 PM	2,470.00	2,498.00									
2:05 PM	2,467.80	2,498.00	0.00	0.00	0.00	0.00	3.76	10.50	81.34	0.00	2.99
2:06 PM	2,467.30	2,498.00	0.00	0.00	0.00	0.00	3.95	10.28	81.02	0.00	
2:07 PM	2,469.70	2,498.00									2.91
2:08 PM	2,470.60	2,498.00	0.00	0.00	0.00	0.00	4.10	10.15	80.57	0.00	2.87
2:09 PM	2,466.80	2,498.00									
2:10 PM	2,467.60	2,498.00	0.00	0.00	0.00	0.00	3.99	10.22	80.83	0.00	2.85
2:11 PM	2,466.30	2,498.00	0.00	0.00	0.00	0.00	4.06	10.19	80.70	0.00	
2:12 PM	2,470.10	2,498.00									2.85
2:13 PM	2,467.10	2,498.00	0.00	0.00	0.00	0.00	4.10	10.17	80.88	0.00	2.77
2:14 PM	2,470.10	2,498.00									
2:15 PM	2,471.30	2,498.00	0.00	0.00	0.00	0.00	4.05	10.21	80.99	0.00	2.91
2:16 PM	2,467.90	2,498.00	0.00	0.00	0.00	0.00	3.88	10.27	81.35	0.00	
2:17 PM	2,468.90	2,498.00									3.02
2:18 PM	2,466.90	2,498.00									
2:19 PM	2,467.00	2,498.00									
2:20 PM	2,465.90	2,498.00									
2:21 PM	2,466.60	2,498.00									
2:22 PM	2,467.90	2,498.00									
2:23 PM	2,466.20	2,498.00									
2:24 PM	2,466.40	2,498.00	0.00	0.00	0.00	0.00	4.12	10.39	79.68	0.00	
2:25 PM	2,467.50	2,498.00									3.49
2:26 PM	2,470.00	2,498.00	0.00	0.00	0.00	0.00	4.14	10.14	79.95	0.00	3.25
2:27 PM	2,468.70	2,498.00									
2:28 PM	2,469.70	2,498.00	0.00	0.00	0.00	0.00	3.78	10.35	80.87	0.00	3.28
2:29 PM	2,467.20	2,498.00	0.00	0.00	0.00	0.00	3.72	10.39	81.14	0.00	
2:30 PM	2,468.50	2,498.00									3.17
2:31 PM	2,466.20	2,498.00	0.00	0.00	0.00	0.00	3.88	10.24	80.92	0.00	3.10
2:32 PM	2,468.40	2,498.00									
2:33 PM	2,468.00	2,498.00	0.00	0.00	0.00	0.00	3.80	10.27	80.92	0.00	2.96
2:34 PM	2,466.50	2,498.00	0.00	0.00	0.00	0.00	3.67	10.33	81.11	0.00	
2:35 PM	2,465.40	2,498.00									2.92
2:36 PM	2,466.50	2,498.00	0.00	0.00	0.00	0.00	3.67	10.33	81.17	0.00	2.87
2:37 PM	2,470.70	2,498.00									
2:38 PM	2,466.60	2,498.00	0.00	0.00	0.00	0.00	3.69	10.38	81.23	0.00	2.79
2:39 PM	2,466.70	2,498.00	0.00	0.00	0.00	0.00	3.59	10.37	81.39	0.00	
2:40 PM	2,469.50	2,498.00									2.75
2:41 PM	2,466.80	2,498.00	0.00	0.00	0.00	0.00	3.56	10.44	81.58	0.00	2.75
2:42 PM	2,466.10	2,498.00									
2:43 PM	2,470.60	2,498.00	0.00	0.00	0.00	0.00	3.61	10.33	81.29	0.00	2.74
2:44 PM	2,466.40	2,498.00	0.00	0.00	0.00	0.00	3.62	10.32	81.18	0.00	

Single Briquette Layer with Air Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
10/19/2011	1152	3.0	2000 g	1850 g	1530 g	3	1:07 PM	2:44 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
1:26 PM	55	156.3	Zone 1
1:55 PM	61	155.4	Zone 2
2:22 PM	58	155	Zone 3

LGA Data													
Port 2								Port 3					
	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen
1:07 PM												
1:08 PM	0.92	0.00	0.00	3.65	9.82	80.71	0.00	1.97	1.15	0.00	0.00	3.56
1:09 PM	0.92	0.00	0.00	3.79	9.83	80.69	0.00					
1:10 PM								2.01	1.17	0.00	0.00	3.60
1:11 PM	0.90	0.00	0.00	3.78	9.85	80.72	0.00	1.83	1.09	0.00	0.00	3.57
1:12 PM												
1:13 PM	0.91	0.00	0.00	3.75	9.82	81.14	0.00	1.75	1.09	0.00	0.00	3.49
1:14 PM	0.89	0.00	0.00	3.81	9.81	81.06	0.00					
1:15 PM								1.75	1.08	0.00	0.00	3.53
1:16 PM	0.92	0.00	0.00	3.83	9.79	80.95	0.00	1.74	1.16	0.00	0.00	3.59
1:17 PM												
1:18 PM	1.05	0.00	0.00	3.91	9.94	80.54	0.00					
1:19 PM								1.91	1.36	0.00	0.00	3.58
1:20 PM	0.87	0.00	0.00	3.90	9.69	80.97	0.00	1.69	1.07	0.00	0.00	3.56
1:21 PM												
1:22 PM	0.88	0.00	0.00	3.95	9.58	81.20	0.00	1.64	1.13	0.00	0.00	3.51
1:23 PM	0.90	0.00	0.00	3.90	9.53	81.05	0.00					
1:24 PM								1.65	1.10	0.00	0.00	3.54
1:25 PM	0.88	0.00	0.00	3.97	9.45	81.04	0.00	1.67	1.05	0.00	0.00	3.57
1:26 PM												
1:27 PM	0.86	0.00	0.00	4.07	9.45	80.94	0.00	1.72	1.02	0.00	0.00	3.69
1:28 PM	0.82	0.00	0.00	4.10	9.45	80.96	0.00					
1:29 PM								1.78	0.97	0.00	0.00	3.71
1:30 PM	0.84	0.00	0.00	4.12	9.42	80.84	0.00	1.79	1.00	0.00	0.00	3.73
1:31 PM												
1:32 PM	0.86	0.00	0.00	4.16	9.36	80.83	0.00	1.78	1.03	0.00	0.00	3.76
1:33 PM	0.88	0.00	0.00	4.28	9.37	80.76	0.00					
1:34 PM								1.88	1.11	0.00	0.00	3.81
1:35 PM	1.04	0.00	0.00	4.27	9.32	80.38	0.00	1.87	1.19	0.00	0.00	3.87
1:36 PM												
1:37 PM	0.98	0.00	0.00	4.22	9.27	80.57	0.00	1.88	1.17	0.00	0.00	3.96
1:38 PM	0.95	0.00	0.00	4.39	9.25	80.49	0.00					
1:39 PM								1.96	1.08	0.00	0.00	3.98
1:40 PM	0.91	0.00	0.00	4.44	9.28	80.27	0.00	2.00	1.07	0.00	0.00	4.02
1:41 PM												
1:42 PM	0.92	0.00	0.00	4.46	9.25	80.28	0.00	1.98	1.10	0.00	0.00	4.05
1:43 PM	0.96	0.00	0.00	4.46	9.19	80.20	0.00					
1:44 PM								2.02	1.16	0.00	0.00	4.13
1:45 PM	0.92	0.00	0.00	4.52	9.16	80.15	0.00	2.07	1.12	0.00	0.00	4.22
1:46 PM												
1:47 PM	0.92	0.00	0.00	4.53	9.15	80.10	0.00	2.06	1.10	0.00	0.00	4.22
1:48 PM	0.89	0.00	0.00	4.50	9.10	80.18	0.00					
1:49 PM								2.10	1.12	0.00	0.00	4.21
1:50 PM	0.90	0.00	0.00	4.60	9.08	80.13	0.00	2.12	1.03	0.00	0.00	4.34
1:51 PM												
1:52 PM	0.87	0.00	0.00	4.66	9.17	79.85	0.00	2.19	1.05	0.00	0.00	4.35
1:53 PM	0.88	0.00	0.00	4.69	9.17	79.81	0.00					

LGA Data												
Port 2								Port 3				
	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen
1:54 PM								2.23	1.08	0.00	0.00	4.37
1:55 PM	0.88	0.00	0.00	4.68	9.17	79.60	0.00	2.27	1.08	0.00	0.00	4.40
1:56 PM												
1:57 PM	0.96	0.00	0.00	4.76	9.14	79.57	0.00	2.32	1.20	0.00	0.00	4.46
1:58 PM	1.11	0.00	0.00	4.74	9.18	79.34	0.00					
1:59 PM								2.34	1.28	0.00	0.00	4.42
2:00 PM	1.10	0.00	0.00	4.81	9.18	79.39	0.00	2.33	1.26	0.00	0.00	4.39
2:01 PM												
2:02 PM	0.94	0.00	0.00	4.79	9.16	79.35	0.00	2.30	1.13	0.00	0.00	4.39
2:03 PM	1.00	0.00	0.00	4.77	9.18	79.14	0.00					
2:04 PM								2.40	1.21	0.00	0.00	4.43
2:05 PM	0.96	0.00	0.00	4.77	9.18	79.41	0.00	2.40	1.12	0.00	0.00	4.52
2:06 PM												
2:07 PM	0.83	0.00	0.00	4.74	9.15	79.67	0.00	2.41	1.03	0.00	0.00	4.47
2:08 PM	0.84	0.00	0.00	4.73	9.06	79.83	0.00					
2:09 PM								2.38	1.04	0.00	0.00	4.48
2:10 PM	1.13	0.00	0.00	4.70	8.99	79.59	0.00	2.37	1.40	0.00	0.00	4.51
2:11 PM												
2:12 PM	1.18	0.00	0.00	4.72	8.89	79.81	0.00	2.36	1.42	0.00	0.00	4.53
2:13 PM	1.16	0.00	0.00	4.66	8.82	80.00	0.00					
2:14 PM								2.41	1.35	0.00	0.00	4.52
2:15 PM	1.02	0.00	0.00	4.74	8.91	79.77	0.00	2.53	1.22	0.00	0.00	4.65
2:16 PM												
2:17 PM	0.98	0.00	0.00	4.83	9.06	79.21	0.00	2.59	1.16	0.00	0.00	4.61
2:18 PM												
2:19 PM												
2:20 PM												
2:21 PM												
2:22 PM												
2:23 PM												
2:24 PM												
2:25 PM	1.00	0.00	0.00	5.20	9.73	76.29	0.02	3.67	1.30	0.00	0.00	5.28
2:26 PM	0.85	0.00	0.00	5.08	9.43	77.76	0.00					
2:27 PM								3.02	1.08	0.00	0.00	4.88
2:28 PM	1.01	0.00	0.00	5.07	9.31	77.70	0.01	2.94	1.16	0.00	0.00	4.80
2:29 PM												
2:30 PM	0.98	0.00	0.00	4.98	9.25	78.01	0.00	2.76	1.16	0.00	0.00	4.78
2:31 PM	0.88	0.00	0.00	4.85	9.19	78.43	0.00					
2:32 PM								2.68	1.10	0.00	0.00	4.66
2:33 PM	0.95	0.00	0.00	4.80	9.04	78.97	0.00	2.55	1.14	0.00	0.00	4.58
2:34 PM												
2:35 PM	0.98	0.00	0.00	4.67	8.97	79.26	0.00	2.49	1.18	0.00	0.00	4.44
2:36 PM	1.05	0.00	0.00	4.64	8.89	79.34	0.00					
2:37 PM								2.40	1.21	0.00	0.00	4.33
2:38 PM	1.09	0.00	0.00	4.58	8.82	79.69	0.00	2.33	1.22	0.00	0.00	4.29
2:39 PM												
2:40 PM	1.00	0.00	0.00	4.58	8.85	79.71	0.00	2.35	1.19	0.00	0.00	4.26
2:41 PM	0.98	0.00	0.00	4.58	8.82	79.78	0.00					
2:42 PM								2.30	1.15	0.00	0.00	4.14
2:43 PM	0.98	0.00	0.00	4.58	8.89	79.74	0.00	2.24	1.13	0.00	0.00	4.03
2:44 PM												

Single Briquette Layer with Air Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
10/19/2011	1152	3.0	2000 g	1850 g	1530 g	3	1:07 PM	2:44 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
1:26 PM	55	156.3	Zone 1
1:55 PM	61	155.4	Zone 2
2:22 PM	58	155	Zone 3

LGA Data

Port 3					Port 4							
	% Carbon Dioxid		% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons
1:07 PM					1.51	1.66	0.00	0.00	3.07	8.40	84.12	0.00
1:08 PM	8.51		82.84	0.00	1.57	1.67	0.00	0.00	3.10	8.53	83.37	0.00
1:09 PM												
1:10 PM	8.51		82.85	0.00	1.67	1.69	0.00	0.00	3.20	8.60	83.10	0.00
1:11 PM	8.21		83.39	0.00								
1:12 PM					1.59	1.61	0.00	0.00	3.14	8.49	83.63	0.00
1:13 PM	7.79		84.22	0.00	1.53	1.66	0.00	0.00	3.13	8.32	83.76	0.00
1:14 PM												
1:15 PM	7.88		84.08	0.00	1.53	1.62	0.00	0.00	3.12	8.33	83.88	0.00
1:16 PM	7.73		84.22	0.00								
1:17 PM					1.53	1.74	0.00	0.00	3.06	8.27	83.81	0.00
1:18 PM												
1:19 PM	8.34		82.80	0.00	1.60	1.73	0.00	0.00	3.13	8.75	83.13	0.00
1:20 PM	7.52		84.58	0.00								
1:21 PM					1.48	1.57	0.00	0.00	3.12	8.32	84.11	0.00
1:22 PM	7.21		85.02	0.00	1.45	1.69	0.00	0.00	3.00	8.12	84.33	0.00
1:23 PM												
1:24 PM	7.15		85.12	0.00	1.43	1.71	0.00	0.00	2.98	8.05	84.56	0.00
1:25 PM	7.06		85.09	0.00								
1:26 PM					1.48	1.58	0.00	0.00	3.04	8.00	84.37	0.00
1:27 PM	7.09		84.89	0.00	1.55	1.58	0.00	0.00	3.20	7.99	84.34	0.00
1:28 PM												
1:29 PM	7.05		84.99	0.00	1.55	1.61	0.00	0.00	3.13	7.94	84.23	0.00
1:30 PM	7.00		85.00	0.00								
1:31 PM					1.58	1.55	0.00	0.00	3.23	7.92	84.37	0.00
1:32 PM	6.87		85.13	0.00	1.61	1.66	0.00	0.00	3.29	7.87	84.27	0.00
1:33 PM												
1:34 PM	6.94		84.44	0.00	1.70	1.73	0.00	0.00	3.35	7.85	83.77	0.00
1:35 PM	6.88		84.55	0.00								
1:36 PM					1.73	1.74	0.00	0.00	3.37	7.82	83.87	0.00
1:37 PM	6.80		84.68	0.00	1.79	1.67	0.00	0.00	3.47	7.80	83.68	0.00
1:38 PM												
1:39 PM	6.86		84.45	0.00	1.83	1.61	0.00	0.00	3.51	7.81	83.73	0.00
1:40 PM	6.85		84.35	0.00								
1:41 PM					1.90	1.61	0.00	0.00	3.60	7.76	83.44	0.00
1:42 PM	6.75		84.32	0.00	1.89	1.65	0.00	0.00	3.61	7.72	83.42	0.00
1:43 PM												
1:44 PM	6.70		84.28	0.00	1.89	1.69	0.00	0.00	3.67	7.71	83.26	0.00
1:45 PM	6.75		83.96	0.00								
1:46 PM					2.02	1.67	0.00	0.00	3.80	7.67	83.06	0.00
1:47 PM	6.68		83.97	0.00	2.06	1.64	0.00	0.00	3.86	7.62	82.88	0.00
1:48 PM												
1:49 PM	6.59		83.94	0.00	2.00	1.70	0.00	0.00	3.86	7.57	82.96	0.00
1:50 PM	6.52		84.13	0.00								
1:51 PM					2.06	1.70	0.00	0.00	3.83	7.57	82.97	0.00
1:52 PM	6.64		83.86	0.00	2.12	1.70	0.00	0.00	3.88	7.56	82.71	0.00
1:53 PM												

LGA Data

Port 3					Port 4							
	% Carbon Dioxid		% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons
1:54 PM	6.70		83.58	0.00	2.16	1.69	0.00	0.00	3.89	7.56	82.76	0.00
1:55 PM	6.73		83.45	0.00								
1:56 PM					2.10	1.78	0.00	0.00	3.89	7.55	82.72	0.00
1:57 PM	6.77		83.18	0.00	2.14	1.78	0.00	0.00	3.92	7.59	82.66	0.00
1:58 PM												
1:59 PM	6.80		83.09	0.00	2.12	1.80	0.00	0.00	3.96	7.55	82.76	0.00
2:00 PM	6.71		83.27	0.00								
2:01 PM					2.10	1.80	0.00	0.00	3.86	7.53	82.85	0.00
2:02 PM	6.62		83.46	0.00	2.02	1.70	0.00	0.00	3.81	7.54	83.10	0.00
2:03 PM												
2:04 PM	6.76		83.17	0.00	2.12	1.78	0.00	0.00	3.86	7.58	82.73	0.00
2:05 PM	6.76		83.17	0.00								
2:06 PM					2.14	1.67	0.00	0.00	3.84	7.59	83.08	0.00
2:07 PM	6.69		83.33	0.00	2.12	1.65	0.00	0.00	3.83	7.58	82.99	0.00
2:08 PM												
2:09 PM	6.50		83.73	0.00	2.16	1.73	0.00	0.00	3.89	7.54	82.95	0.00
2:10 PM	6.48		83.22	0.00								
2:11 PM					2.21	1.86	0.00	0.00	3.92	7.54	82.53	0.00
2:12 PM	6.39		83.53	0.00	2.16	1.90	0.00	0.00	3.81	7.49	82.60	0.00
2:13 PM												
2:14 PM	6.38		83.46	0.00	2.15	1.83	0.00	0.00	3.78	7.54	82.69	0.00
2:15 PM	6.71		82.90	0.00								
2:16 PM					2.31	1.84	0.00	0.00	3.92	7.61	82.59	0.00
2:17 PM	6.75		82.93	0.00	2.31	1.76	0.00	0.00	3.99	7.62	82.44	0.00
2:18 PM												
2:19 PM												
2:20 PM												
2:21 PM												
2:22 PM												
2:23 PM												
2:24 PM												
2:25 PM	9.31		76.27	0.00	2.97	1.67	0.00	0.00	4.36	9.85	77.51	0.00
2:26 PM												
2:27 PM	7.86		79.85	0.00	2.60	1.64	0.00	0.00	4.23	8.78	79.64	0.00
2:28 PM	7.55		80.52	0.00								
2:29 PM					2.56	1.75	0.00	0.00	4.20	8.40	80.34	0.00
2:30 PM	7.14		81.31	0.00	2.38	1.66	0.00	0.00	4.01	8.16	81.19	0.00
2:31 PM												
2:32 PM	7.03		81.73	0.00	2.28	1.66	0.00	0.00	3.90	8.04	81.59	0.00
2:33 PM	6.83		82.26	0.00								
2:34 PM					2.15	1.72	0.00	0.00	3.76	7.95	81.84	0.00
2:35 PM	6.77		82.47	0.00	2.09	1.74	0.00	0.00	3.69	7.87	82.23	0.00
2:36 PM												
2:37 PM	6.70		82.81	0.00	1.96	1.76	0.00	0.00	3.59	7.79	82.55	0.00
2:38 PM	6.65		82.99	0.00								
2:39 PM					1.88	1.73	0.00	0.00	3.55	7.76	82.93	0.00
2:40 PM	6.67		83.28	0.00	1.85	1.73	0.00	0.00	3.50	7.72	83.16	0.00
2:41 PM												
2:42 PM	6.66		83.46	0.00	1.75	1.73	0.00	0.00	3.40	7.72	83.37	0.00
2:43 PM	6.65		83.63	0.00								
2:44 PM					1.69	1.75	0.00	0.00	3.30	7.70	83.47	0.00

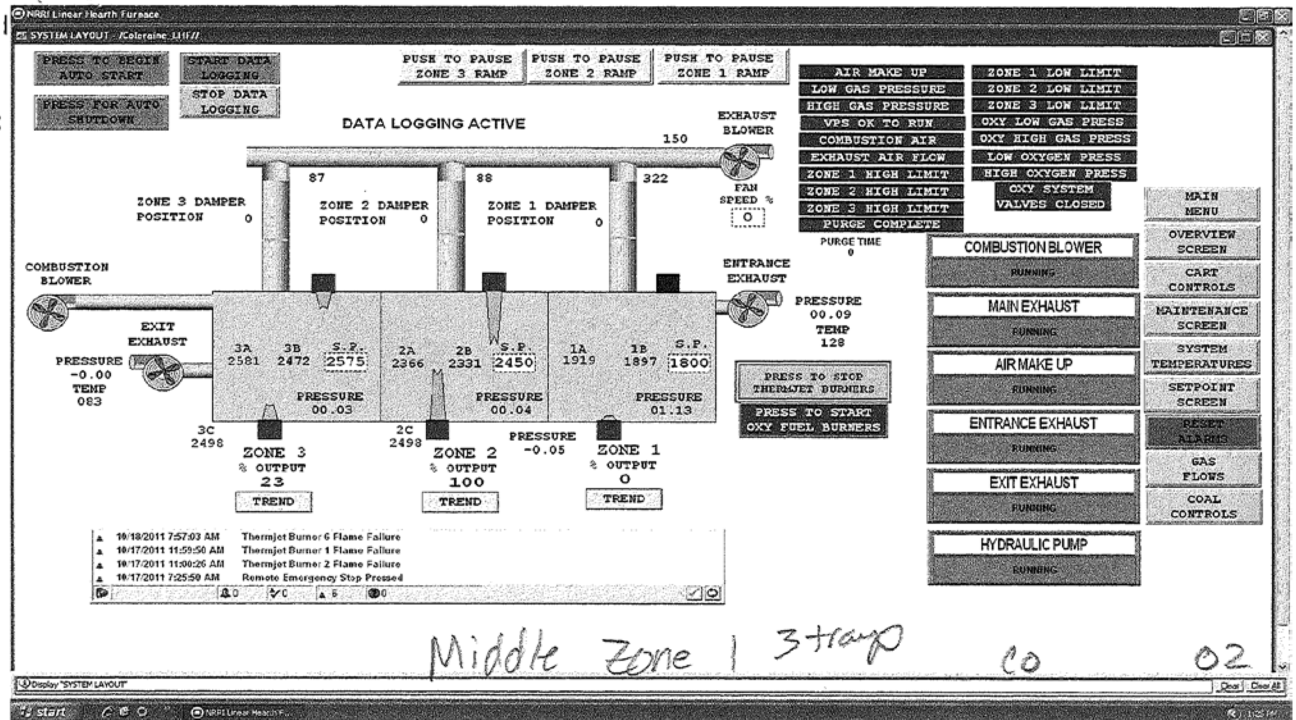
Single Briquette Layer with Air Burners

Date
10/19/2011

	Testo Emission Data				
	% O2	ppm CO	ppm NO	ppm NO2	% CO2
1:07 PM	0.26	32,906.00	86.00	86.00	8.31
1:08 PM	0.25	33,496.00	87.00	87.00	8.24
1:09 PM	0.26	33,707.00	87.00	87.00	8.27
1:10 PM	0.39	13,169.00	89.00	89.00	9.50
1:11 PM	0.46	7,332.00	90.00	90.00	10.05
1:12 PM	0.45	10,523.00	89.00	89.00	10.15
1:13 PM	0.44	11,225.00	87.00	87.00	10.22
1:14 PM	0.43	13,538.00	85.00	85.00	10.19
1:15 PM	0.42	13,912.00	83.00	83.00	10.24
1:16 PM	0.43	14,142.00	81.00	81.00	10.30
1:17 PM	0.48	13,318.00	80.00	80.00	10.33
1:18 PM	0.49	14,618.00	79.00	79.00	10.30
1:19 PM	0.48	16,320.00	77.00	77.00	10.21
1:20 PM	0.49	18,536.00	76.00	76.00	10.09
1:21 PM	0.49	19,168.00	75.00	75.00	10.07
1:22 PM	0.51	18,888.00	74.00	74.00	10.05
1:23 PM	0.50	19,207.00	74.00	74.00	10.04
1:24 PM	0.51	20,046.00	74.00	74.00	10.02
1:25 PM	0.47	19,735.00	74.00	74.00	10.04
1:26 PM	0.48	20,441.00	74.00	74.00	9.97
1:27 PM	0.51	21,774.00	73.00	73.00	9.93
1:28 PM	0.50	22,232.00	73.00	73.00	9.92
1:29 PM	0.51	20,724.00	73.00	73.00	9.98
1:30 PM	0.49	20,600.00	73.00	73.00	9.99
1:31 PM	0.53	20,937.00	73.00	73.00	9.96
1:32 PM	0.53	22,948.00	74.00	74.00	9.93
1:33 PM	0.53	23,575.00	73.00	73.00	9.90
1:34 PM	0.52	23,746.00	74.00	74.00	9.93
1:35 PM	0.53	22,648.00	74.00	74.00	9.98
1:36 PM	0.53	22,934.00	74.00	74.00	10.00
1:37 PM	0.52	23,099.00	74.00	74.00	10.03
1:38 PM	0.54	24,870.00	74.00	74.00	10.05
1:39 PM	0.50	26,837.00	74.00	74.00	10.14
1:40 PM	0.54	27,057.00	75.00	75.00	10.15
1:41 PM	0.55	26,423.00	75.00	75.00	10.18
1:42 PM	0.51	27,146.00	75.00	75.00	10.21
1:43 PM	0.49	27,245.00	75.00	75.00	10.22
1:44 PM	0.52	27,611.00	75.00	75.00	10.32
1:45 PM	0.50	29,096.00	76.00	76.00	10.44
1:46 PM	0.48	29,469.00	76.00	76.00	10.45
1:47 PM	0.50	29,061.00	76.00	76.00	10.41
1:48 PM	0.49	28,037.00	76.00	76.00	10.38
1:49 PM	0.51	27,669.00	76.00	76.00	10.37
1:50 PM	0.51	26,785.00	76.00	76.00	10.38
1:51 PM	0.52	28,932.00	76.00	76.00	10.45
1:52 PM	0.52	28,320.00	76.00	76.00	10.43
1:53 PM	0.50	26,505.00	76.00	76.00	10.36

	Testo Emissior	Testo Emission Data				
		% O2	ppm CO	ppm NO	ppm NO2	% CO2
1:54 PM	0.58	0.50	26,405.00	76.00	76.00	10.31
1:55 PM	0.58	0.48	25,788.00	76.00	76.00	10.29
1:56 PM	0.58	0.49	23,609.00	75.00	75.00	10.15
1:57 PM	0.58	0.50	23,818.00	75.00	75.00	10.09
1:58 PM	0.58	0.47	22,742.00	75.00	75.00	10.07
1:59 PM	0.58	0.47	17,972.00	74.00	74.00	10.04
2:00 PM	0.58	0.45	19,908.00	74.00	74.00	10.01
2:01 PM	0.58	0.51	20,597.00	73.00	73.00	9.96
2:02 PM	0.58	0.48	21,778.00	73.00	73.00	9.86
2:03 PM	0.59	0.46	22,323.00	73.00	73.00	9.83
2:04 PM	0.59	0.47	21,895.00	73.00	73.00	9.85
2:05 PM	0.59	0.49	21,335.00	73.00	73.00	9.84
2:06 PM	0.59	0.48	22,038.00	73.00	73.00	9.83
2:07 PM	0.59	0.50	21,768.00	73.00	73.00	9.82
2:08 PM	0.59	0.54	21,570.00	73.00	73.00	9.77
2:09 PM	0.59	0.55	22,279.00	73.00	73.00	9.78
2:10 PM	0.59	0.55	21,813.00	73.00	73.00	9.76
2:11 PM	0.59	0.55	19,608.00	73.00	73.00	9.81
2:12 PM	0.59	0.53	19,368.00	72.00	72.00	9.83
2:13 PM	0.59	0.55	19,822.00	72.00	72.00	9.85
2:14 PM	0.59	0.56	20,771.00	71.00	71.00	9.80
2:15 PM	0.59	0.55	21,505.00	71.00	71.00	9.79
2:16 PM	0.59	0.55	21,738.00	71.00	71.00	9.77
2:17 PM	0.60	0.53	21,604.00	71.00	71.00	9.76
2:18 PM	0.60	0.52	22,208.00	71.00	71.00	9.78
2:19 PM	0.60	0.52	21,591.00	71.00	71.00	9.81
2:20 PM	0.60	0.56	21,623.00	71.00	71.00	9.78
2:21 PM	0.60	0.53	22,977.00	71.00	71.00	9.74
2:22 PM	0.60	0.55	22,367.00	71.00	71.00	9.72
2:23 PM	0.60	0.53	21,753.00	71.00	71.00	9.75
2:24 PM	0.60	0.52	22,030.00	72.00	72.00	9.75
2:25 PM	0.60	0.54	21,698.00	72.00	72.00	9.74
2:26 PM	0.60	0.57	22,761.00	71.00	71.00	9.70
2:27 PM	0.60	0.54	21,132.00	71.00	71.00	9.74
2:28 PM	0.60	0.51	21,994.00	71.00	71.00	9.76
2:29 PM	0.60	0.51	20,152.00	71.00	71.00	9.80
2:30 PM	0.60	0.50	19,620.00	71.00	71.00	9.84
2:31 PM	0.60	0.51	20,351.00	71.00	71.00	9.79
2:32 PM	0.61	0.53	21,587.00	71.00	71.00	9.76
2:33 PM	0.61	0.55	22,118.00	71.00	71.00	9.73
2:34 PM	0.61	0.56	21,597.00	70.00	70.00	9.76
2:35 PM	0.61	0.56	20,437.00	70.00	70.00	9.79
2:36 PM	0.61	0.56	21,725.00	70.00	70.00	9.78
2:37 PM	0.61	0.56	20,044.00	70.00	70.00	9.78
2:38 PM	0.61	0.55	21,866.00	70.00	70.00	9.74
2:39 PM	0.61	0.55	22,164.00	70.00	70.00	9.74
2:40 PM	0.61	0.54	21,539.00	69.00	69.00	9.72
2:41 PM	0.61	0.55	21,496.00	70.00	70.00	9.72
2:42 PM	0.61	0.56	21,260.00	69.00	69.00	9.73
2:43 PM	0.61	0.55	21,477.00	69.00	69.00	9.73
2:44 PM	0.61	0.55	19,721.00	69.00	69.00	9.76

Wednesday, October 19, 2011 **1:25:52 PM** 100% Fused

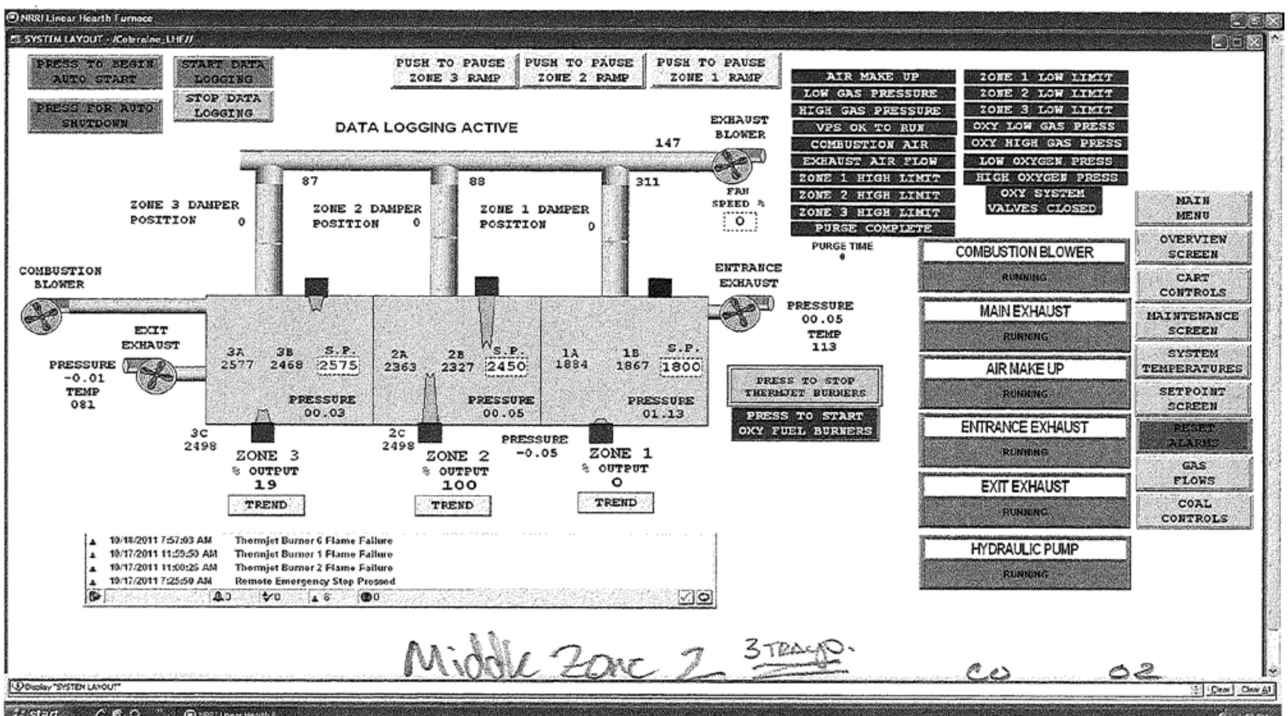


Test # 1152 Tray 6,7, SP.
CAR SPEED 3.0
MIX P3/.9

~~Convey~~
Prime

2.5575 0.0000
2.4686
.4786

Wednesday, October 19, 2011 **1:53:18 PM**

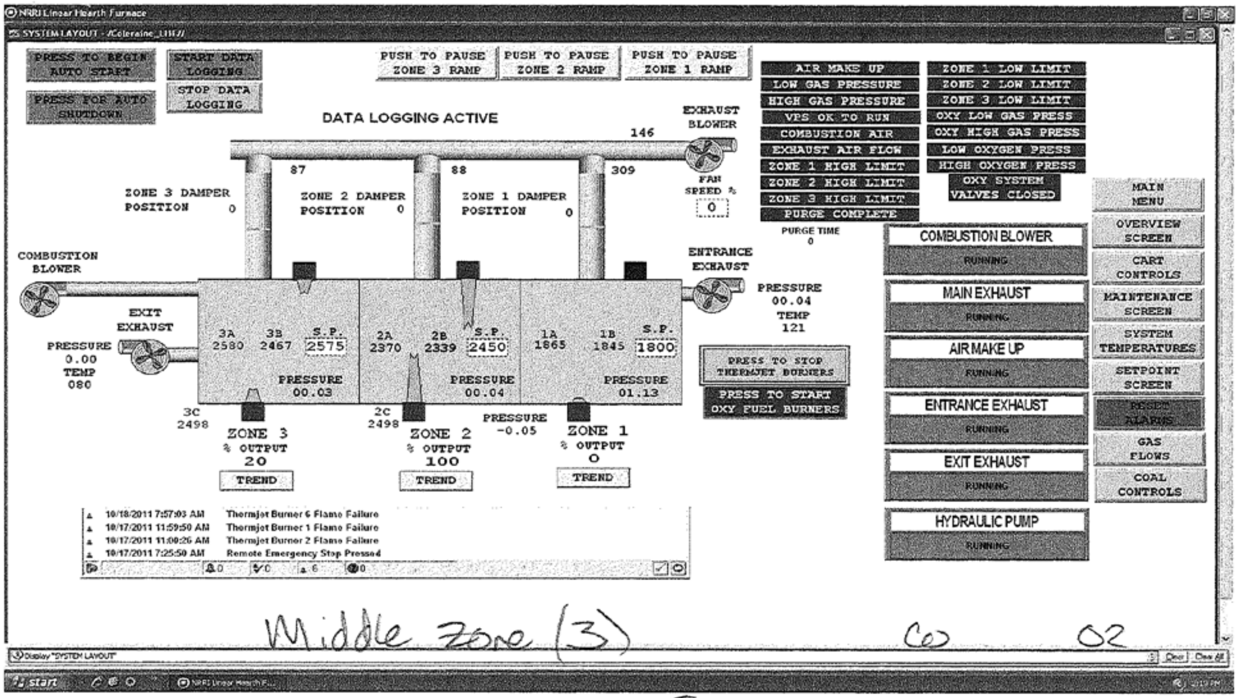


Test # 1152 6,7, SP
CAR SPEED 3.0
MIX P3/.9

~~Convey~~
Prime

3.0879 0.0000
2.9010
2.3253

Wednesday, October 19, 2011 **2:20:06 PM**



Test # 1152 4,7,SR.

CAR SPEED 3.0

MIX P269

INT. 5.17

~~Convey~~

~~Prime~~

Total Time.

3.1150
3.2463
3.0237
2.5978

0.0000

Single Briquette Layer with Oxy Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
3/24/2011	1109	7.0	2000 g	1850 g	1530 g	4	11:41 AM	12:27 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
11:20 AM	120	167	No Sample
11:50 AM	105	165	With Sample
12:05 PM	115	159	With Sample

	LHF Data													
	Cart Pressure	Entrance Exhaust Output	Entrance Pressure	Exhaust Pressure	Exit Exhaust Output	OI Inches per Minute	Zone 1 Exhaust Output	Zone 1 Gas Flow	Zone 1 Oxygen Flow	Zone 1 PID CV	Zone 1 Pressure	Zone 1 Temp A	Zone 1 Temp B	Zone 2 Exhaust Output
11:41 AM	-0.04	100.00	0.07	0.00	100.00	7.00	0.00	177.59	245.88	0.00	1.13	2086.30	2008.00	0.00
11:42 AM	-0.04	100.00	0.03	0.00	100.00	7.00	0.00	175.82	266.88	0.00	1.13	2079.30	1998.70	0.00
11:43 AM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	176.91	257.50	0.00	1.13	2072.00	1989.40	0.00
11:44 AM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	175.61	288.88	0.00	1.13	2069.80	1985.50	0.00
11:45 AM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	173.37	256.88	0.00	1.13	2063.40	1977.50	0.00
11:46 AM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	174.72	258.00	0.00	1.13	2058.60	1972.10	0.00
11:47 AM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	175.61	259.63	0.00	1.13	2051.60	1963.60	0.00
11:48 AM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	173.11	243.13	0.00	1.13	2045.50	1955.20	0.00
11:49 AM	-0.04	100.00	0.07	0.00	100.00	7.00	0.00	173.47	269.38	0.00	1.13	2041.10	1949.60	0.00
11:50 AM	-0.04	100.00	0.06	0.00	100.00	7.00	0.00	171.34	252.88	0.00	1.13	2029.80	1940.70	0.00
11:51 AM	-0.04	100.00	0.08	0.00	100.00	7.00	0.00	173.89	236.50	0.00	1.13	2020.90	1932.40	0.00
11:52 AM	-0.04	100.00	0.07	0.00	100.00	7.00	0.00	173.78	262.75	0.00	1.13	2018.80	1930.30	0.00
11:53 AM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	167.85	282.38	0.00	1.13	2013.10	1924.90	0.00
11:54 AM	-0.04	100.00	0.06	0.00	100.00	7.00	0.00	173.00	239.63	0.00	1.13	2012.30	1925.80	0.00
11:55 AM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	174.04	279.50	0.00	1.13	2016.60	1929.60	0.00
11:56 AM	-0.04	100.00	0.06	0.00	100.00	7.00	0.00	175.61	263.63	0.00	1.13	2017.70	1933.00	0.00
11:57 AM	-0.04	100.00	0.07	0.00	100.00	7.00	0.00	172.33	241.88	0.00	1.13	2020.10	1938.70	0.00
11:58 AM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	174.15	261.88	0.00	1.13	2024.80	1943.10	0.00
11:59 AM	-0.04	100.00	0.06	0.00	100.00	7.00	0.00	172.01	264.00	0.00	1.13	2028.70	1945.90	0.00
12:00 PM	-0.04	100.00	0.07	0.00	100.00	7.00	0.00	172.64	237.63	0.00	1.13	2033.90	1953.00	0.00
12:01 PM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	172.54	251.13	0.00	1.13	2036.20	1953.70	0.00
12:02 PM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	171.13	259.13	0.00	1.13	2039.50	1957.60	0.00
12:03 PM	-0.04	100.00	0.06	0.00	100.00	7.00	0.00	173.73	275.63	0.00	1.13	2043.90	1963.50	0.00
12:04 PM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	171.13	241.50	0.00	1.13	2037.90	1957.60	0.00
12:05 PM	-0.03	100.00	0.06	0.00	100.00	7.00	0.00	172.64	249.00	0.00	1.13	2037.10	1957.40	0.00
12:06 PM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	173.52	230.75	0.00	1.13	2037.10	1956.20	0.00
12:07 PM	-0.04	100.00	0.06	0.00	100.00	7.00	0.00	174.25	261.38	0.00	1.13	2035.20	1954.20	0.00
12:08 PM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	172.43	241.25	0.00	1.13	2040.30	1958.60	0.00
12:09 PM	-0.04	100.00	0.03	0.00	100.00	7.00	0.00	171.55	273.38	0.00	1.13	2041.00	1958.90	0.00
12:10 PM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	172.95	273.88	0.00	1.13	2043.40	1961.60	0.00
12:11 PM	-0.04	100.00	0.03	0.00	100.00	7.00	0.00	172.07	259.00	0.00	1.13	2050.50	1968.70	0.00
12:12 PM	-0.04	100.00	0.03	0.00	100.00	7.00	0.00	175.40	258.00	0.00	1.13	2054.00	1969.80	0.00
12:13 PM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	175.71	263.38	0.00	1.13	2055.50	1971.90	0.00
12:14 PM	-0.04	100.00	0.03	0.00	100.00	7.00	0.00	174.88	281.75	0.00	1.13	2058.40	1975.50	0.00
12:15 PM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	177.17	261.00	0.00	1.13	2054.70	1973.20	0.00
12:16 PM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	174.36	249.00	0.00	1.13	2053.20	1972.60	0.00
12:17 PM	-0.04	100.00	0.03	0.00	100.00	7.00	0.00	176.28	263.25	0.00	1.13	2049.50	1970.00	0.00
12:18 PM	-0.04	100.00	0.03	0.00	100.00	7.00	0.00	173.32	282.50	0.00	1.13	2048.20	1970.90	0.00
12:19 PM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	178.11	265.50	0.00	1.13	2048.50	1972.60	0.00
12:20 PM	-0.04	100.00	0.02	0.00	100.00	7.00	0.00	175.61	260.25	0.00	1.13	2050.50	1973.70	0.00
12:21 PM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	174.20	279.00	0.00	1.13	2053.20	1976.40	0.00
12:22 PM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	176.75	233.25	0.00	1.13	2060.70	1983.00	0.00
12:23 PM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	176.65	256.75	0.00	1.13	2062.70	1980.80	0.00
12:24 PM	-0.04	100.00	0.05	0.00	100.00	7.00	0.00	177.48	267.75	0.00	1.13	2065.40	1984.30	0.00
12:25 PM	-0.04	100.00	0.04	0.00	100.00	7.00	0.00	174.72	247.00	0.00	1.13	2069.70	1989.20	0.00
12:26 PM	-0.04	100.00	0.06	0.00	100.00	7.00	0.00	175.97	264.88	0.00	1.13	2070.30	1988.60	0.00
12:27 PM	-0.04	100.00	0.07	0.00	100.00	7.00	0.00	177.43	238.88	0.00	1.13	2073.20	1990.70	0.00

Single Briquette Layer with Oxy Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
3/24/2011	1109	7.0	2000 g	1850 g	1530 g	4	11:41 AM	12:27 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
11:20 AM	120	167	No Sample
11:50 AM	105	165	With Sample
12:05 PM	115	159	With Sample

	Zone 2 Gas Flow	Zone 2 Oxygen Flow	Zone 2 PID CV	Zone 2 Pressure	Zone 2 Temp A	Zone 2 Temp B	Zone 2 Temp C	one 3 Exhaust Outp	Zone 3 Gas Flow	one 3 Oxygen Flo	Zone 3 PID CV	Zone 3 Pressure	Zone 3 Temp A	Zone 3 Temp B
11:41 AM	343.24	518.23	34.60	0.03	2461.20	2461.80	2498.00	0.00	657.31	973.93	68.42	0.03	2597.60	3276.70
11:42 AM	346.98	512.86	35.27	0.03	2461.80	2461.60	2498.00	0.00	660.08	980.02	69.29	0.03	2596.00	3276.70
11:43 AM	346.72	528.72	35.16	0.03	2464.10	2462.20	2498.00	0.00	668.20	1003.28	70.59	0.03	2593.80	3276.70
11:44 AM	341.31	505.74	34.48	0.03	2467.20	2463.90	2498.00	0.00	666.33	1015.14	69.43	0.02	2597.20	3276.70
11:45 AM	347.66	530.09	35.01	0.03	2467.30	2462.00	2498.00	0.00	661.78	1000.78	69.19	0.02	2598.10	3276.70
11:46 AM	348.28	527.72	35.52	0.03	2467.50	2462.80	2498.00	0.00	658.29	1005.93	68.10	0.02	2600.70	3276.70
11:47 AM	355.88	525.35	37.76	0.03	2463.00	2459.40	2498.00	0.00	657.48	1004.37	68.48	0.02	2599.80	3276.70
11:48 AM	364.93	533.09	39.71	0.03	2460.50	2459.30	2498.00	0.00	656.01	995.16	68.22	0.02	2600.40	3276.70
11:49 AM	365.29	544.96	40.07	0.03	2461.90	2461.10	2498.00	0.00	660.08	997.50	69.24	0.02	2598.20	3276.70
11:50 AM	372.42	552.95	41.20	0.03	2461.30	2458.50	2498.00	0.00	658.13	992.66	68.77	0.02	2599.10	3276.70
11:51 AM	372.00	559.19	42.15	0.03	2462.00	2460.20	2498.00	0.00	662.84	991.73	70.10	0.03	2596.60	3276.70
11:52 AM	370.13	558.19	42.01	0.03	2463.50	2463.20	2498.00	0.00	666.98	988.60	70.86	0.02	2595.80	3276.70
11:53 AM	384.54	574.18	44.58	0.03	2459.40	2459.00	2498.00	0.00	671.94	987.67	72.27	0.03	2593.00	3276.70
11:54 AM	393.59	590.66	46.75	0.03	2456.80	2458.90	2498.00	0.00	675.59	1028.72	73.40	0.03	2591.60	3276.70
11:55 AM	396.14	592.66	46.94	0.03	2459.10	2460.10	2498.00	0.00	676.89	1029.50	73.57	0.03	2592.30	3276.70
11:56 AM	403.57	584.04	49.40	0.03	2455.80	2458.60	2498.00	0.00	682.34	1022.17	74.81	0.03	2590.70	3276.70
11:57 AM	411.79	613.14	50.41	0.03	2456.80	2458.40	2498.00	0.00	684.86	1006.24	74.99	0.03	2590.90	3276.70
11:58 AM	416.73	621.63	52.08	0.03	2455.50	2456.80	2498.00	0.00	681.93	1005.46	74.38	0.03	2594.10	3276.70
11:59 AM	426.77	623.13	54.59	0.03	2452.40	2455.80	2498.00	0.00	686.81	1021.39	75.59	0.03	2592.50	3276.70
12:00 PM	432.34	636.86	55.42	0.03	2454.20	2457.80	2498.00	0.00	681.85	1044.65	74.49	0.03	2596.10	3276.70
12:01 PM	439.41	649.85	56.54	0.03	2454.90	2456.30	2498.00	0.00	682.66	1016.86	74.78	0.02	2595.90	3276.70
12:02 PM	445.45	664.59	58.91	0.03	2452.50	2455.40	2498.00	0.00	688.35	1039.34	76.60	0.02	2593.10	3276.70
12:03 PM	447.73	663.09	58.87	0.03	2454.90	2459.30	2498.00	0.00	689.33	1041.37	76.99	0.02	2592.80	3276.70
12:04 PM	447.99	682.82	59.77	0.03	2457.10	2459.90	2498.00	0.00	696.39	1044.02	78.03	0.03	2591.50	3276.70
12:05 PM	450.18	679.95	60.88	0.03	2457.50	2465.20	2498.00	0.00	694.93	1046.83	77.86	0.03	2593.00	3276.70
12:06 PM	449.92	676.70	59.58	0.03	2463.20	2467.30	2498.00	0.00	695.09	1048.39	78.05	0.03	2593.50	3276.70
12:07 PM	439.67	659.22	57.94	0.03	2466.80	2469.40	2498.00	0.00	701.19	1054.79	78.45	0.03	2593.60	3276.70
12:08 PM	429.74	650.60	55.28	0.03	2470.80	2472.80	2498.00	0.00	701.03	1062.29	67.63	0.02	2594.50	3276.70
12:09 PM	424.17	632.87	53.91	0.03	2469.80	2470.20	2498.00	0.00	654.63	959.10	68.16	0.02	2590.50	3276.70
12:10 PM	422.20	628.00	52.64	0.03	2469.10	2469.50	2498.00	0.00	651.54	974.40	67.19	0.02	2590.50	3276.70
12:11 PM	407.11	613.51	49.40	0.03	2473.50	2472.20	2498.00	0.00	647.32	994.54	65.15	0.02	2592.70	3276.70
12:12 PM	399.10	608.89	46.57	0.03	2473.30	2473.10	2498.00	0.00	641.71	940.52	64.93	0.02	2590.60	3276.70
12:13 PM	386.31	588.79	44.03	0.03	2474.20	2474.30	2498.00	0.00	634.97	947.86	63.20	0.02	2592.30	3276.70
12:14 PM	371.38	563.44	41.60	0.03	2472.70	2473.70	2498.00	0.00	632.13	948.49	62.51	0.02	2591.10	3276.70
12:15 PM	372.42	560.31	41.34	0.03	2469.50	2471.20	2498.00	0.00	630.58	944.27	61.90	0.02	2590.20	3276.70
12:16 PM	372.31	547.33	40.23	0.03	2469.50	2469.90	2498.00	0.00	619.37	939.43	60.01	0.02	2592.10	3276.70
12:17 PM	368.00	549.95	39.89	0.03	2467.30	2466.50	2498.00	0.00	616.77	941.62	59.23	0.02	2591.40	3276.70
12:18 PM	359.88	538.59	38.28	0.03	2468.40	2468.40	2498.00	0.00	611.00	933.34	58.45	0.02	2590.50	3276.70
12:19 PM	353.59	545.83	36.63	0.03	2469.40	2469.10	2498.00	0.00	603.85	898.22	56.86	0.02	2592.00	3276.70
12:20 PM	348.65	533.09	35.59	0.03	2468.70	2467.50	2498.00	0.00	602.55	886.98	57.03	0.02	2588.60	3276.70
12:21 PM	345.42	515.73	34.84	0.03	2467.50	2466.10	2498.00	0.00	597.92	901.65	56.28	0.02	2588.80	3276.70
12:22 PM	343.24	514.49	34.36	0.03	2465.70	2464.80	2498.00	0.00	583.70	883.55	54.03	0.02	2591.10	3276.70
12:23 PM	345.32	515.11	33.61	0.03	2465.10	2460.70	2498.00	0.00	572.33	853.73	52.10	0.02	2593.30	3276.70
12:24 PM	342.20	514.11	34.09	0.03	2461.60	2460.00	2498.00	0.00	563.39	836.25	51.64	0.02	2591.60	3276.70
12:25 PM	341.47	509.74	34.13	0.03	2459.50	2459.90	2498.00	0.00	568.02	837.81	51.40	0.02	2589.70	3276.70
12:26 PM	349.43	516.86	35.32	0.03	2455.20	2457.30	2498.00	0.00	571.76	840.77	52.82	0.02	2584.60	3276.70
12:27 PM	342.98	522.23	34.03	0.03	2457.20	2459.50	2498.00	0.00	572.24	857.48	53.00	0.02	2582.70	3276.70

Single Briquette Layer with Oxy Burners

Date	Sample Number	Run Speed	Hearth Layer (Anthracite, per ca	Briquette P269, per car	Cover Layer hracite, per	Number of Sample Carts	Start Time	Stop Time
3/24/2011	1109	7.0	2000 g	1850 g	1530 g	4	11:41 AM	12:27 PM

Air Flow Measurements			
Time	**Flow (ft/min)**	**Temp (degF)**	**Notes**
11:20 AM	120	167	No Sample
11:50 AM	105	165	With Sample
12:05 PM	115	159	With Sample

	LHF Data	LGA Data																	
		Port 1								Port 2								Port 3	
	Zone 3 Temp C	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor
11:41 AM	2498.00																	9.25	20.47
11:42 AM	2498.00	14.23	20.47	0.06	0.00	12.74	23.01	14.71	0.00	10.87	20.47	0.05	0.00	12.13	18.89	25.08	0.00	9.59	20.47
11:43 AM	2498.00	15.10	20.47	0.06	0.00	13.87	22.96	12.16	0.01										
11:44 AM	2498.00									11.26	20.47	0.06	0.00	12.70	18.95	23.87	0.00	10.00	20.47
11:45 AM	2498.00	15.08	20.47	0.05	0.00	14.26	22.12	12.08	0.10	11.37	20.47	0.06	0.00	12.63	19.10	23.22	0.00		
11:46 AM	2498.00																	10.07	20.47
11:47 AM	2498.00	14.63	20.47	0.06	0.00	14.29	21.88	12.62	0.17	11.37	20.47	0.05	0.00	12.64	19.08	23.58	0.00	10.02	20.47
11:48 AM	2498.00	14.98	20.47	0.05	0.00	14.61	21.07	12.73	0.26										
11:49 AM	2498.00									11.34	20.47	0.06	0.00	12.42	19.07	23.82	0.00	9.94	20.47
11:50 AM	2498.00	15.25	20.47	0.05	0.00	15.21	20.87	11.84	0.30	11.46	20.47	0.06	0.00	12.53	18.92	23.67	0.00		
11:51 AM	2498.00																	10.06	20.47
11:52 AM	2498.00	16.67	20.47	0.06	0.00	16.57	20.39	8.50	0.42	11.69	20.47	0.06	0.00	12.79	18.96	22.97	0.00	10.34	20.47
11:53 AM	2498.00	16.48	20.47	0.05	0.00	16.61	20.03	9.14	0.42										
11:54 AM	2498.00									11.74	20.47	0.06	0.00	13.10	18.83	22.61	0.00	10.52	20.47
11:55 AM	2498.00	17.49	20.47	0.06	0.00	16.81	19.79	7.88	0.36	12.34	20.47	0.05	0.00	13.61	18.77	21.09	0.00		
11:56 AM	2498.00																	10.87	20.47
11:57 AM	2498.00	17.88	20.47	0.05	0.00	16.60	19.89	7.79	0.30	12.73	20.47	0.05	0.00	13.92	18.68	20.22	0.00	11.00	20.47
11:58 AM	2498.00	17.98	20.47	0.06	0.00	16.29	19.89	8.41	0.21										
11:59 AM	2498.00									12.65	20.47	0.05	0.00	13.84	18.48	20.67	0.00	11.04	20.47
12:00 PM	2498.00	17.44	20.47	0.06	0.00	15.57	20.35	9.49	0.13	13.13	20.47	0.06	0.00	14.11	18.39	20.03	0.00		
12:01 PM	2498.00																	11.27	20.47
12:02 PM	2498.00	17.05	20.47	0.06	0.00	14.88	20.75	10.76	0.07	13.45	20.47	0.06	0.00	14.35	18.42	19.36	0.00	11.54	20.47
12:03 PM	2498.00	17.55	20.47	0.06	0.00	14.86	21.20	9.84	0.04										
12:04 PM	2498.00									14.08	20.47	0.06	0.00	14.79	18.40	18.01	0.00	11.96	20.47
12:05 PM	2498.00	17.47	20.47	0.06	0.00	15.14	21.72	8.43	0.02	14.39	20.47	0.06	0.00	14.96	18.56	17.01	0.00		
12:06 PM	2498.00																	12.22	20.47
12:07 PM	2498.00	17.77	20.47	0.05	0.00	15.52	22.12	6.89	0.01	14.46	20.47	0.06	0.00	14.95	18.62	16.97	0.00	12.50	20.47
12:08 PM	2498.00	17.83	20.47	0.06	0.00	15.83	21.77	6.84	0.00										
12:09 PM	2498.00									14.86	20.47	0.05	0.00	14.94	18.63	16.37	0.00	12.60	20.47
12:10 PM	2498.00	16.50	20.47	0.06	0.00	15.01	21.76	9.83	0.00	14.44	20.47	0.05	0.00	14.56	18.36	17.92	0.00		
12:11 PM	2498.00																	12.53	20.47
12:12 PM	2498.00	16.00	20.47	0.06	0.00	14.58	22.04	10.92	0.00	14.43	20.47	0.06	0.00	14.25	18.42	18.28	0.00	12.36	20.47
12:13 PM	2498.00	14.85	20.47	0.06	0.00	13.57	22.28	13.94	0.00										
12:14 PM	2498.00									13.89	20.47	0.06	0.00	13.77	18.58	19.56	0.00	12.00	20.47
12:15 PM	2498.00	14.65	20.47	0.06	0.00	13.37	22.71	13.73	0.00	13.93	20.47	0.06	0.00	13.70	18.82	19.40	0.00		
12:16 PM	2498.00																	11.96	20.47
12:17 PM	2498.00	15.36	20.47	0.06	0.00	13.92	22.93	11.52	0.00	14.12	20.47	0.06	0.00	14.01	19.03	18.49	0.00	12.05	20.47
12:18 PM	2498.00	15.63	20.47	0.06	0.00	14.27	22.70	11.08	0.00										
12:19 PM	2498.00									14.09	20.47	0.05	0.00	13.91	19.34	17.93	0.00	12.02	20.47
12:20 PM	2498.00	15.33	20.47	0.06	0.00	13.98	22.94	11.61	0.00	13.89	20.47	0.06	0.00	13.60	19.56	18.43	0.00		
12:21 PM	2498.00																	11.76	20.47
12:22 PM	2498.00	13.89	20.47	0.06	0.00	13.08	22.98	14.60	0.00										
12:23 PM	2498.00									14.91	20.47	0.05	0.00	14.28	21.66	13.61	0.00	12.73	20.47
12:24 PM	2498.00	13.87	20.47	0.06	0.00	12.63	22.42	15.88	0.00	13.28	20.47	0.06	0.00	12.86	20.26	19.32	0.00		
12:25 PM	2498.00																	11.47	20.47
12:26 PM	2498.00	12.68	20.47	0.06	0.00	11.90	22.31	18.72	0.00	12.84	20.47	0.06	0.00	12.65	19.88	21.03	0.00	11.09	20.47
12:27 PM	2498.00	14.69	20.47	0.06	0.00	13.08	22.49	14.61	0.00										

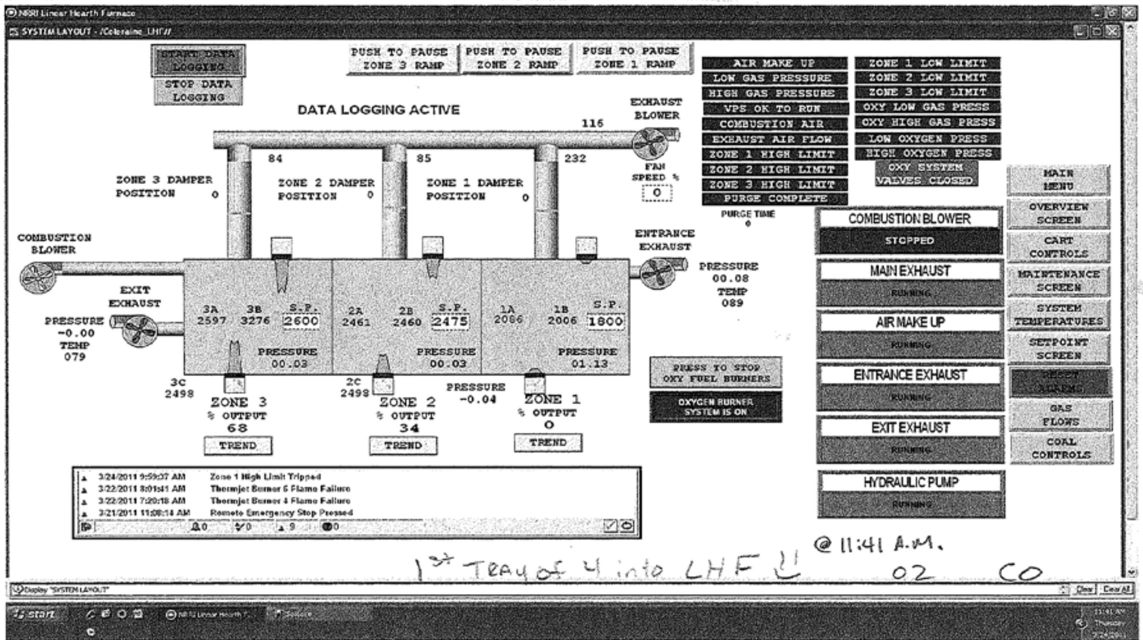
Single Briquette Layer with Oxy Burners

Date	Sample Numl	Run Speed	Hearth Layer (Anthracite, per c	Briquette (P269, per cart)	Cover Layer thracite, per c	Number of Sample Carts	Start Time	Stop Time
3/24/2011	1109	7.0	2000 g	1850 g	1530 g	4	11:41 AM	12:27 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF	Notes
11:20 AM	120	167	No Sample
11:50 AM	105	165	With Sample
12:05 PM	115	159	With Sample

							Port 4								Testo Emission Data					
	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% O2	ppm CO	ppm NO	ppm NO2	ppm SO2	% CO2
11:41 AM	0.05	0.00	11.86	14.25	33.21	0.00	9.89	20.47	0.05	0.00	12.24	15.95	29.87	0.00	0.95	53	5	0	0	14.71
11:42 AM	0.05	0.00	12.21	14.18	32.38	0.00									0.96	81	5	0	0	14.70
11:43 AM							10.17	20.47	0.06	0.00	12.73	15.93	28.98	0.00	0.95	122	6	0	0	14.70
11:44 AM	0.05	0.00	12.84	14.02	31.13	0.00	10.56	20.47	0.05	0.00	13.21	15.88	27.96	0.00	0.95	164	7	0	0	14.70
11:45 AM															0.92	233	8	0	0	14.73
11:46 AM	0.05	0.00	12.75	13.99	31.11	0.00	10.60	20.47	0.05	0.00	12.92	15.97	28.08	0.00	0.90	325	10	0	0	14.74
11:47 AM	0.05	0.00	12.64	14.07	31.57	0.00									0.91	530	14	0	0	14.73
11:48 AM							10.50	20.47	0.05	0.00	12.76	15.93	28.51	0.00	0.91	887	21	0	0	14.73
11:49 AM	0.05	0.00	12.52	14.07	31.40	0.00	10.44	20.47	0.05	0.00	12.81	15.92	28.17	0.00	0.99	1343	34	0	0	14.67
11:50 AM															1.00	1718	47	0	0	14.67
11:51 AM	0.05	0.00	12.55	14.15	31.47	0.00	10.54	20.47	0.05	0.00	13.06	15.95	28.05	0.00	0.97	1995	62	0	0	14.68
11:52 AM	0.05	0.00	12.85	14.16	30.74	0.00									1.01	2013	74	0	0	14.66
11:53 AM							10.80	20.47	0.06	0.00	13.29	15.92	27.51	0.00	0.97	2036	90	0	0	14.69
11:54 AM	0.05	0.00	13.43	14.03	30.07	0.00	11.09	20.47	0.05	0.00	13.66	15.80	26.51	0.00	0.91	2465	116	0	0	14.74
11:55 AM															0.49	2245	117	0	0	15.04
11:56 AM	0.05	0.00	13.50	14.03	29.23	0.00	11.27	20.47	0.06	0.00	13.62	15.90	25.89	0.00	0.28	1598	108	0	0	15.20
11:57 AM	0.05	0.00	13.66	13.96	28.81	0.00									0.30	1169	94	0	0	15.18
11:58 AM							11.37	20.47	0.05	0.00	13.91	15.86	25.77	0.00	0.32	664	76	0	0	15.17
11:59 AM	0.05	0.00	13.76	13.80	28.80	0.00	11.44	20.47	0.05	0.00	14.05	15.70	25.65	0.00	0.32	424	64	0	0	15.17
12:00 PM															0.28	316	55	0	0	15.19
12:01 PM	0.05	0.00	13.97	13.72	28.26	0.00	11.58	20.47	0.06	0.00	14.18	15.68	25.27	0.00	0.31	224	48	0	0	15.17
12:02 PM	0.05	0.00	14.11	13.63	27.94	0.00									0.35	154	42	0	0	15.14
12:03 PM							11.81	20.47	0.05	0.00	14.24	15.74	24.81	0.00	0.35	111	37	0	0	15.14
12:04 PM	0.05	0.00	14.31	13.73	27.14	0.00	12.12	20.47	0.05	0.00	14.55	15.75	24.23	0.00	0.30	98	33	0	0	15.18
12:05 PM															0.33	76	31	0	1	15.16
12:06 PM	0.05	0.00	14.50	13.66	26.37	0.00	12.48	20.47	0.05	0.00	14.77	15.70	23.39	0.00	0.32	70	29	0	1	15.17
12:07 PM	0.05	0.00	14.77	13.55	25.78	0.00									0.33	62	27	0	1	15.16
12:08 PM							12.64	20.47	0.05	0.00	14.99	15.60	22.94	0.00	0.31	73	26	0	1	15.18
12:09 PM	0.05	0.00	14.78	13.46	25.61	0.00	12.72	20.47	0.05	0.00	15.06	15.53	22.81	0.00	0.29	78	25	0	0	15.19
12:10 PM															0.29	80	25	0	0	15.19
12:11 PM	0.05	0.00	14.74	13.49	26.12	0.00	12.65	20.47	0.05	0.00	14.97	15.34	23.22	0.00	0.25	107	12	0	0	15.22
12:12 PM	0.05	0.00	14.26	13.56	26.94	0.00									0.21	132	6	0	0	15.25
12:13 PM							12.45	20.47	0.05	0.00	14.61	15.36	24.16	0.00	0.22	125	6	0	0	15.24
12:14 PM	0.05	0.00	13.97	13.70	27.64	0.00	12.32	20.47	0.05	0.00	14.47	15.36	24.49	0.00	0.19	120	6	0	0	15.26
12:15 PM															0.21	115	6	0	0	15.25
12:16 PM	0.05	0.00	13.71	13.80	27.76	0.00	12.32	20.47	0.05	0.00	14.41	15.41	24.33	0.00	0.20	111	5	0	0	15.26
12:17 PM	0.05	0.00	13.84	13.91	27.44	0.00									0.21	132	6	0	0	15.25
12:18 PM							12.37	20.47	0.05	0.00	14.31	15.60	24.20	0.00	0.22	125	6	0	0	15.24
12:19 PM	0.05	0.00	13.83	14.08	27.59	0.00	12.34	20.47	0.05	0.00	14.15	15.75	24.46	0.00	0.19	120	6	0	0	15.26
12:20 PM															0.21	115	6	0	0	15.25
12:21 PM	0.05	0.00	13.47	14.18	28.26	0.00	11.96	20.47	0.05	0.00	13.72	15.75	25.47	0.00	0.20	111	5	0	0	15.26
12:22 PM															0.18	113	5	0	0	15.27
12:23 PM	0.05	0.00	13.61	16.34	24.01	0.00	12.46	20.47	0.05	0.00	13.54	17.43	23.08	0.00	0.14	116	5	0	0	15.30
12:24 PM															0.14	113	4	0	0	15.30
12:25 PM	0.05	0.00	12.49	15.14	28.72	0.00	11.48	20.47	0.06	0.00	12.68	16.64	26.61	0.00	0.12	112	4	0	0	15.32
12:26 PM	0.05	0.00	12.23	14.91	29.78	0.00									0.13	106	4	0	0	15.30
12:27 PM							11.27	20.47	0.06	0.00	12.52	16.50	27.39	0.00	0.12	98	4	0	0	15.31

Thursday, March 24, 2011 11:41:09 AM

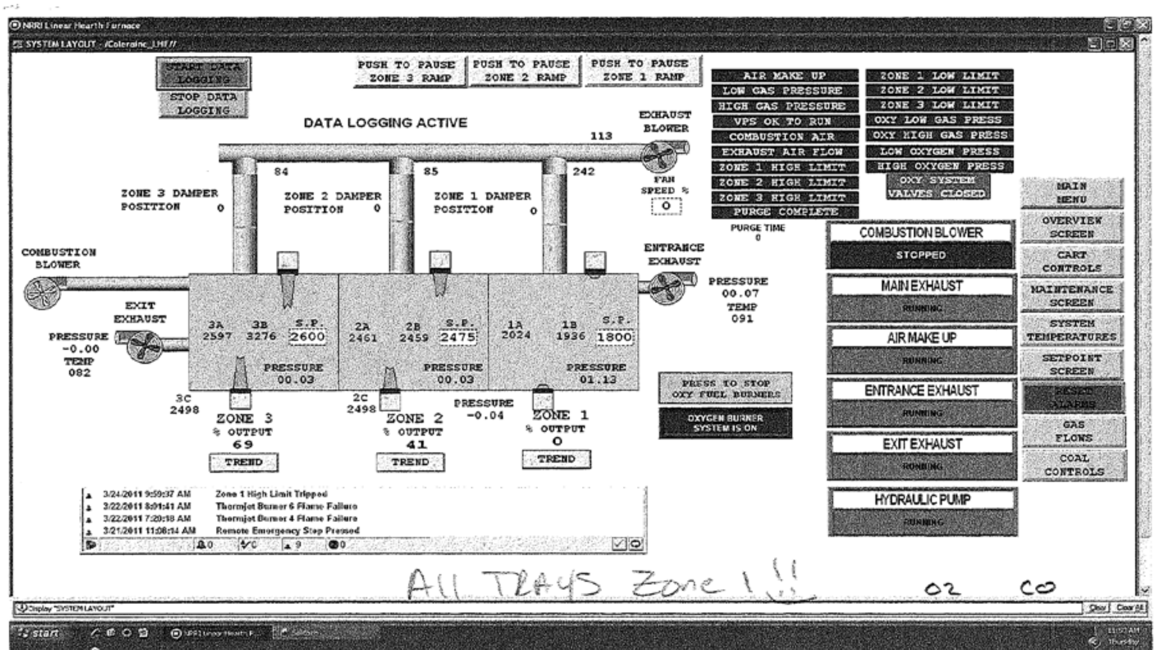


Test # 1-4
CAR SPEED 7
MIX P2A w/Cover
INT. 5.6.

Convey
Prime

0.000 14.2250
10.9682
9.5918
10.1692

Thursday, March 24, 2011 11:50:36 AM

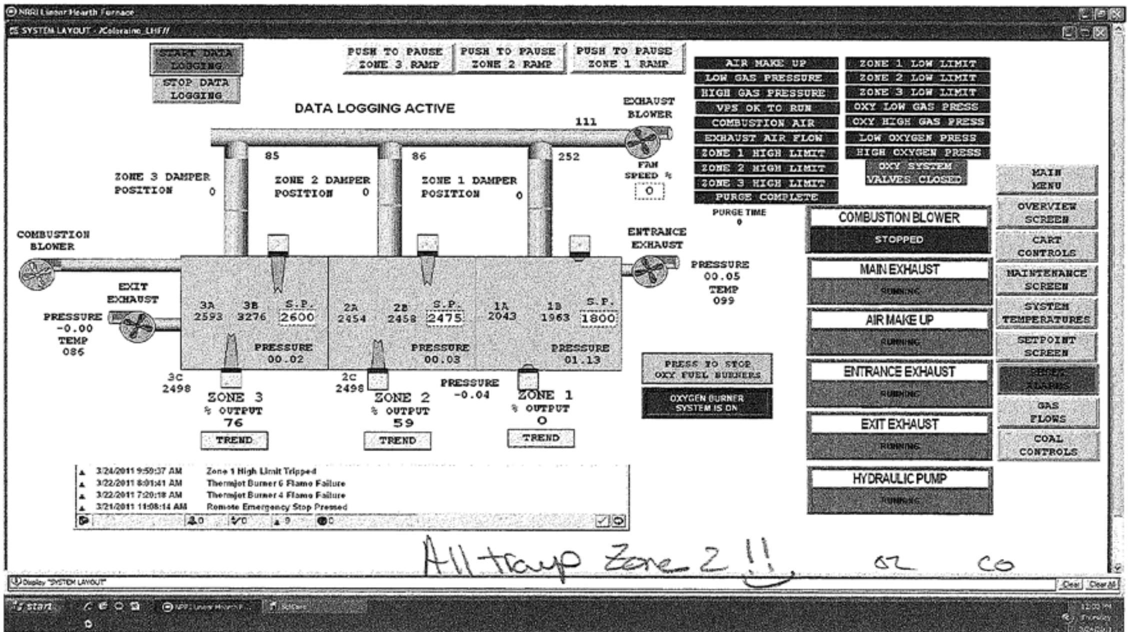


Test # 1-4
CAR SPEED 7
MIX B7LA w/ Cover
INT. 5.6.

Convey
Prime

0.000 16.6727
11.6883
10.3430
10.8018

Thursday, March 24, 2011 **12:03:56 PM**

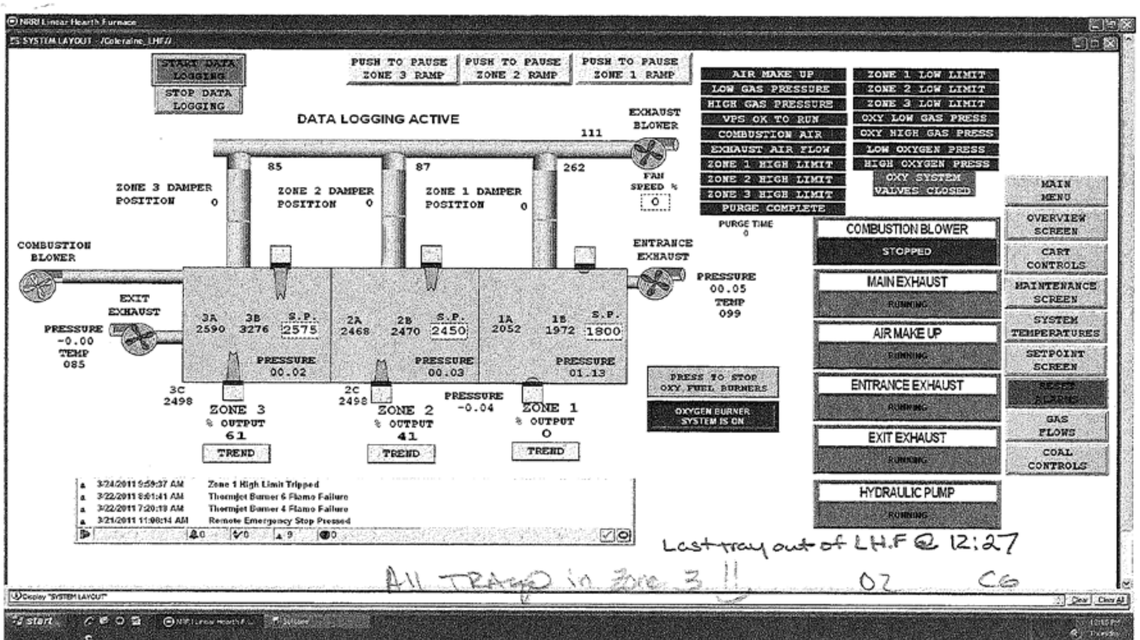


Test # 1-4
CAR SPEED 7
MIX P269 - w/cover
INT. SG.

~~Convey~~
~~Prime~~

0.000 17.4717
14.3889
12.2233
12.1249

Thursday, March 24, 2011 **12:15:10 PM**



Test # 1-4
CAR SPEED 7
MIX P269 w/cover
INT. SG.

~~Convey~~
~~Prime~~

Total Time 38:01

0.000 14.6536
13.9289
11.9586
12.3155

Single Briquette Layer withMedium Volatile Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
4/12/2011	1114	6.0	193 g/min	2000 g	1850 g	1530 g	4	11:37 AM	12:30 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
11:05 AM	120	163.1	No Sample
12:05 PM	150	156	With Sample

	LHF Data										
	Cart Pressure	Entrance Exhaust Output	Entrance Pressure	Exhaust Pressure	Exit Exhaust Output	OI Inches per Minute	Zone 1 Exhaust Output	Zone 1 Gas Flow	Zone 1 Oxygen Flow	Zone 1 PID CV	Zone 1 Pressure
11:37 AM	-0.03	100.00	0.03	0.00	100.00	6.00	0.00	178.26	283.13	0.00	1.13
11:38 AM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	179.56	293.88	0.00	1.13
11:39 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	178.52	269.13	0.00	1.13
11:40 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	179.98	273.00	0.00	1.13
11:41 AM	-0.03	100.00	0.07	0.00	100.00	6.00	0.00	182.64	258.38	0.00	1.13
11:42 AM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	177.95	259.63	0.00	1.13
11:43 AM	-0.03	100.00	0.09	0.00	100.00	6.00	0.00	175.45	283.25	0.00	1.13
11:44 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	178.31	287.88	0.00	1.13
11:45 AM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	179.98	280.50	0.00	1.13
11:46 AM	-0.03	100.00	0.08	0.00	100.00	6.00	0.00	180.03	253.13	0.00	1.13
11:47 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	176.91	281.25	0.00	1.13
11:48 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	178.11	253.38	0.00	1.13
11:49 AM	-0.03	100.00	0.07	0.00	100.00	6.00	0.00	179.10	274.75	0.00	1.13
11:50 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	180.14	281.50	0.00	1.13
11:51 AM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	179.41	277.25	0.00	1.13
11:52 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	178.26	259.63	0.00	1.13
11:53 AM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	178.31	261.00	0.00	1.13
11:54 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	176.91	237.38	0.00	1.13
11:55 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	177.85	251.38	0.00	1.13
11:56 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	176.86	256.88	0.00	1.13
11:57 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	177.59	253.00	0.00	1.13
11:58 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	177.90	263.88	0.00	1.13
11:59 AM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	174.41	250.88	0.00	1.13
12:00 PM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	176.44	236.88	0.00	1.13
12:01 PM	-0.03	100.00	0.07	0.00	100.00	6.00	0.00	176.80	240.25	0.00	1.13
12:02 PM	-0.03	100.00	0.08	0.00	100.00	6.00	0.00	175.45	259.75	0.00	1.13
12:03 PM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	173.06	276.00	0.00	1.13
12:04 PM	-0.03	100.00	0.08	0.00	100.00	6.00	0.00	176.49	292.63	0.00	1.13
12:05 PM	-0.03	100.00	0.10	0.00	100.00	6.00	0.00	177.12	248.25	0.00	1.13
12:06 PM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	176.23	258.25	0.00	1.13
12:07 PM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	177.59	259.88	0.00	1.13
12:08 PM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	177.48	264.25	0.00	1.13
12:09 PM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	177.64	273.38	0.00	1.13
12:10 PM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	178.00	244.38	0.00	1.13
12:11 PM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	178.21	244.25	0.00	1.13
12:12 PM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	179.51	239.13	0.00	1.13
12:13 PM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	178.99	289.38	0.00	1.13
12:14 PM	-0.03	100.00	0.07	0.00	100.00	6.00	0.00	176.39	289.50	0.00	1.13
12:15 PM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	180.87	287.63	0.00	1.13
12:16 PM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	178.99	281.75	0.00	1.13
12:17 PM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	179.77	273.88	0.00	1.13
12:18 PM	-0.03	100.00	0.03	0.00	100.00	6.00	0.00	177.79	279.50	0.00	1.13
12:19 PM	-0.03	100.00	0.02	0.00	100.00	6.00	0.00	177.38	253.50	0.00	1.13
12:20 PM	-0.03	100.00	0.03	0.00	100.00	6.00	0.00	179.30	262.13	0.00	1.13
12:21 PM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	178.68	256.75	0.00	1.13
12:22 PM	-0.03	100.00	0.02	0.00	100.00	6.00	0.00	176.75	273.75	0.00	1.13
12:23 PM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	178.89	278.63	0.00	1.13
12:24 PM	-0.03	100.00	0.07	0.00	100.00	6.00	0.00	181.18	242.75	0.00	1.13
12:25 PM	-0.03	100.00	0.05	0.00	100.00	6.00	0.00	181.65	240.75	0.00	1.13
12:26 PM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	180.14	251.63	0.00	1.13
12:27 PM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	179.77	256.38	0.00	1.13
12:28 PM	-0.03	100.00	0.03	0.00	100.00	6.00	0.00	180.14	289.25	0.00	1.13
12:29 PM	-0.03	100.00	0.03	0.00	100.00	6.00	0.00	179.62	251.25	0.00	1.13
12:30 PM											

Single Briquette Layer withMedium Volatile Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer (Anthracite, per cart	Briquette (P269, per cart)	Cover Layer Anthracite, per car	Number of Sample Carts	Start Time	Stop Time
4/12/2011	1114	6.0	193 g/min	2000 g	1850 g	1530 g	4	11:37 AM	12:30 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
11:05 AM	120	163.1	No Sample
12:05 PM	150	156	With Sample

	LHF Data													
	Zone 1 Temp A	Zone 1 Temp B	Zone 2 Exhaust Output	Zone 2 Gas Flow	Zone 2 Oxygen Flow	Zone 2 PID CV	Zone 2 Pressure	Zone 2 Temp A	Zone 2 Temp B	Zone 2 Temp C	Zone 3 Exhaust Output	Zone 3 Gas Flow	Zone 3 Oxygen Flow	Zone 3 PID CV
11:37 AM	2062.20	1991.20	0.00	476.29	698.05	59.46	0.03	2452.80	2463.00	2498.00	0.00	252.61	375.27	10.00
11:38 AM	2055.50	1980.40	0.00	472.86	704.17	59.76	0.03	2455.50	2464.30	2498.00	0.00	252.93	394.94	10.00
11:39 AM	2053.80	1973.00	0.00	468.12	701.55	58.93	0.03	2460.40	2466.50	2498.00	0.00	253.50	401.03	10.00
11:40 AM	2052.10	1972.60	0.00	468.49	703.05	58.64	0.03	2463.20	2470.20	2498.00	0.00	252.77	416.02	10.00
11:41 AM	2043.60	1958.70	0.00	476.08	702.42	59.58	0.03	2462.90	2470.20	2498.00	0.00	251.88	395.72	10.00
11:42 AM	2041.60	1956.40	0.00	474.78	716.16	59.98	0.03	2463.90	2471.80	2498.00	0.00	252.85	345.77	10.00
11:43 AM	2043.30	1957.40	0.00	473.17	707.79	59.71	0.03	2466.20	2473.90	2498.00	0.00	250.82	342.80	10.00
11:44 AM	2032.70	1946.00	0.00	483.94	740.01	61.24	0.03	2464.20	2472.30	2498.00	0.00	251.47	346.86	10.00
11:45 AM	2026.60	1940.80	0.00	477.80	711.66	61.32	0.03	2465.60	2474.40	2498.00	0.00	253.26	353.42	10.00
11:46 AM	2026.20	1942.40	0.00	475.77	707.29	60.31	0.03	2469.30	2478.80	2498.00	0.00	252.44	396.50	10.00
11:47 AM	2016.20	1935.70	0.00	474.21	709.92	58.94	0.03	2473.40	2479.40	2498.00	0.00	253.58	389.32	10.00
11:48 AM	2008.90	1929.40	0.00	466.25	710.16	57.68	0.03	2476.70	2481.40	2498.00	0.00	252.69	335.00	10.00
11:49 AM	2006.20	1924.60	0.00	456.42	692.56	55.71	0.03	2481.00	2486.90	2498.00	0.00	253.58	352.79	10.00
11:50 AM	2000.10	1918.30	0.00	456.11	691.93	56.31	0.03	2477.70	2483.40	2498.00	0.00	254.15	382.92	10.00
11:51 AM	1997.00	1914.60	0.00	460.37	692.18	56.62	0.03	2475.40	2481.20	2498.00	0.00	252.93	346.39	10.00
11:52 AM	1997.00	1917.20	0.00	460.89	689.06	56.58	0.03	2473.20	2479.10	2498.00	0.00	253.34	384.01	10.00
11:53 AM	1998.70	1918.60	0.00	469.37	688.81	58.30	0.03	2466.90	2474.40	2498.00	0.00	251.96	419.92	10.00
11:54 AM	1998.90	1918.70	0.00	472.86	716.16	59.95	0.03	2462.40	2470.40	2498.00	0.00	252.77	392.76	10.00
11:55 AM	2001.70	1923.80	0.00	480.66	722.65	61.33	0.03	2458.20	2470.20	2498.00	0.00	251.14	360.13	10.00
11:56 AM	2006.10	1926.60	0.00	486.59	728.65	62.71	0.03	2454.10	2466.80	2498.00	0.00	251.55	339.06	10.00
11:57 AM	2006.60	1927.10	0.00	491.32	727.52	63.53	0.03	2452.80	2463.20	2498.00	0.00	251.39	342.80	10.00
11:58 AM	2011.60	1933.20	0.00	496.84	757.37	64.01	0.03	2451.60	2463.90	2498.00	0.00	250.58	345.93	10.00
11:59 AM	2016.70	1939.30	0.00	500.84	737.26	67.75	0.03	2446.20	2462.20	2498.00	0.00	249.19	361.22	10.00
12:00 PM	2018.00	1939.90	0.00	584.27	850.52	83.89	0.03	2448.00	2460.10	2498.00	0.00	250.49	414.92	10.00
12:01 PM	2021.20	1942.40	0.00	583.80	886.36	83.45	0.03	2457.00	2469.00	2498.00	0.00	249.52	400.41	10.00
12:02 PM	2026.50	1947.30	0.00	572.15	844.53	82.62	0.03	2463.30	2475.10	2498.00	0.00	250.82	345.61	10.00
12:03 PM	2021.20	1942.60	0.00	583.13	860.26	84.28	0.03	2463.80	2477.40	2498.00	0.00	249.93	342.65	10.00
12:04 PM	2024.90	1946.80	0.00	578.86	863.39	82.34	0.03	2471.30	2483.10	2498.00	0.00	249.36	335.47	10.00
12:05 PM	2027.60	1950.30	0.00	566.90	859.39	81.48	0.03	2474.90	2487.50	2498.00	0.00	249.76	344.21	10.00
12:06 PM	2025.80	1947.30	0.00	563.98	835.29	80.43	0.03	2478.90	2487.90	2498.00	0.00	250.25	415.39	10.00
12:07 PM	2028.60	1949.90	0.00	557.22	837.66	78.91	0.03	2482.30	2491.30	2498.00	0.00	250.25	414.46	10.00
12:08 PM	2033.90	1958.60	0.00	479.98	708.42	61.38	0.03	2481.70	2491.10	2498.00	0.00	253.18	420.23	10.00
12:09 PM	2039.70	1961.60	0.00	486.74	737.14	62.43	0.03	2474.40	2485.90	2498.00	0.00	252.12	413.05	10.00
12:10 PM	2041.70	1963.10	0.00	479.83	722.15	60.84	0.03	2474.10	2483.70	2498.00	0.00	252.69	348.42	10.00
12:11 PM	2045.10	1969.80	0.00	472.23	703.17	58.05	0.03	2477.00	2484.40	2498.00	0.00	252.61	355.45	10.00
12:12 PM	2052.10	1971.60	0.00	474.11	697.93	59.48	0.03	2469.50	2483.10	2498.00	0.00	253.01	405.87	10.00
12:13 PM	2054.50	1973.90	0.00	465.26	710.04	57.89	0.03	2470.00	2481.90	2498.00	0.00	252.69	337.50	10.00
12:14 PM	2057.80	1978.80	0.00	452.16	676.82	54.37	0.03	2475.10	2483.50	2498.00	0.00	253.01	342.80	10.00
12:15 PM	2056.60	1979.30	0.00	449.55	671.58	54.42	0.03	2471.10	2481.50	2498.00	0.00	252.53	387.92	10.00
12:16 PM	2050.20	1974.30	0.00	440.92	668.08	52.69	0.03	2472.00	2482.60	2498.00	0.00	251.79	414.77	10.00
12:17 PM	2049.00	1971.00	0.00	434.21	654.72	50.46	0.03	2474.00	2481.70	2498.00	0.00	253.83	402.59	10.00
12:18 PM	2049.40	1974.30	0.00	426.82	623.63	50.06	0.03	2471.00	2482.60	2498.00	0.00	251.79	337.50	10.00
12:19 PM	2045.80	1973.00	0.00	419.39	633.12	48.34	0.03	2471.90	2480.20	2498.00	0.00	251.71	379.64	10.00
12:20 PM	2044.20	1972.70	0.00	417.98	631.49	47.23	0.03	2471.20	2480.50	2498.00	0.00	252.61	417.73	10.00
12:21 PM	2045.50	1978.20	0.00	407.48	608.52	45.52	0.03	2471.70	2480.60	2498.00	0.00	253.01	393.85	10.00
12:22 PM	2043.60	1970.80	0.00	406.85	611.64	45.32	0.03	2468.80	2476.20	2498.00	0.00	253.26	327.97	10.00
12:23 PM	2046.10	1971.70	0.00	402.69	615.51	44.61	0.03	2467.50	2476.70	2498.00	0.00	254.48	338.43	10.00
12:24 PM	2052.00	1976.60	0.00	398.27	586.54	43.09	0.03	2468.20	2476.40	2498.00	0.00	254.64	425.23	10.00
12:25 PM	2055.00	1974.60	0.00	404.35	609.14	44.03	0.03	2463.30	2469.30	2498.00	0.00	254.88	411.96	10.00
12:26 PM	2061.80	1979.40	0.00	397.91	599.78	43.00	0.03	2463.50	2468.60	2498.00	0.00	253.91	405.87	10.00
12:27 PM	2066.40	1988.10	0.00	391.09	594.16	41.02	0.03	2466.00	2469.30	2498.00	0.00	254.96	394.79	10.00
12:28 PM	2066.30	1987.20	0.00	399.99	605.02	42.10	0.03	2461.30	2465.60	2498.00	0.00	253.99	395.41	10.00
12:29 PM	2063.70	1985.40	0.00	398.01	603.40	42.25	0.03	2459.30	2467.00	2498.00	0.00	253.26	406.49	10.00
12:30 PM														

Single Briquette Layer withMedium Volatile Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer Anthracite, per car	Briquette (P269, per cart)	Cover Layer Anthracite, per car	Number of Sample Carts	Start Time	Stop Time
4/12/2011	1114	6.0	193 g/min	2000 g	1850 g	1530 g	4	11:37 AM	12:30 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
11:05 AM	120	163.1	No Sample
12:05 PM	150	156	With Sample

	LHF Data				LGA Data											
					Port 1								Port 2			
	Zone 3 Pressure	Zone 3 Temp A	Zone 3 Temp B	Zone 3 Temp C	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen
11:37 AM	0.03	2574.90	3276.70	2498.00	16.41	20.60	0.07	0.00	12.64	23.45	11.81	0.00	11.21	20.60	0.07	0.00
11:38 AM	0.03	2574.30	3276.70	2498.00												
11:39 AM	0.03	2575.00	3276.70	2498.00	17.04	20.60	0.07	0.00	13.27	22.81	10.92	0.00	11.18	20.60	0.07	0.00
11:40 AM	0.03	2575.80	3276.70	2498.00	17.54	20.60	0.07	0.00	13.99	22.45	9.52	0.07				
11:41 AM	0.03	2576.00	3276.70	2498.00									11.40	20.60	0.07	0.00
11:42 AM	0.03	2578.90	3276.70	2498.00	17.48	20.60	0.07	0.00	14.14	21.75	10.22	0.15	11.23	20.60	0.07	0.00
11:43 AM	0.03	2580.40	3276.70	2498.00												
11:44 AM	0.03	2578.00	3276.70	2498.00	16.69	20.60	0.07	0.00	13.63	21.33	12.42	0.16	11.06	20.60	0.07	0.00
11:45 AM	0.03	2578.50	3276.70	2498.00	16.61	20.60	0.07	0.00	13.98	20.98	12.00	0.27				
11:46 AM	0.03	2580.60	3276.70	2498.00									11.16	20.60	0.07	0.00
11:47 AM	0.03	2581.30	3276.70	2498.00	17.10	20.60	0.07	0.00	14.37	20.79	11.19	0.29	11.14	20.60	0.07	0.00
11:48 AM	0.03	2581.00	3276.70	2498.00												
11:49 AM	0.03	2579.70	3276.70	2498.00	16.26	20.60	0.07	0.00	13.95	20.69	12.90	0.31	11.26	20.60	0.07	0.00
11:50 AM	0.03	2580.10	3276.70	2498.00	16.93	20.60	0.07	0.00	14.12	20.86	12.06	0.28				
11:51 AM	0.03	2578.80	3276.70	2498.00									11.32	20.60	0.07	0.00
11:52 AM	0.03	2578.60	3276.70	2498.00	17.40	20.60	0.07	0.00	14.34	20.46	11.41	0.33	11.42	20.60	0.07	0.00
11:53 AM	0.03	2577.20	3276.70	2498.00												
11:54 AM	0.03	2575.90	3276.70	2498.00	18.15	20.60	0.07	0.00	14.72	20.08	10.60	0.28	11.25	20.60	0.07	0.00
11:55 AM	0.03	2577.30	3276.70	2498.00	17.96	20.60	0.07	0.00	14.38	19.60	11.95	0.23				
11:56 AM	0.03	2580.30	3276.70	2498.00									11.27	20.60	0.07	0.00
11:57 AM	0.03	2579.50	3276.70	2498.00	18.12	20.60	0.07	0.00	14.46	19.86	11.30	0.18	11.25	20.60	0.07	0.00
11:58 AM	0.03	2581.10	3276.70	2498.00												
11:59 AM	0.03	2583.20	3276.70	2498.00	18.36	20.60	0.07	0.00	14.30	19.86	11.48	0.13	11.31	20.60	0.07	0.00
12:00 PM	0.03	2582.40	3276.70	2498.00	18.16	20.60	0.07	0.00	14.17	20.24	11.24	0.08				
12:01 PM	0.03	2583.40	3276.70	2498.00									11.27	20.60	0.07	0.00
12:02 PM	0.03	2585.80	3276.70	2498.00	18.62	20.60	0.07	0.00	14.50	20.53	10.09	0.04	11.72	20.60	0.07	0.00
12:03 PM	0.03	2583.90	3276.70	2498.00												
12:04 PM	0.03	2586.40	3276.70	2498.00	19.01	20.60	0.07	0.00	14.94	20.89	8.15	0.02	11.97	20.60	0.07	0.00
12:05 PM	0.03	2586.30	3276.70	2498.00	19.08	20.60	0.07	0.00	15.23	20.97	7.56	0.01				
12:06 PM	0.03	2588.80	3276.70	2498.00									12.16	20.60	0.07	0.00
12:07 PM	0.03	2589.60	3276.70	2498.00	19.27	20.60	0.07	0.00	15.63	21.44	6.00	0.01	12.30	20.60	0.07	0.00
12:08 PM	0.03	2588.00	3276.70	2498.00												
12:09 PM	0.03	2588.60	3276.70	2498.00	18.99	20.60	0.07	0.00	15.15	20.87	7.71	0.00	12.22	20.60	0.07	0.00
12:10 PM	0.03	2591.00	3276.70	2498.00	17.54	20.60	0.07	0.00	13.96	21.03	11.23	0.00				
12:11 PM	0.03	2593.10	3276.70	2498.00									11.86	20.60	0.07	0.00
12:12 PM	0.03	2593.40	3276.70	2498.00	17.49	20.60	0.07	0.00	13.65	21.57	11.17	0.00	11.77	20.60	0.07	0.00
12:13 PM	0.03	2594.20	3276.70	2498.00												
12:14 PM	0.03	2595.80	3276.70	2498.00	16.09	20.60	0.07	0.00	12.42	21.29	14.87	0.00	11.31	20.60	0.07	0.00
12:15 PM	0.03	2593.80	3276.70	2498.00	15.97	20.60	0.07	0.00	12.13	21.57	15.30	0.00				
12:16 PM	0.03	2593.10	3276.70	2498.00									11.30	20.60	0.07	0.00
12:17 PM	0.03	2592.50	3276.70	2498.00	16.35	20.60	0.07	0.00	12.64	22.31	13.26	0.00	11.34	20.60	0.07	0.00
12:18 PM	0.03	2590.60	3276.70	2498.00												
12:19 PM	0.03	2588.20	3276.70	2498.00	16.91	20.60	0.07	0.00	12.86	22.18	12.25	0.00	11.49	20.60	0.07	0.00
12:20 PM	0.03	2589.20	3276.70	2498.00												
12:21 PM	0.03	2591.40	3276.70	2498.00	16.64	20.60	0.07	0.00	13.14	22.73	11.62	0.00	12.54	20.60	0.07	0.00
12:22 PM	0.03	2594.70	3276.70	2498.00	16.50	20.60	0.07	0.00	12.82	22.74	12.04	0.00				
12:23 PM	0.03	2593.10	3276.70	2498.00									11.29	20.60	0.07	0.00
12:24 PM	0.03	2595.40	3276.70	2498.00	15.98	20.60	0.07	0.00	12.42	22.67	13.59	0.00	11.03	20.60	0.07	0.00
12:25 PM	0.03	2597.60	3276.70	2498.00												
12:26 PM	0.03	2599.10	3276.70	2498.00	15.98	20.60	0.07	0.00	12.33	22.56	13.54	0.00	10.80	20.60	0.07	0.00
12:27 PM	0.02	2601.00	3276.70	2498.00	15.92	20.60	0.07	0.00	11.89	21.74	15.55	0.00				
12:28 PM	0.03	2600.00	3276.70	2498.00									10.65	20.60	0.07	0.00
12:29 PM	0.03	2596.60	3276.70	2498.00	15.12	20.60	0.07	0.00	11.29	21.47	17.74	0.00	10.31	20.60	0.07	0.00
12:30 PM																

Single Briquette Layer withMedium Volatile Coal in Coal Feeder

Date	Sample Numbe	Run Speed	Coal Feeder Throughput	Hearth Layer (Anthracite, per cart	Briquette (P269, per cart)	Cover Layer Anthracite, per car	Number of Sample Carts	Start Time	Stop Time
4/12/2011	1114	6.0	193 g/min	2000 g	1850 g	1530 g	4	11:37 AM	12:30 PM

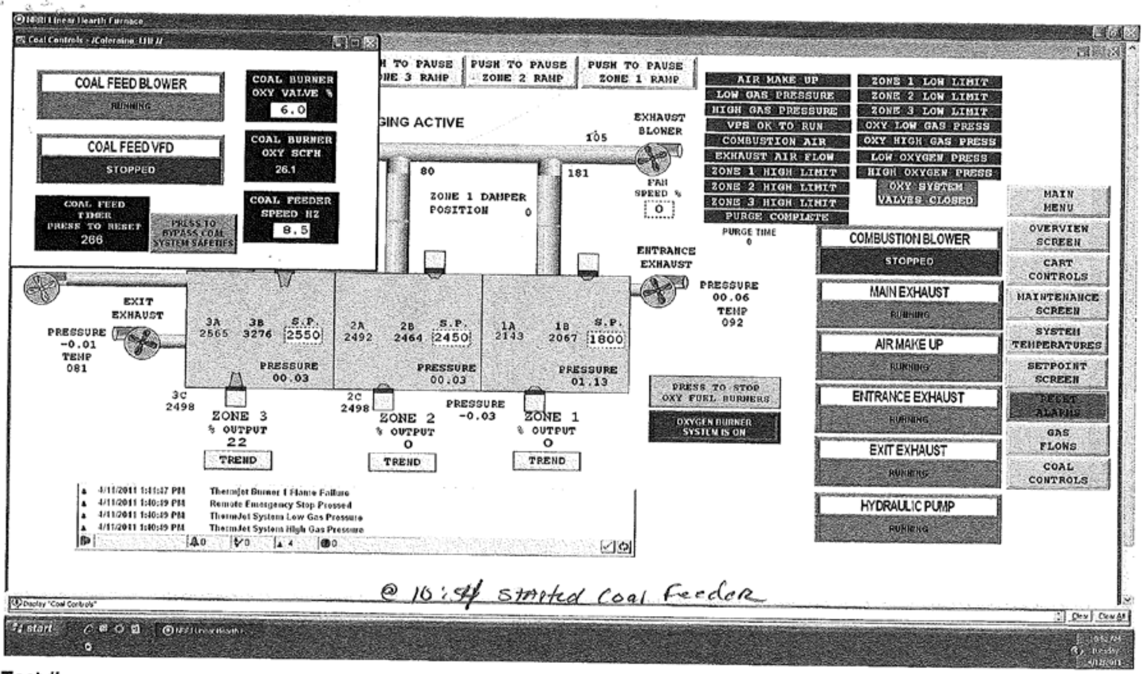
Air Flow Measurements			
Time	**Flow (ft/min)**	**Temp (degF)**	**Notes**
11:05 AM	120	163.1	No Sample
12:05 PM	150	156	With Sample

	Port 2				Port 3								Port 4				
	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen
11:37 AM	9.38	22.26	25.05	0.00													
11:38 AM					8.50	20.60	0.07	0.00	7.17	16.63	38.33	0.00	6.98	20.60	0.07	0.00	6.82
11:39 AM	9.50	22.04	24.99	0.00	8.61	20.60	0.07	0.00	7.30	16.56	38.06	0.00					
11:40 AM													7.18	20.60	0.07	0.00	7.08
11:41 AM	9.72	22.19	24.23	0.00	8.72	20.60	0.07	0.00	7.40	16.50	37.97	0.00	7.25	20.60	0.07	0.00	7.13
11:42 AM	9.67	21.89	24.85	0.00													
11:43 AM					8.69	20.60	0.07	0.00	7.37	16.26	38.21	0.00	7.21	20.60	0.07	0.00	7.19
11:44 AM	9.53	21.74	25.48	0.00	8.60	20.60	0.07	0.00	7.39	16.26	38.34	0.00					
11:45 AM													7.17	20.60	0.07	0.00	7.15
11:46 AM	9.59	21.73	25.06	0.00	8.65	20.60	0.07	0.00	7.41	16.20	38.22	0.00	7.15	20.60	0.07	0.00	7.19
11:47 AM	9.61	21.81	25.27	0.00													
11:48 AM					8.64	20.60	0.07	0.00	7.48	16.20	38.39	0.00	7.17	20.60	0.07	0.00	7.18
11:49 AM	9.66	21.78	24.79	0.00	8.68	20.60	0.07	0.00	7.41	16.19	38.35	0.00					
11:50 AM					8.64	20.60	0.07	0.00	7.45	16.18	38.20	0.00	7.20	20.60	0.07	0.00	7.17
11:51 AM	9.73	21.95	24.56	0.00									7.24	20.60	0.07	0.00	7.25
11:52 AM	9.76	22.07	24.12	0.00													
11:53 AM					8.76	20.60	0.07	0.00	7.51	16.23	37.87	0.00	7.31	20.60	0.07	0.00	7.32
11:54 AM	9.73	21.75	24.59	0.00	8.79	20.60	0.07	0.00	7.53	16.08	37.90	0.00					
11:55 AM													7.35	20.60	0.07	0.00	7.34
11:56 AM	9.67	21.70	24.64	0.00	8.80	20.60	0.07	0.00	7.59	16.12	38.00	0.00	7.29	20.60	0.07	0.00	7.29
11:57 AM	9.68	21.63	24.96	0.00													
11:58 AM					8.84	20.60	0.07	0.00	7.58	16.09	37.89	0.00	7.39	20.60	0.07	0.00	7.31
11:59 AM	9.64	21.53	24.98	0.00	8.85	20.60	0.07	0.00	7.59	15.96	38.03	0.00					
12:00 PM													7.34	20.60	0.07	0.00	7.41
12:01 PM	9.60	21.39	25.36	0.00	8.86	20.60	0.07	0.00	7.57	15.97	37.87	0.00	7.41	20.60	0.07	0.00	7.38
12:02 PM	9.84	21.55	24.20	0.00													
12:03 PM					9.00	20.60	0.07	0.00	7.75	16.02	37.55	0.00	7.55	20.60	0.07	0.00	7.62
12:04 PM	10.08	21.49	23.61	0.00	9.16	20.60	0.07	0.00	7.94	15.96	37.15	0.00					
12:05 PM													7.68	20.60	0.07	0.00	7.71
12:06 PM	10.25	21.47	23.19	0.00	9.29	20.60	0.07	0.00	8.08	15.88	36.84	0.00	7.87	20.60	0.07	0.00	7.96
12:07 PM	10.40	21.40	22.85	0.00													
12:08 PM					9.42	20.60	0.07	0.00	8.19	15.81	36.78	0.00	7.89	20.60	0.07	0.00	8.02
12:09 PM	10.45	21.29	23.23	0.00	9.34	20.60	0.07	0.00	8.23	15.67	36.77	0.00					
12:10 PM													7.83	20.60	0.07	0.00	8.02
12:11 PM	10.26	20.94	24.18	0.00	9.31	20.60	0.07	0.00	8.06	15.65	37.07	0.00	7.81	20.60	0.07	0.00	7.85
12:12 PM	10.16	21.04	24.40	0.00													
12:13 PM					9.20	20.60	0.07	0.00	8.08	15.64	37.50	0.00	7.60	20.60	0.07	0.00	7.79
12:14 PM	9.86	20.79	25.63	0.00	9.08	20.60	0.07	0.00	7.85	15.66	37.72	0.00					
12:15 PM													7.49	20.60	0.07	0.00	7.62
12:16 PM	9.74	21.06	25.46	0.00	9.01	20.60	0.07	0.00	7.82	15.65	37.87	0.00	7.44	20.60	0.07	0.00	7.55
12:17 PM	9.80	21.29	24.99	0.00													
12:18 PM					8.95	20.60	0.07	0.00	7.72	15.71	37.90	0.00	7.49	20.60	0.07	0.00	7.47
12:19 PM	10.00	21.55	24.40	0.00	8.98	20.60	0.07	0.00	7.69	15.83	37.72	0.00					
12:20 PM													7.53	20.60	0.07	0.00	7.54
12:21 PM	10.71	23.24	19.76	0.00	10.14	20.60	0.07	0.00	8.30	17.95	33.19	0.00					
12:22 PM													8.25	20.60	0.07	0.00	7.89
12:23 PM	9.88	21.82	24.36	0.00	9.13	20.60	0.07	0.00	7.71	16.48	36.83	0.00	7.51	20.60	0.07	0.00	7.51
12:24 PM	9.73	21.52	25.06	0.00													
12:25 PM					8.97	20.60	0.07	0.00	7.67	16.21	37.50	0.00	7.36	20.60	0.07	0.00	7.42
12:26 PM	9.49	21.35	26.07	0.00	8.75	20.60	0.07	0.00	7.47	16.02	38.33	0.00					
12:27 PM													7.14	20.60	0.07	0.00	7.12
12:28 PM	9.14	21.25	26.79	0.00	8.59	20.60	0.07	0.00	7.21	15.92	38.71	0.00	7.00	20.60	0.07	0.00	6.93
12:29 PM	8.93	20.98	27.79	0.00													
12:30 PM					8.41	20.60	0.07	0.00	7.07	15.93	39.26	0.00	6.89	20.60	0.07	0.00	6.77

Single Briquette Layer withMedium Volatile Coal in Coal Feeder

	Port 4			Testo Emission Data				
	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% O2	ppm CO	ppm NOx	ppm SO2	% CO2
11:37 AM				-0.57	123147	169	0	20.84
11:38 AM	16.50	40.77	0.00	-0.56	105258	165	0	21.08
11:39 AM				-0.56	91598	162	0	20.91
11:40 AM	16.54	40.16	0.00	-0.56	89507	158	0	20.68
11:41 AM	16.49	39.90	0.00	-0.56	90105	157	0	20.67
11:42 AM				-0.56	91663	155	0	20.50
11:43 AM	16.32	40.28	0.00	-0.55	103967	153	0	19.96
11:44 AM				-0.55	108299	153	0	19.68
11:45 AM	16.25	40.41	0.00	-0.54	111862	152	0	19.48
11:46 AM	16.22	40.29	0.00	-0.53	117302	152	0	19.11
11:47 AM				-0.52	119467	153	0	19.06
11:48 AM	16.24	40.35	0.00	-0.51	125428	153	0	19.03
11:49 AM				-0.51	107758	153	0	18.82
11:50 AM	16.30	40.23	0.00	-0.50	107232	153	0	18.91
11:51 AM	16.28	40.17	0.00	-0.49	89068	153	0	19.32
11:52 AM				-0.48	91724	151	0	19.18
11:53 AM	16.31	39.83	0.00	-0.48	121041	150	0	19.13
11:54 AM				-0.48	120746	149	0	18.99
11:55 AM	16.20	39.91	0.00	-0.48	116286	148	0	18.50
11:56 AM	16.14	39.95	0.00	-0.47	90641	148	0	18.18
11:57 AM				-0.47	90562	147	0	18.33
11:58 AM	16.08	39.92	0.00	-0.47	83492	144	0	18.40
11:59 AM				-0.47	88439	142	0	18.23
12:00 PM	16.04	39.93	0.00	-0.47	117396	139	0	18.28
12:01 PM	16.04	39.79	0.00	-0.46	94850	138	0	18.36
12:02 PM				-0.46	103980	136	0	18.51
12:03 PM	16.11	39.43	0.00	-0.46	74952	135	0	18.83
12:04 PM				-0.45	89406	134	0	18.99
12:05 PM	16.09	38.96	0.00	-0.45	79340	133	0	18.92
12:06 PM	16.04	38.62	0.00	-0.44	81150	133	0	19.10
12:07 PM				-0.44	108468	133	0	19.22
12:08 PM	15.91	38.54	0.00	-0.43	65984	133	0	19.41
12:09 PM				-0.43	81600	132	0	19.38
12:10 PM	15.75	38.82	0.00	-0.43	94223	132	0	19.42
12:11 PM	15.73	39.19	0.00	-0.42	102220	130	0	19.44
12:12 PM				-0.42	93027	129	0	19.70
12:13 PM	15.66	39.63	0.00	-0.42	105611	128	0	19.88
12:14 PM				-0.41	82933	126	0	19.70
12:15 PM	15.69	39.76	0.00	-0.40	100666	124	0	19.62
12:16 PM	15.80	39.89	0.00	-0.41	148440	122	0	19.82
12:17 PM				-0.39	123982	121	0	20.15
12:18 PM	15.91	39.74	0.00	-0.38	106921	120	0	20.68
12:19 PM				-0.38	108552	119	0	20.77
12:20 PM	16.02	39.58	0.00	-0.39	96691	117	0	20.74
12:21 PM				-0.38	102076	117	0	20.53
12:22 PM	17.79	35.94	0.00	-0.38	131378	117	0	20.61
12:23 PM	16.61	38.73	0.00	-0.38	105548	117	0	20.72
12:24 PM				-0.38	114693	116	0	20.58
12:25 PM	16.31	39.38	0.00	-0.37	118724	115	0	20.61
12:26 PM				-0.37	89928	114	0	20.56
12:27 PM	16.08	40.35	0.00	-0.36	114035	113	0	20.04
12:28 PM	16.00	40.96	0.00	-0.36	153098	112	0	19.73
12:29 PM				-0.34	121571	111	0	19.70
12:30 PM	16.06	41.23	0.00	-0.35	127287	110	0	19.86

Tuesday, April 12, 2011 10:52:49 AM



Test # ________

CAR SPEED ________

MIX ________ JIM Walters

INT. ________

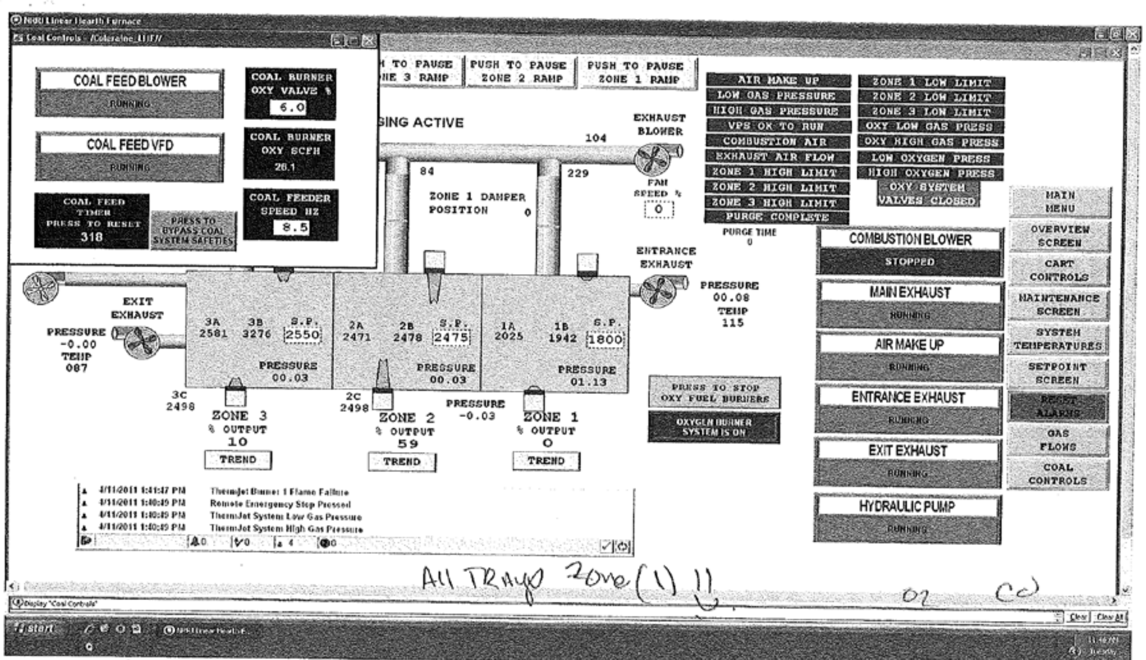
Convey ____________

Prime ____________

1st sample into Zone 1 @ 11:37A.M

4th & Last sample out of Zone 3 @ 12:30P.M

Tuesday, April 12, 2011 11:46:26 AM



Test # 114

CAR SPEED 6

MIX P269 4 Trays

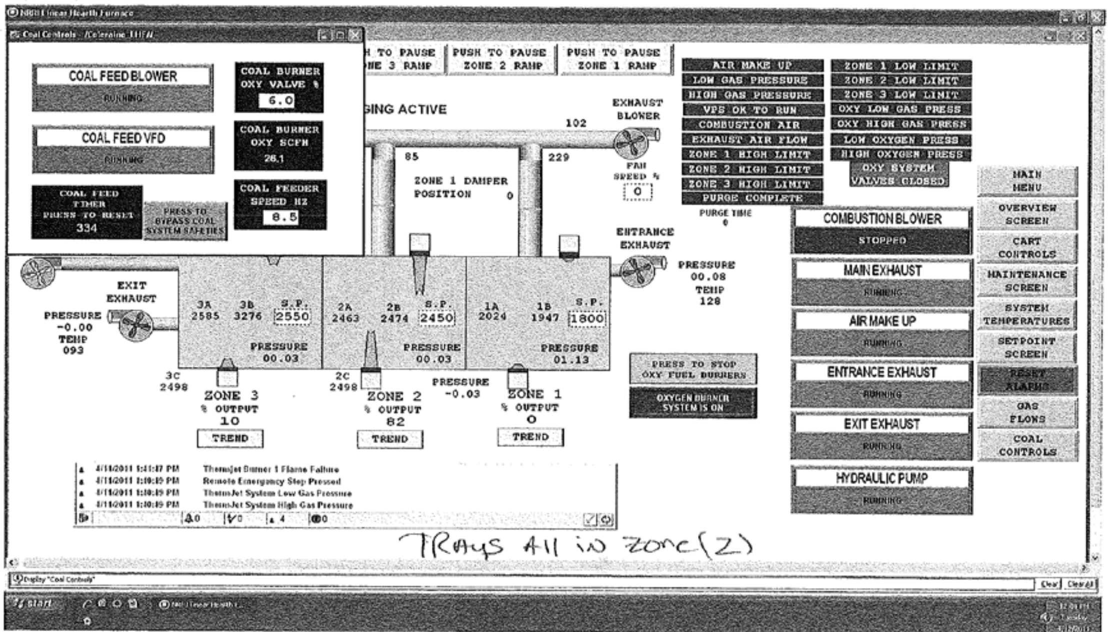
INT. SG1

Convey 7.0 | 13.0

Prime 1.0 | 8.0

0 000 17.0959
11.1381
8.6399
7.1741

Tuesday, April 12, 2011 **12:01:56 PM**



Test # 1114

CAR SPEED 6

MIX P269 at Tray coal burner.

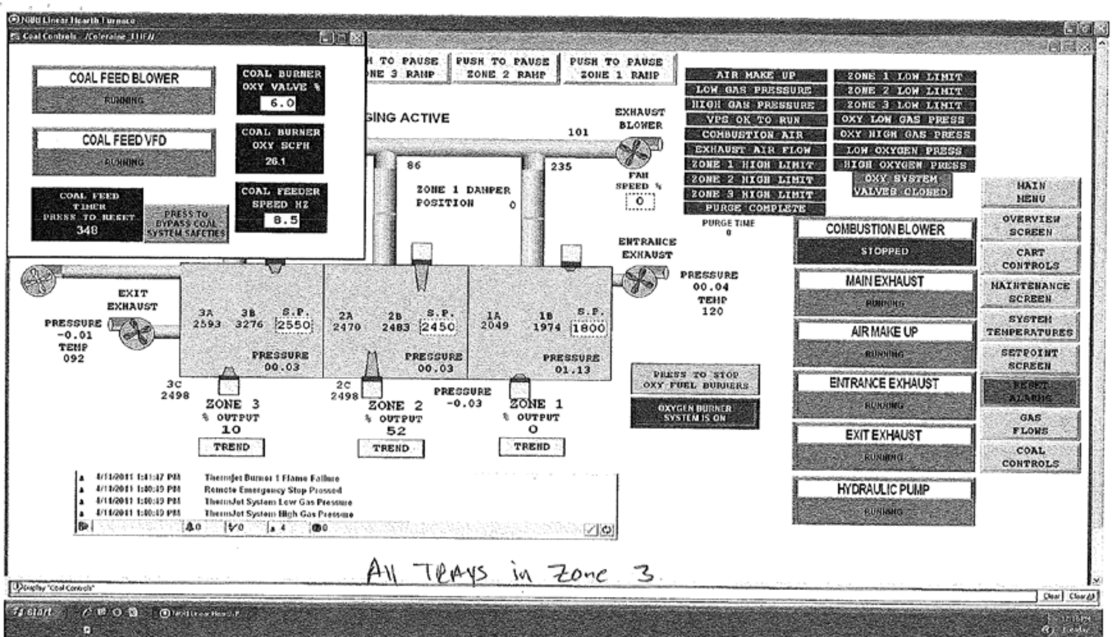
INT. 54.

Convey 7.0 | 13.0

Prime 1.0 | 8.0

0.000 19.0079
11.9748
9.1586
7.6799

Tuesday, April 12, 2011 **12:16:41 PM**



Test # 1114

CAR SPEED 6

MIX P269 4 TRAYS Coal Feeder

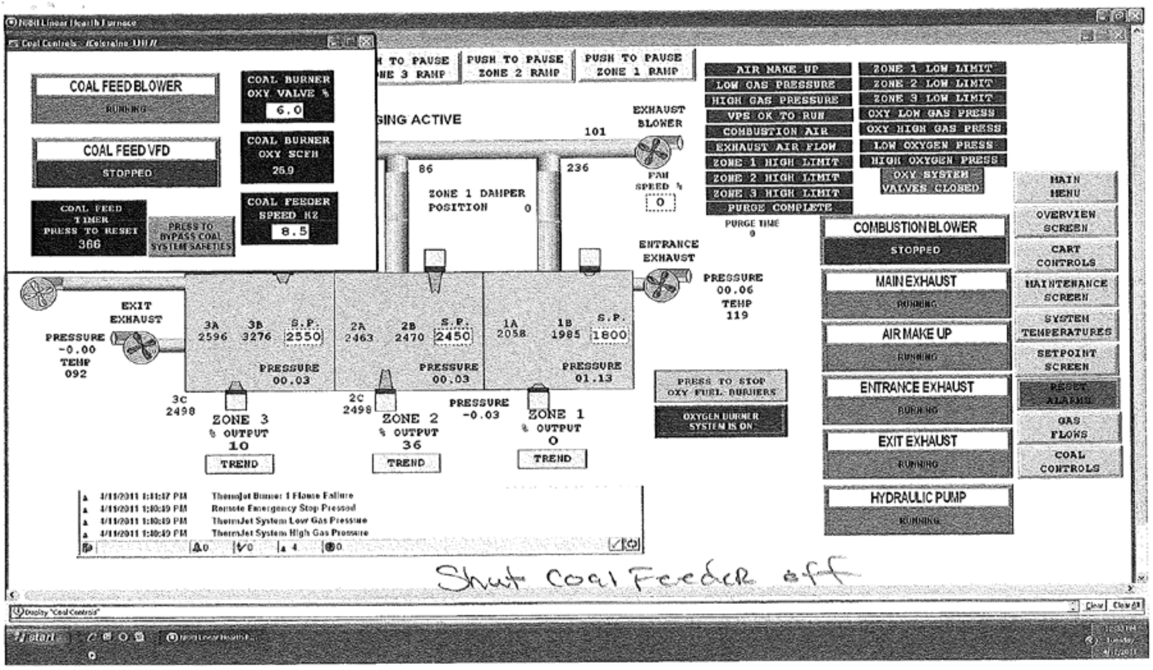
INT. 54.

Convey 7.0 | 13.0

Prime 1.0 | 8.0

0.000 16.3509
11.3361
8.9513
7.4888

Tuesday, April 12, 2011 **12:33:58 PM**



Test # ________ **Convey**____________

CAR SPEED _______ **Prime**_____________

MIX _______

INT.

Single Briquette Layer with High Volatile Sub-Bituminous Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
4/13/2011	1115	6.0	36.5 g/min	2000 g	1850 g	1530 g	4	12:14 PM	1:08 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
12:10 PM	150	168.7	No Sample
12:50 PM	158	164.5	With Sample

	LHF Data											
	Cart Pressure	Entrance Exhaust Output	Entrance Pressure	Exhaust Pressure	Exit Exhaust Output	OI Inches per Minute	Zone 1 Exhaust Output	Zone 1 Gas Flow	Zone 1 Oxygen Flow	Zone 1 PID CV	Zone 1 Pressure	Zone 1 Temp A
12:14 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	183.00	259.63	0.00	1.13	2166.80
12:15 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	179.41	289.50	0.00	1.13	2162.30
12:16 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	179.93	283.13	0.00	1.13	2150.70
12:17 PM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	182.17	251.50	0.00	1.13	2140.80
12:18 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	182.84	274.88	0.00	1.13	2135.40
12:19 PM	-0.04	100.00	0.00	0.00	100.00	6.00	0.00	180.97	265.38	0.00	1.13	2121.40
12:20 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	181.91	288.00	0.00	1.13	2112.10
12:21 PM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	182.11	252.88	0.00	1.13	2106.40
12:22 PM	-0.04	100.00	0.00	0.00	100.00	6.00	0.00	180.45	249.75	0.00	1.13	2093.50
12:23 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	184.46	273.13	0.00	1.13	2084.70
12:24 PM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	183.83	288.50	0.00	1.13	2077.70
12:25 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	183.31	297.25	0.00	1.13	2074.20
12:26 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	183.47	290.88	0.00	1.13	2072.30
12:27 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	183.78	282.25	0.00	1.13	2069.00
12:28 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	183.05	294.00	0.00	1.13	2067.30
12:29 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	183.73	291.25	0.00	1.13	2063.70
12:30 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	184.41	276.88	0.00	1.13	2061.20
12:31 PM	-0.03	100.00	0.02	0.00	100.00	6.00	0.00	181.02	268.25	0.00	1.13	2061.30
12:32 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	180.60	252.63	0.00	1.13	2056.80
12:33 PM	-0.03	100.00	0.04	0.00	100.00	6.00	0.00	178.89	258.00	0.00	1.13	2053.80
12:34 PM	-0.03	100.00	0.02	0.00	100.00	6.00	0.00	181.02	262.75	0.00	1.13	2053.30
12:35 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	177.48	282.63	0.00	1.13	2052.70
12:36 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	177.85	289.75	0.00	1.13	2054.20
12:37 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	178.83	239.38	0.00	1.13	2058.60
12:38 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	176.54	257.50	0.00	1.13	2060.30
12:39 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	176.80	273.63	0.00	1.13	2064.60
12:40 PM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	178.05	291.38	0.00	1.13	2072.40
12:41 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	178.73	242.75	0.00	1.13	2076.40
12:42 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	179.82	274.13	0.00	1.13	2084.60
12:43 PM	-0.04	100.00	0.06	0.00	100.00	6.00	0.00	178.63	252.50	0.00	1.13	2091.60
12:44 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	179.72	281.50	0.00	1.13	2095.30
12:45 PM	-0.03	100.00	0.02	0.00	100.00	6.00	0.00	179.72	272.38	0.00	1.13	2101.10
12:46 PM	-0.03	100.00	0.02	0.00	100.00	6.00	0.00	178.68	269.00	0.00	1.13	2107.30
12:47 PM	-0.04	100.00	0.00	0.00	100.00	6.00	0.00	180.71	267.25	0.00	1.13	2110.80
12:48 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	180.34	287.25	0.00	1.13	2117.30
12:49 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	181.54	263.88	0.00	1.13	2122.20
12:50 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	180.45	250.63	0.00	1.13	2131.10
12:51 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	181.23	249.50	0.00	1.13	2141.80
12:52 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	181.80	268.25	0.00	1.13	2147.50
12:53 PM	-0.03	100.00	0.02	0.00	100.00	6.00	0.00	182.22	283.63	0.00	1.13	2145.70
12:54 PM	-0.03	100.00	0.02	0.00	100.00	6.00	0.00	181.49	262.25	0.00	1.13	2148.30
12:55 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	182.84	284.38	0.00	1.13	2147.10
12:56 PM	-0.04	100.00	-0.01	0.00	100.00	6.00	0.00	184.93	272.88	0.00	1.13	2145.50
12:57 PM	-0.04	100.00	0.00	0.00	100.00	6.00	0.00	182.90	289.25	0.00	1.13	2143.80
12:58 PM	-0.04	100.00	0.00	0.00	100.00	6.00	0.00	183.21	305.63	0.00	1.13	2142.90
12:59 PM	-0.04	100.00	-0.01	0.00	100.00	6.00	0.00	182.64	262.25	0.00	1.13	2146.90
1:00 PM	-0.03	100.00	-0.01	0.00	100.00	6.00	0.00	181.59	297.75	0.00	1.13	2145.90
1:01 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	180.08	277.00	0.00	1.13	2146.80
1:02 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	183.88	283.88	0.00	1.13	2154.50
1:03 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	184.30	284.13	0.00	1.13	2155.20
1:04 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	183.21	296.50	0.00	1.13	2161.50
1:05 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	182.06	250.75	0.00	1.13	2168.70
1:06 PM	-0.04	100.00	0.00	0.00	100.00	6.00	0.00	184.56	283.00	0.00	1.13	2169.80
1:07 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	180.66	286.25	0.00	1.13	2171.40
1:08 PM												

Single Briquette Layer with High Volatile Sub-Bituminous Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer Anthracite, per car	Number of Sample Carts	Start Time	Stop Time
4/13/2011	1115	6.0	36.5 g/min	2000 g	1850 g	1530 g	4	12:14 PM	1:08 PM

Air Flow Measurements			
Time	**Flow (ft/min)**	**Temp (degF)**	**Notes**
12:10 PM	150	168.7	No Sample
12:50 PM	158	164.5	With Sample

	LHF Data																
	Zone 1 Temp B	Zone 2 Exhaust Output	Zone 2 Gas Flow	Zone 2 Oxygen Flow	Zone 2 PID CV	Zone 2 Pressure	Zone 2 Temp A	Zone 2 Temp B	Zone 2 Temp C	Zone 3 Exhaust Output	Zone 3 Gas Flow	Zone 3 Oxygen Flow	Zone 3 PID CV	Zone 3 Pressure	Zone 3 Temp A	Zone 3 Temp B	Zone 3 Temp C
12:14 PM	2084.30	0.00	217.99	312.56	0.00	0.03	2503.10	2484.10	2498.00	0.00	257.64	407.27	407.27	0.02	0.02	3276.70	2498.00
12:15 PM	2080.70	0.00	214.92	332.04	0.00	0.03	2502.70	2485.00	2498.00	0.00	255.53	343.58	343.58	0.02	0.02	3276.70	2498.00
12:16 PM	2068.10	0.00	216.27	315.81	0.00	0.03	2504.50	2483.60	2498.00	0.00	255.04	395.25	395.25	0.02	0.02	3276.70	2498.00
12:17 PM	2058.40	0.00	217.42	330.04	0.00	0.03	2506.10	2483.90	2498.00	0.00	257.24	395.41	395.41	0.02	0.02	3276.70	2498.00
12:18 PM	2051.30	0.00	219.13	339.54	0.00	0.03	2505.40	2483.50	2498.00	0.00	258.05	404.93	404.93	0.02	0.02	3276.70	2498.00
12:19 PM	2037.20	0.00	218.25	330.17	0.00	0.03	2504.00	2480.90	2498.00	0.00	258.54	407.27	407.27	0.02	0.02	3276.70	2498.00
12:20 PM	2027.10	0.00	218.30	319.43	0.00	0.03	2504.60	2480.30	2498.00	0.00	257.73	336.09	336.09	0.02	0.02	3276.70	2498.00
12:21 PM	2020.30	0.00	217.73	334.17	0.00	0.03	2504.70	2481.10	2498.00	0.00	257.40	423.20	423.20	0.02	0.02	3276.70	2498.00
12:22 PM	2009.60	0.00	217.31	329.17	0.00	0.03	2496.40	2475.30	2498.00	0.00	257.16	374.34	374.34	0.02	0.02	3276.70	2498.00
12:23 PM	1999.80	0.00	218.72	328.30	0.00	0.03	2490.50	2471.00	2498.00	0.00	259.03	364.66	364.66	0.02	0.02	3276.70	2498.00
12:24 PM	1993.00	0.00	219.13	326.17	0.00	0.03	2488.70	2468.90	2498.00	0.00	258.62	402.44	402.44	0.02	0.02	3276.70	2498.00
12:25 PM	1988.00	0.00	218.51	331.92	0.00	0.03	2480.70	2462.50	2498.00	0.00	259.35	386.36	386.36	0.02	0.02	3276.70	2498.00
12:26 PM	1986.10	0.00	218.46	342.16	0.00	0.03	2474.70	2457.20	2498.00	0.00	259.19	372.15	372.15	0.02	0.02	3276.70	2498.00
12:27 PM	1984.20	0.00	218.46	347.28	0.00	0.03	2471.90	2455.80	2498.00	0.00	259.19	365.91	365.91	0.02	0.02	3276.70	2498.00
12:28 PM	1980.10	0.00	218.67	332.54	0.00	0.03	2464.00	2450.10	2498.00	0.00	259.03	374.80	374.80	0.02	0.02	3276.70	2498.00
12:29 PM	1975.90	0.00	218.61	333.54	0.00	0.03	2455.70	2443.00	2498.00	0.00	259.11	374.65	374.65	0.02	0.02	3276.70	2498.00
12:30 PM	1973.80	0.00	219.29	324.05	1.23	0.03	2451.40	2438.60	2498.00	0.00	258.86	426.48	426.48	0.02	0.02	3276.70	2498.00
12:31 PM	1972.10	0.00	231.88	361.64	5.15	0.03	2442.10	2432.20	2498.00	0.00	255.94	411.96	411.96	0.02	0.02	3276.70	2498.00
12:32 PM	1968.90	0.00	329.04	510.24	29.21	0.03	2440.30	2434.00	2498.00	0.00	254.31	358.73	358.73	0.02	0.02	3276.70	2498.00
12:33 PM	1966.60	0.00	338.92	513.86	31.80	0.03	2443.60	2440.70	2498.00	0.00	252.61	368.40	368.40	0.02	0.02	3276.70	2498.00
12:34 PM	1966.70	0.00	353.85	528.35	34.52	0.03	2445.80	2446.20	2498.00	0.00	253.18	379.96	379.96	0.02	0.02	3276.70	2498.00
12:35 PM	1968.40	0.00	361.70	538.46	36.77	0.03	2448.90	2449.30	2498.00	0.00	253.01	335.78	335.78	0.02	0.02	3276.70	2498.00
12:36 PM	1970.50	0.00	381.10	561.56	40.54	0.03	2448.20	2453.70	2498.00	0.00	252.28	372.00	372.00	0.02	0.02	3276.70	2498.00
12:37 PM	1977.20	0.00	387.71	568.18	42.03	0.03	2452.60	2457.90	2498.00	0.00	253.26	412.11	412.11	0.02	0.02	3276.70	2498.00
12:38 PM	1978.90	0.00	399.93	602.65	44.72	0.03	2453.80	2456.60	2498.00	0.00	251.39	410.40	410.40	0.02	0.02	3276.70	2498.00
12:39 PM	1985.30	0.00	420.95	616.63	48.71	0.03	2451.80	2457.50	2498.00	0.00	253.50	374.65	374.65	0.02	0.02	3276.70	2498.00
12:40 PM	1994.30	0.00	428.49	630.74	50.52	0.03	2455.00	2460.70	2498.00	0.00	252.77	348.11	348.11	0.02	0.02	3276.70	2498.00
12:41 PM	1997.50	0.00	432.65	638.99	49.84	0.03	2463.70	2463.50	2498.00	0.00	252.93	366.22	366.22	0.02	0.02	3276.70	2498.00
12:42 PM	2007.00	0.00	424.43	643.61	50.37	0.03	2468.70	2467.80	2498.00	0.00	253.58	367.31	367.31	0.02	0.02	3276.70	2498.00
12:43 PM	2016.60	0.00	427.40	640.98	49.49	0.03	2474.90	2475.40	2498.00	0.00	252.85	415.24	415.24	0.02	0.02	3276.70	2498.00
12:44 PM	2017.50	0.00	427.29	637.86	49.67	0.03	2478.40	2478.10	2498.00	0.00	252.20	417.42	417.42	0.02	0.02	3276.70	2498.00
12:45 PM	2023.50	0.00	431.82	644.98	51.19	0.03	2478.20	2480.20	2498.00	0.00	252.85	369.19	369.19	0.02	0.02	3276.70	2498.00
12:46 PM	2030.70	0.00	438.11	649.97	52.50	0.03	2478.60	2482.10	2498.00	0.00	252.12	358.57	358.57	0.02	0.02	3276.70	2498.00
12:47 PM	2031.90	0.00	352.03	527.47	33.88	0.03	2473.60	2479.40	2498.00	0.00	255.61	352.79	352.79	0.03	0.03	3276.70	2498.00
12:48 PM	2036.50	0.00	356.45	532.97	34.15	0.03	2469.20	2475.60	2498.00	0.00	255.45	390.73	390.73	0.03	0.03	3276.70	2498.00
12:49 PM	2041.70	0.00	351.09	538.71	32.10	0.03	2471.10	2476.70	2498.00	0.00	256.59	411.96	411.96	0.03	0.03	3276.70	2498.00
12:50 PM	2046.90	0.00	339.49	515.11	29.79	0.03	2473.20	2477.90	2498.00	0.00	256.51	413.83	413.83	0.02	0.02	3276.70	2498.00
12:51 PM	2055.90	0.00	323.63	485.51	25.61	0.03	2479.30	2480.70	2498.00	0.00	257.81	364.03	364.03	0.03	0.03	3276.70	2498.00
12:52 PM	2064.40	0.00	304.28	447.18	21.83	0.03	2483.50	2483.40	2498.00	0.00	257.16	354.51	354.51	0.02	0.02	3276.70	2498.00
12:53 PM	2066.50	0.00	297.21	442.93	20.86	0.03	2480.30	2481.80	2498.00	0.00	258.21	360.60	360.60	0.03	0.03	3276.70	2498.00
12:54 PM	2067.60	0.00	286.60	425.20	18.00	0.03	2482.30	2478.80	2498.00	0.00	258.78	371.84	371.84	0.02	0.02	3276.70	2498.00
12:55 PM	2068.60	0.00	275.52	420.45	14.77	0.03	2484.90	2480.20	2498.00	0.00	259.03	408.21	408.21	0.03	0.03	3276.70	2498.00
12:56 PM	2071.20	0.00	270.26	417.83	13.50	0.03	2482.40	2478.90	2498.00	0.00	259.27	402.12	402.12	0.02	0.02	3276.70	2498.00
12:57 PM	2069.30	0.00	261.26	383.74	10.67	0.03	2484.00	2479.10	2498.00	0.00	260.33	353.73	353.73	0.02	0.02	3276.70	2498.00
12:58 PM	2070.80	0.00	248.21	374.75	7.48	0.03	2486.20	2477.70	2498.00	0.00	259.51	413.67	413.67	0.03	0.03	3276.70	2498.00
12:59 PM	2076.00	0.00	235.10	362.01	4.49	0.03	2487.50	2476.80	2498.00	0.00	258.46	383.08	383.08	0.02	0.02	3276.70	2498.00
1:00 PM	2072.10	0.00	228.96	349.53	2.76	0.03	2485.90	2474.80	2498.00	0.00	256.43	338.59	338.59	0.02	0.02	3276.70	2498.00
1:01 PM	2071.80	0.00	221.06	338.04	0.70	0.03	2485.20	2472.20	2498.00	0.00	256.83	425.07	425.07	0.02	0.02	3276.70	2498.00
1:02 PM	2077.90	0.00	217.52	345.15	0.00	0.03	2485.70	2470.80	2498.00	0.00	258.05	362.63	362.63	0.02	0.02	3276.70	2498.00
1:03 PM	2074.70	0.00	217.57	344.16	0.00	0.03	2484.40	2462.30	2498.00	0.00	257.97	345.15	345.15	0.02	0.02	3276.70	2498.00
1:04 PM	2078.90	0.00	217.05	310.31	0.00	0.03	2486.50	2463.00	2498.00	0.00	259.68	395.25	395.25	0.02	0.02	3276.70	2498.00
1:05 PM	2087.80	0.00	216.17	317.06	0.00	0.03	2484.40	2465.10	2498.00	0.00	258.38	425.54	425.54	0.02	0.02	3276.70	2498.00
1:06 PM	2083.80	0.00	217.26	314.56	0.00	0.03	2483.50	2463.60	2498.00	0.00	259.03	379.64	379.64	0.02	0.02	3276.70	2498.00
1:07 PM	2086.90	0.00	215.18	309.19	0.00	0.03	2483.20	2466.50	2498.00	0.00	258.78	351.55	351.55	0.02	0.02	3276.70	2498.00
1:08 PM																	

Single Briquette Layer with High Volatile Sub-Bituminous Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer Anthracite, per cart	Briquette P269, per cart	Cover Layer Anthracite, per cart	Number of Sample Carts	Start Time	Stop Time
4/13/2011	1115	6.0	36.5 g/min	2000 g	1850 g	1530 g	4	12:14 PM	1:08 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
12:10 PM	150	168.7	No Sample
12:50 PM	158	164.5	With Sample

	LGA Data																			
	Port 1								Port 2								Port 3			
	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen
12:14 PM																	0.28	20.45	0.07	0.00
12:15 PM	0.00	20.45	0.08	0.66	0.32	31.28	39.41	0.00	1.42	20.45	0.07	0.00	1.57	22.89	47.05	0.00	0.29	20.45	0.07	0.00
12:16 PM	0.00	20.45	0.08	0.00	0.42	33.52	36.79	0.00												
12:17 PM									1.53	20.45	0.07	0.00	1.63	23.31	46.31	0.00	0.31	20.45	0.07	0.00
12:18 PM	0.67	20.45	0.07	0.00	0.62	33.10	36.43	0.00	1.59	20.45	0.07	0.00	1.73	23.36	46.02	0.00				
12:19 PM																	0.32	20.45	0.07	0.00
12:20 PM	2.49	20.45	0.08	0.00	1.15	33.57	33.29	0.05	1.63	20.45	0.07	0.00	1.80	22.91	46.38	0.00	0.33	20.45	0.07	0.00
12:21 PM																				
12:22 PM	4.12	20.45	0.07	0.00	2.04	32.37	31.26	0.10	2.35	20.45	0.07	0.00	2.19	26.33	40.82	0.00				
12:23 PM																	0.60	20.45	0.07	0.00
12:24 PM	6.09	20.45	0.07	0.00	3.75	30.21	29.32	0.20	1.95	20.45	0.07	0.00	2.09	22.94	45.59	0.00	0.56	20.45	0.07	0.00
12:25 PM	8.32	20.45	0.07	0.00	5.70	29.13	24.91	0.27												
12:26 PM									2.11	20.45	0.07	0.00	2.16	22.52	45.79	0.00	0.65	20.45	0.07	0.00
12:27 PM	8.36	20.45	0.07	0.00	6.18	26.79	27.24	0.24	2.18	20.45	0.07	0.00	2.30	21.90	46.53	0.00				
12:28 PM																	0.77	20.45	0.07	0.00
12:29 PM	9.45	20.45	0.07	0.00	7.08	26.33	25.13	0.23	2.36	20.45	0.07	0.00	2.43	21.98	46.04	0.00	0.91	20.45	0.07	0.00
12:30 PM	10.46	20.45	0.07	0.00	7.89	25.21	24.20	0.25												
12:31 PM									2.53	20.45	0.07	0.00	2.56	21.88	45.57	0.00	1.08	20.45	0.07	0.00
12:32 PM	11.83	20.45	0.07	0.00	8.79	24.50	22.59	0.21	2.74	20.45	0.07	0.00	2.71	21.80	45.30	0.00				
12:33 PM																	1.22	20.45	0.07	0.00
12:34 PM	11.55	20.45	0.07	0.00	8.74	23.95	23.47	0.18	3.04	20.45	0.07	0.00	2.94	21.68	44.59	0.00	1.47	20.45	0.07	0.00
12:35 PM	12.89	20.45	0.07	0.00	9.57	23.76	21.04	0.15												
12:36 PM									3.38	20.45	0.07	0.00	3.33	21.18	44.45	0.00	1.80	20.45	0.07	0.00
12:37 PM	12.92	20.45	0.07	0.00	9.47	23.53	21.37	0.12	3.80	20.45	0.07	0.00	3.70	20.70	44.12	0.00				
12:38 PM																	2.23	20.45	0.07	0.00
12:39 PM	13.64	20.45	0.07	0.00	10.02	23.91	19.30	0.07	4.23	20.45	0.07	0.00	4.06	20.24	43.53	0.00	2.61	20.45	0.07	0.00
12:40 PM	13.96	20.45	0.07	0.00	10.29	23.89	18.49	0.03												
12:41 PM									4.68	20.45	0.07	0.00	4.50	19.90	42.82	0.00	3.10	20.45	0.07	0.00
12:42 PM	14.63	20.45	0.07	0.00	10.86	24.16	16.67	0.01	5.26	20.45	0.07	0.00	4.97	20.03	41.60	0.00				
12:43 PM																	3.30	20.45	0.07	0.00
12:44 PM	12.46	20.45	0.07	0.00	9.85	25.26	19.24	0.00	5.50	20.45	0.07	0.00	5.00	20.86	39.93	0.00	3.01	20.45	0.07	0.00
12:45 PM	12.74	20.45	0.07	0.00	9.92	26.41	17.61	0.00												
12:46 PM									5.68	20.45	0.07	0.00	5.07	21.67	38.77	0.00	2.79	20.45	0.07	0.00
12:47 PM	12.85	20.45	0.07	0.00	9.60	26.38	17.96	0.00	5.54	20.45	0.07	0.00	5.03	20.64	40.23	0.00				
12:48 PM																	3.10	20.45	0.07	0.00
12:49 PM	13.05	20.45	0.07	0.00	9.83	25.69	18.51	0.00	5.69	20.45	0.07	0.00	5.29	19.97	40.78	0.00	3.55	20.45	0.07	0.00
12:50 PM	12.16	20.45	0.07	0.00	9.11	26.07	19.85	0.00												
12:51 PM									6.02	20.45	0.07	0.00	5.41	19.92	40.25	0.00	3.86	20.45	0.07	0.00
12:52 PM	10.01	20.45	0.07	0.00	7.71	25.90	24.78	0.00	5.90	20.45	0.07	0.00	5.34	19.54	41.02	0.00				
12:53 PM																	3.93	20.45	0.07	0.00
12:54 PM	8.93	20.45	0.07	0.00	6.73	26.51	26.55	0.00	5.94	20.45	0.07	0.00	5.25	19.58	40.96	0.00	4.08	20.45	0.07	0.00
12:55 PM	8.56	20.45	0.07	0.00	6.40	27.27	26.70	0.00												
12:56 PM									6.04	20.45	0.07	0.00	5.34	19.67	40.58	0.00	4.27	20.45	0.07	0.00
12:57 PM	8.59	20.45	0.07	0.00	6.39	27.72	25.93	0.00	6.30	20.45	0.07	0.00	5.36	20.07	39.49	0.00				
12:58 PM																	4.45	20.45	0.07	0.00
12:59 PM	8.08	20.45	0.07	0.00	6.23	28.54	25.66	0.00	6.35	20.45	0.07	0.00	5.36	20.37	39.08	0.00	4.46	20.45	0.07	0.00
1:00 PM	7.80	20.45	0.07	0.00	6.09	28.86	25.84	0.00												
1:01 PM									6.32	20.45	0.07	0.00	5.32	20.56	39.01	0.00	4.45	20.45	0.07	0.00
1:02 PM	7.16	20.45	0.07	0.00	5.55	28.86	27.51	0.00	6.22	20.45	0.07	0.00	5.14	20.70	39.27	0.00				
1:03 PM																	4.35	20.45	0.07	0.00
1:04 PM	6.24	20.45	0.07	0.00	4.97	29.09	28.80	0.00	5.91	20.45	0.07	0.00	4.93	20.73	40.07	0.00	4.14	20.45	0.07	0.00
1:05 PM	4.97	20.45	0.07	0.00	4.13	28.20	32.78	0.00												
1:06 PM									5.46	20.45	0.07	0.00	4.60	20.50	41.18	0.00	3.82	20.45	0.07	0.00
1:07 PM	4.25	20.45	0.07	0.00	3.62	28.08	34.19	0.00	5.17	20.45	0.07	0.00	4.38	20.42	41.93	0.00				
1:08 PM																	3.59	20.45	0.07	0.00

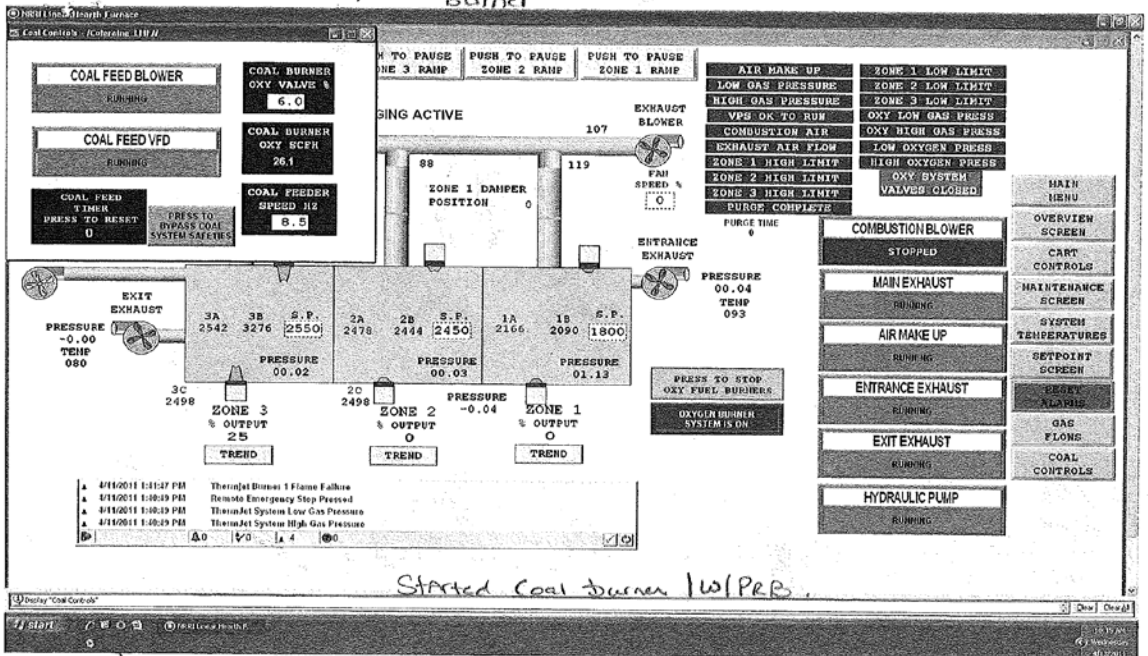
Single Briquette Layer with High Volatile Sub-Bituminous Coal in Coal Feeder

Date	Sample Numb	Run Speed	Coal Feeder Throughput	Hearth Layer Anthracite, per cart	Briquette (P269, per cart)	Cover Layer Anthracite, per ca	Number of Sample Carts	Start Time	Stop Time
4/13/2011	1115	6.0	36.5 g/min	2000 g	1850 g	1530 g	4	12:14 PM	1:08 PM

Air Flow Measurements			
Time	Flow (ft/min)	Temp (degF)	Notes
12:10 PM	150	168.7	No Sample
12:50 PM	158	164.5	With Sample

	Port 3				Port 4								Testo Emission Data				
	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% O2	ppm CO	ppm NOx	ppm SO2	% CO2
12:14 PM	0.73	18.59	54.43	0.00	0.00	20.45	0.07	0.00	0.42	18.54	55.60	0.00	1.05	222	1923	57	27.09
12:15 PM	0.76	18.78	54.23	0.00									0.63	764	1953	26	27.74
12:16 PM					0.00	20.45	0.07	0.00	0.43	18.83	55.37	0.00	0.40	3432	1962	0	28.39
12:17 PM	0.73	18.98	53.99	0.00	0.00	20.45	0.07	0.00	0.43	19.02	55.16	0.00	0.28	10719	1904	0	28.91
12:18 PM													0.22	16227	1731	0	28.75
12:19 PM	0.75	19.14	53.82	0.00	0.00	20.45	0.07	0.00	0.40	19.29	54.65	0.00	0.16	20928	1475	0	28.57
12:20 PM	0.78	19.12	53.88	0.00									0.11	31318	1171	0	28.35
12:21 PM					0.00	20.45	0.07	0.00	0.38	19.49	54.58	0.00	0.06	42320	906	0	27.54
12:22 PM													0.02	51944	751	0	26.78
12:23 PM	0.86	21.68	50.12	0.00	0.00	20.45	0.07	0.00	0.43	21.45	52.13	0.00	0.00	62689	681	0	26.24
12:24 PM	0.88	19.83	52.42	0.00									-0.02	70341	650	0	25.52
12:25 PM					0.00	20.45	0.07	0.00	0.42	20.45	53.30	0.00	-0.04	79932	621	0	24.86
12:26 PM	0.96	19.41	52.71	0.00	0.00	20.45	0.07	0.00	0.39	20.29	53.52	0.00	-0.06	91583	606	0	24.43
12:27 PM													-0.07	98170	604	0	23.97
12:28 PM	1.06	19.05	53.03	0.00	0.00	20.45	0.07	0.00	0.43	20.20	53.56	0.00	-0.08	96660	594	0	23.30
12:29 PM	1.13	18.92	52.83	0.00									-0.09	100649	580	0	23.01
12:30 PM					0.00	20.45	0.07	0.00	0.39	20.27	53.43	0.00	-0.10	111176	558	0	22.51
12:31 PM	1.21	18.80	52.74	0.00	0.00	20.45	0.07	0.00	0.41	20.24	53.29	0.00	-0.11	112235	540	0	22.30
12:32 PM													-0.12	125364	517	0	21.96
12:33 PM	1.38	18.68	52.51	0.00	0.02	20.45	0.07	0.00	0.44	20.27	53.21	0.00	-0.12	135727	490	0	21.41
12:34 PM	1.54	18.65	52.01	0.00									-0.14	141341	467	0	20.89
12:35 PM					0.18	20.45	0.07	0.00	0.47	20.46	52.83	0.00	-0.14	153609	447	0	20.60
12:36 PM	1.89	18.51	51.53	0.00	0.46	20.45	0.07	0.00	0.60	20.64	52.18	0.00	-0.15	168514	430	0	20.55
12:37 PM													-0.15	172709	415	0	20.47
12:38 PM	2.24	18.22	50.71	0.00	0.82	20.45	0.07	0.00	0.74	20.68	51.58	0.00	-0.16	180774	405	0	20.60
12:39 PM	2.62	17.91	50.09	0.00									-0.15	177767	393	0	20.72
12:40 PM					1.21	20.45	0.07	0.00	0.94	20.49	50.92	0.00	-0.14	117819	381	0	20.78
12:41 PM	3.08	17.73	49.28	0.00	1.72	20.45	0.07	0.00	1.29	20.33	50.28	0.00	-0.16	163095	372	0	20.72
12:42 PM													-0.15	117573	361	0	20.78
12:43 PM	3.15	17.73	48.89	0.00	1.78	20.45	0.07	0.00	1.36	20.00	50.31	0.00	-0.16	162332	353	0	21.06
12:44 PM	2.93	18.21	48.86	0.00									-0.16	168735	346	0	21.56
12:45 PM					1.51	20.45	0.07	0.00	1.21	20.19	50.52	0.00	-0.15	170699	341	0	22.21
12:46 PM	2.71	18.24	49.45	0.00	1.23	20.45	0.08	0.00	1.15	20.38	50.97	0.00	-0.15	176223	332	0	22.75
12:47 PM													-0.14	170277	320	0	22.86
12:48 PM	2.90	18.17	48.92	0.00	1.58	20.45	0.08	0.00	1.25	20.91	49.87	0.00	-0.15	175568	306	0	22.66
12:49 PM	3.30	17.61	48.60	0.00									-0.13	108927	295	0	22.51
12:50 PM					2.08	20.45	0.07	0.00	1.56	20.37	49.55	0.00	-0.14	141400	286	0	22.57
12:51 PM	3.58	17.39	47.99	0.00	2.38	20.45	0.08	0.00	1.87	19.81	49.25	0.00	-0.14	145251	277	0	22.86
12:52 PM													-0.13	142225	270	0	22.94
12:53 PM	3.63	17.14	48.27	0.00	2.53	20.45	0.07	0.00	2.03	19.29	49.59	0.00	-0.12	125279	263	0	22.93
12:54 PM	3.69	17.11	47.98	0.00									-0.12	110823	255	0	23.03
12:55 PM					2.75	20.45	0.07	0.00	2.17	19.12	49.44	0.00	-0.13	103099	248	0	23.48
12:56 PM	3.76	17.07	47.65	0.00	2.99	20.45	0.07	0.00	2.35	19.05	48.78	0.00	-0.12	100370	241	0	23.75
12:57 PM													-0.11	95003	235	0	24.09
12:58 PM	3.89	17.15	47.30	0.00	3.17	20.45	0.07	0.00	2.50	19.08	48.53	0.00	-0.11	93640	231	0	24.58
12:59 PM	3.93	17.25	47.02	0.00									-0.10	93462	225	0	24.86
1:00 PM					3.23	20.45	0.07	0.00	2.57	18.95	48.31	0.00	-0.09	92421	220	0	25.14
1:01 PM	3.92	17.22	47.04	0.00	3.19	20.45	0.07	0.00	2.55	18.82	48.70	0.00	-0.09	91179	217	0	25.42
1:02 PM													-0.08	82139	215	0	25.36
1:03 PM	3.81	17.29	47.33	0.00	3.10	20.45	0.07	0.00	2.46	18.79	48.93	0.00	-0.08	72700	213	0	25.40
1:04 PM	3.61	17.33	47.87	0.00									-0.07	65501	213	0	25.47
1:05 PM					2.89	20.45	0.07	0.00	2.31	18.63	49.52	0.00	-0.07	57122	216	0	25.23
1:06 PM	3.28	17.28	48.77	0.00	2.59	20.45	0.07	0.00	2.11	18.45	50.18	0.00	-0.06	50293	220	0	24.93
1:07 PM													-0.05	39847	233	0	24.95
1:08 PM	3.05	17.29	49.20	0.00	2.39	20.45	0.07	0.00	2.01	18.39	50.90	0.00	-0.04	25641	255	0	25.09

Wednesday, April 13, 2011 PRB - Coal Burner 10:15:53 AM

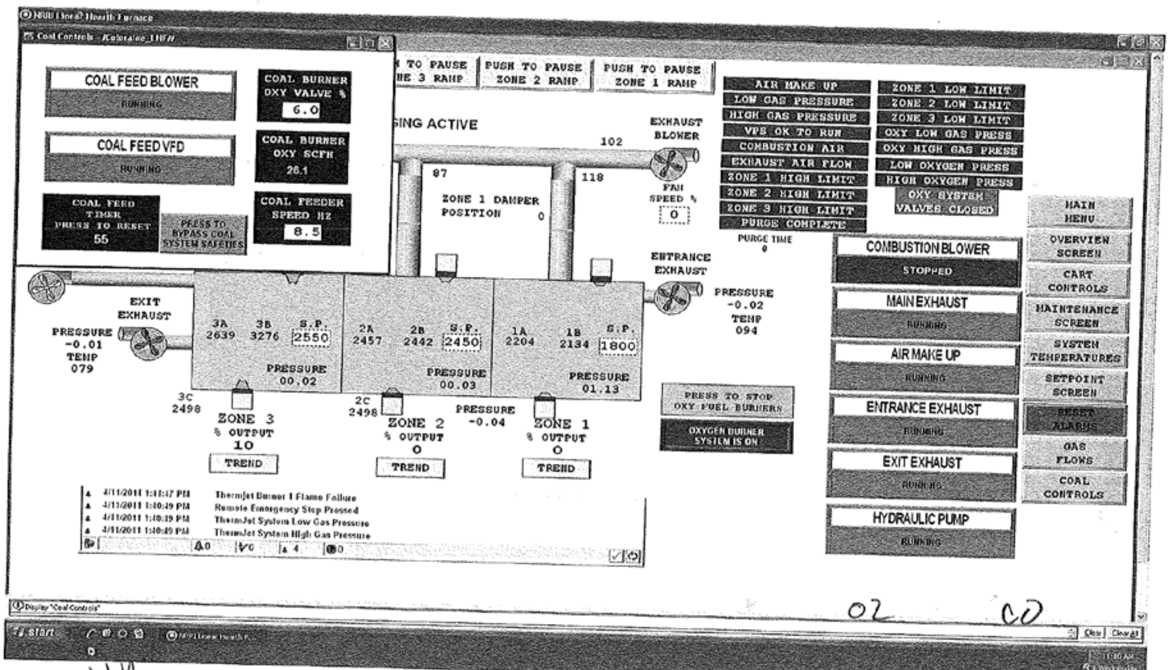


Started Coal burner 1 w/PRB.

Test # N/A
CAR SPEED 6 →
MIX N/A
INT. S.M.

Convey 7.0 / 14.0
Prime 1.0 / 8.0

Wednesday, April 13, 2011 11:11:03 AM



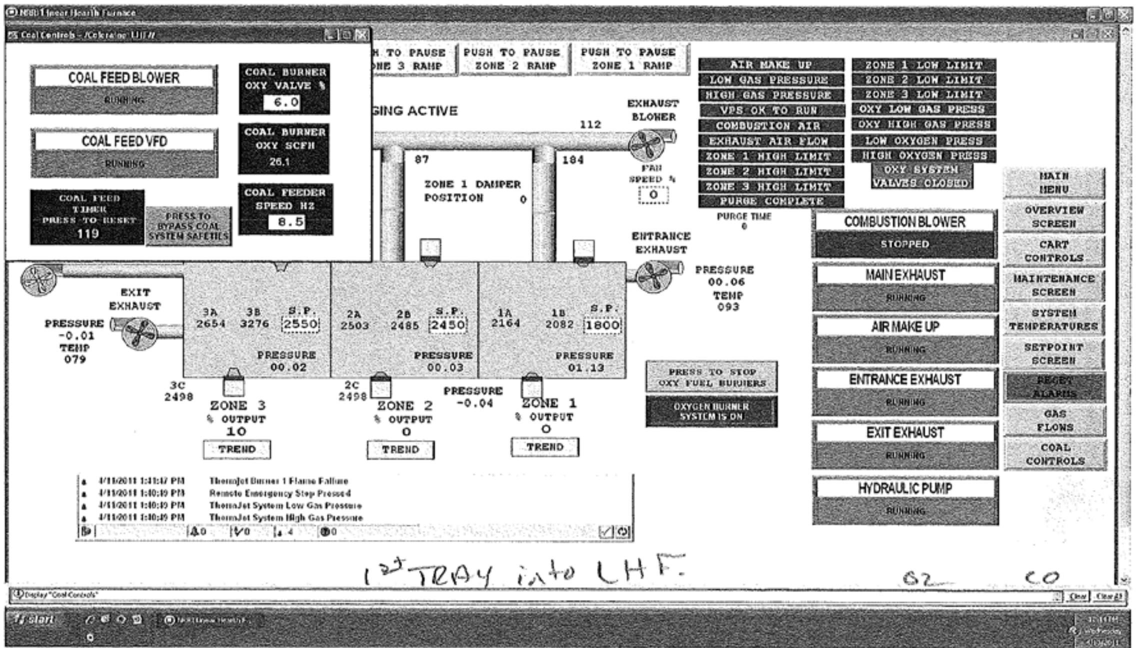
O2 CO

Test # N/A
CAR SPEED Atmosphere
MIX N/A
INT. S.M.

Convey 5.0 / 9.0
Prime 1.0 / 8.0

0.008 2.8665
3.2335
1.9596
1.9294

Wednesday, April 13, 2011 **12:14:59 PM**



Test # 1115
CAR SPEED 6
MIX P269 4 TRAYS
INT. SG

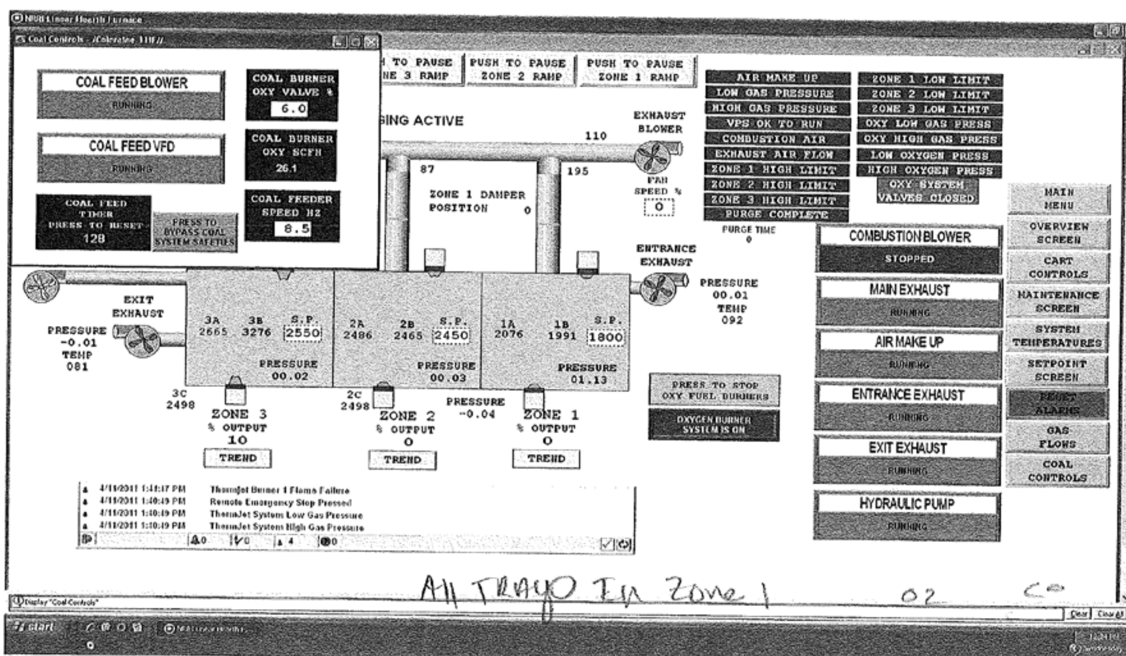
PRB Coal

Convey 5.0 / 9.0
Prime 1.0 / 8.0

0.0035

0.000
1.5306
0.3103
0.000

Wednesday, April 13, 2011 **12:24:43 PM**



Test # 1115
CAR SPEED 6
MIX P269 4 TRAYS 2 Anth Front 2 Anth behind
INT. SG.

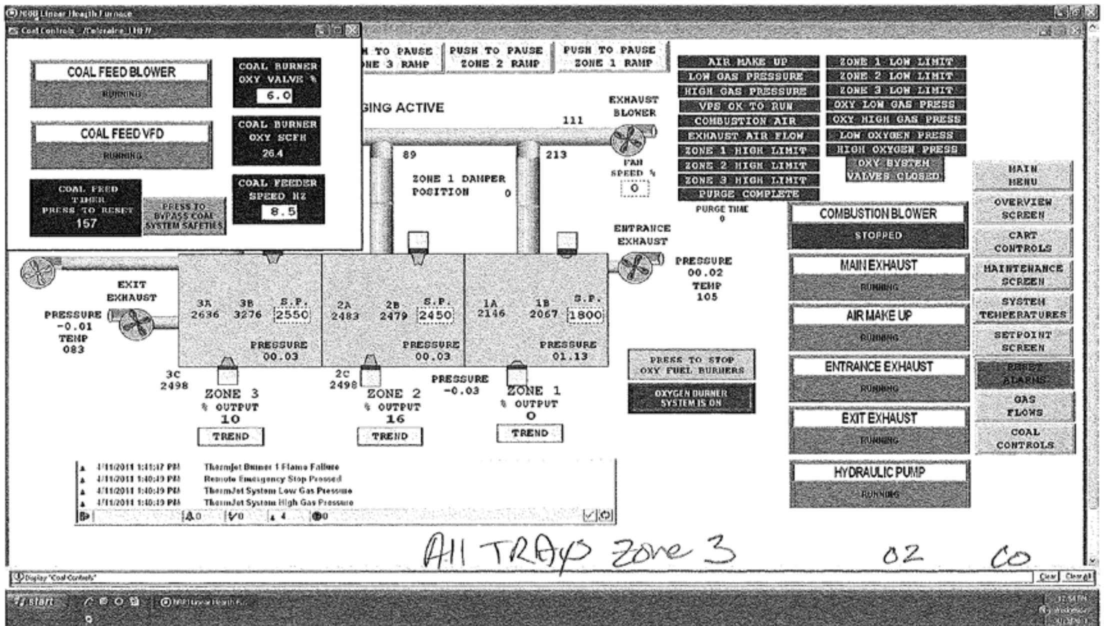
Convey 5.0 | 9.0
Prime 1.0 | 8.0

PRB coal.

0.000

8.3558
2.1835
0.7724
0.0000

Wednesday, April 13, 2011 12:55:00 PM



Test # 1115
CAR SPEED 6
MIX P269 PRB Coal
INT. 5/1

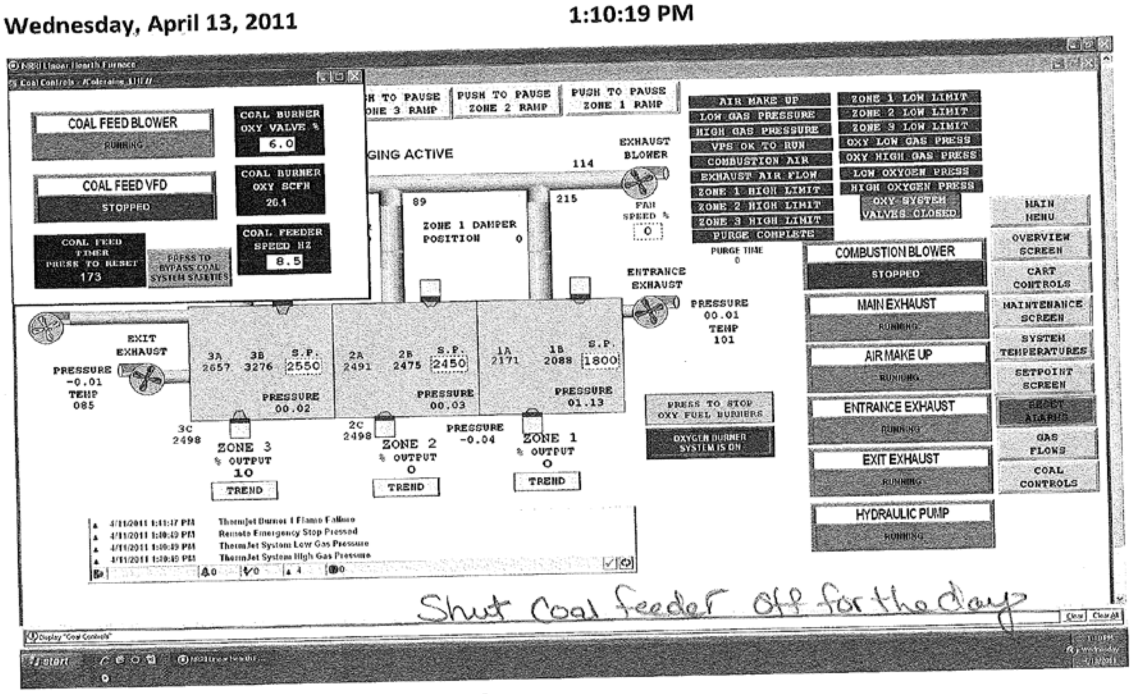
Convey 5.0 | 9.0
Prime 1.0 | 8.0

4 TRAYS Sample
Zanth front & back of Sample TRAYS

Total Time: 0.000
44:01

8.5903
6.2963
4.4453
3.1740

Wednesday, April 13, 2011 1:10:19 PM



Test # ________
CAR SPEED _______
MIX _______
INT.

Convey____________
Prime____________

Continuing to ...

Single Briquette Layer with High Volatile Bituminous Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
4/26/2011	1121	6.0	144 g/min	2000 g	1850 g	1530 g	4	11:27 AM	12:20 AM

Air Flow Measurements

Time	Flow (ft/min)	Temp (degF)	Notes
11:05 AM	123	154	No Sample
11:55 AM	147	151.7	With Sample
12:10 PM	138	151	With Sample (all in Zone 3)

LHF Data

	Cart Pressure	Entrance Exhaust Output	Entrance Pressure	Exhaust Pressure	Exit Exhaust Output	OI Inches per Minute	Zone 1 Exhaust Output	Zone 1 Gas Flow	Zone 1 Oxygen Flow	Zone 1 PID CV	Zone 1 Pressure	Zone 1 Temp A
11:27 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.73	244.88	0.00	1.13	2036.20
11:28 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	177.74	279.00	0.00	1.13	2031.10
11:29 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	180.92	272.38	0.00	1.13	2028.30
11:30 AM	-0.04	100.00	0.09	0.00	100.00	6.00	0.00	179.36	291.88	0.00	1.13	2029.60
11:31 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	178.68	245.88	0.00	1.13	2023.90
11:32 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	176.49	255.38	0.00	1.13	2019.10
11:33 AM	-0.04	100.00	0.09	0.00	100.00	6.00	0.00	180.45	250.00	0.00	1.13	2018.40
11:34 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	176.80	245.50	0.00	1.13	2008.40
11:35 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	183.16	273.50	0.00	1.13	2002.00
11:36 AM	-0.04	100.00	0.06	0.00	100.00	6.00	0.00	178.73	255.88	0.00	1.13	1998.30
11:37 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	179.51	275.50	0.00	1.13	1988.70
11:38 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	177.90	279.88	0.00	1.13	1984.30
11:39 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	179.25	265.75	0.00	1.13	1982.30
11:40 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	179.77	272.75	0.00	1.13	1978.40
11:41 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.05	249.38	0.00	1.13	1973.90
11:42 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	177.38	259.13	0.00	1.13	1974.10
11:43 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	176.18	287.50	0.00	1.13	1977.10
11:44 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.83	290.13	0.00	1.13	1975.30
11:45 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	180.45	261.75	0.00	1.13	1975.80
11:46 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	178.37	252.75	0.00	1.13	1977.20
11:47 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	179.82	274.50	0.00	1.13	1975.30
11:48 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.05	287.75	0.00	1.13	1977.00
11:49 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	177.17	264.13	0.00	1.13	1981.90
11:50 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	177.85	261.13	0.00	1.13	1980.00
11:51 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	177.69	288.00	0.00	1.13	1981.40
11:52 AM	-0.03	100.00	0.06	0.00	100.00	6.00	0.00	179.46	278.88	0.00	1.13	1985.80
11:53 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	179.67	256.63	0.00	1.13	1984.70
11:54 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	178.00	257.75	0.00	1.13	1985.60
11:55 AM	-0.04	100.00	0.06	0.00	100.00	6.00	0.00	178.16	258.13	0.00	1.13	1990.20
11:56 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	178.52	273.38	0.00	1.13	1988.20
11:57 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	178.37	277.75	0.00	1.13	1991.20
11:58 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	178.94	271.88	0.00	1.13	1995.80
11:59 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	178.89	238.50	0.00	1.13	1998.10
12:00 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	180.76	257.25	0.00	1.13	1999.60
12:01 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	179.04	252.75	0.00	1.13	2002.70
12:02 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	181.28	271.13	0.00	1.13	2008.00
12:03 PM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	178.00	284.38	0.00	1.13	2009.90
12:04 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.83	273.25	0.00	1.13	2011.20
12:05 PM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	177.06	245.50	0.00	1.13	2013.90
12:06 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	180.34	268.50	0.00	1.13	2006.70
12:07 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	179.77	251.63	0.00	1.13	2006.20
12:08 PM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	178.26	273.50	0.00	1.13	2006.10
12:09 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	180.08	261.75	0.00	1.13	2001.40
12:10 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	178.11	281.38	0.00	1.13	2002.00
12:11 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	180.76	275.38	0.00	1.13	2005.60
12:12 PM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	179.46	282.00	0.00	1.13	2003.40
12:13 PM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	179.77	254.38	0.00	1.13	2003.10
12:14 PM	-0.04	100.00	0.08	0.00	100.00	6.00	0.00	179.04	283.38	0.00	1.13	2010.20
12:15 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	180.55	277.38	0.00	1.13	2013.50
12:16 PM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.05	257.75	0.00	1.13	2018.20
12:17 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	181.75	284.75	0.00	1.13	2023.10
12:18 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	176.39	273.38	0.00	1.13	2024.50
12:19 PM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	180.87	287.13	0.00	1.13	2022.50
12:20 PM												

Single Briquette Layer with High Volatile Bituminous Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer Anthracite, per car	Number of Sample Carts	Start Time	Stop Time
4/26/2011	1121	6.0	144 g/min	2000 g	1850 g	1530 g	4	11:27 AM	12:20 AM

Air Flow Measurements			
Time	**Flow (ft/min)**	**Temp (degF)**	**Notes**
11:05 AM	123	154	No Sample
11:55 AM	147	151.7	With Sample
12:10 PM	138	151	With Sample (all in Zone 3)

	LHF Data																
	Zone 1 Temp B	Zone 2 Exhaust Output	Zone 2 Gas Flow	Zone 2 Oxygen Flow	Zone 2 PID CV	Zone 2 Pressure	Zone 2 Temp A	Zone 2 Temp B	Zone 2 Temp C	Zone 3 Exhaust Output	Zone 3 Gas Flow	Zone 3 Oxygen Flow	Zone 3 PID CV	Zone 3 Pressure	Zone 3 Temp A	Zone 3 Temp B	Zone 3 Temp C
11:27 AM	1927.70	0.00	427.86	640.73	50.14	0.03	2444.90	2455.70	2498.00	0.00	255.29	376.21	10.00	0.03	2577.00	3276.70	2498.00
11:28 AM	1924.20	0.00	427.08	637.99	49.18	0.03	2446.90	2456.20	2498.00	0.00	255.69	356.23	10.00	0.03	2576.70	3276.70	2498.00
11:29 AM	1921.30	0.00	424.95	645.98	47.84	0.03	2450.50	2456.70	2498.00	0.00	256.02	402.59	10.00	0.03	2578.10	3276.70	2498.00
11:30 AM	1923.70	0.00	416.16	624.00	47.04	0.03	2452.20	2459.10	2498.00	0.00	256.26	393.23	10.00	0.03	2578.10	3276.70	2498.00
11:31 AM	1924.90	0.00	423.60	634.49	48.91	0.03	2447.70	2455.40	2498.00	0.00	255.78	415.24	10.00	0.03	2576.10	3276.70	2498.00
11:32 AM	1926.30	0.00	426.41	644.48	49.04	0.03	2447.30	2454.20	2498.00	0.00	256.02	403.68	10.00	0.03	2573.10	3276.70	2498.00
11:33 AM	1929.80	0.00	425.32	647.85	48.41	0.03	2449.60	2456.80	2498.00	0.00	255.13	396.19	10.00	0.03	2572.70	3276.70	2498.00
11:34 AM	1931.60	0.00	429.43	642.23	50.05	0.03	2446.00	2452.40	2498.00	0.00	254.23	414.30	10.00	0.03	2570.30	3276.70	2498.00
11:35 AM	1933.50	0.00	440.30	651.10	51.06	0.03	2444.30	2452.40	2498.00	0.00	253.83	351.86	10.00	0.03	2569.70	3276.70	2498.00
11:36 AM	1934.60	0.00	511.61	781.34	69.24	0.03	2452.10	2458.30	2498.00	0.00	252.61	363.72	10.00	0.03	2570.10	3276.70	2498.00
11:37 AM	1931.80	0.00	503.13	759.49	66.55	0.03	2463.20	2467.40	2498.00	0.00	255.29	339.53	10.00	0.03	2572.30	3276.70	2498.00
11:38 AM	1931.60	0.00	497.77	759.49	64.43	0.03	2468.70	2473.90	2498.00	0.00	254.07	341.24	10.00	0.03	2573.00	3276.70	2498.00
11:39 AM	1938.80	0.00	491.79	733.52	62.58	0.03	2474.00	2477.50	2498.00	0.00	254.88	406.49	10.00	0.03	2572.70	3276.70	2498.00
11:40 AM	1943.60	0.00	493.61	722.40	63.55	0.03	2470.60	2476.10	2498.00	0.00	254.96	415.70	10.00	0.03	2573.40	3276.70	2498.00
11:41 AM	1937.50	0.00	492.67	739.01	64.03	0.03	2469.30	2475.40	2498.00	0.00	254.31	411.65	10.00	0.03	2573.10	3276.70	2498.00
11:42 AM	1937.00	0.00	497.04	738.39	63.71	0.03	2468.20	2475.90	2498.00	0.00	254.88	352.79	10.00	0.03	2573.90	3276.70	2498.00
11:43 AM	1938.70	0.00	490.65	734.89	63.41	0.03	2467.40	2475.70	2498.00	0.00	255.86	347.33	10.00	0.03	2573.00	3276.70	2498.00
11:44 AM	1941.50	0.00	489.14	732.64	62.75	0.03	2465.90	2473.80	2498.00	0.00	253.99	362.16	10.00	0.03	2570.50	3276.70	2498.00
11:45 AM	1945.70	0.00	498.50	734.77	64.23	0.03	2461.10	2472.00	2498.00	0.00	254.07	423.04	10.00	0.03	2572.10	3276.70	2498.00
11:46 AM	1938.80	0.00	490.28	730.14	63.66	0.03	2460.50	2471.50	2498.00	0.00	255.04	410.40	10.00	0.03	2575.30	3276.70	2498.00
11:47 AM	1939.50	0.00	491.79	738.26	63.41	0.03	2458.20	2467.60	2498.00	0.00	256.10	340.31	10.00	0.03	2575.50	3276.70	2498.00
11:48 AM	1944.00	0.00	495.27	737.64	64.04	0.03	2454.80	2468.50	2498.00	0.00	254.15	401.50	10.00	0.03	2576.00	3276.70	2498.00
11:49 AM	1944.70	0.00	482.90	737.64	61.90	0.03	2456.90	2471.80	2498.00	0.00	255.13	411.96	10.00	0.02	2578.60	3276.70	2498.00
11:50 AM	1940.90	0.00	488.57	728.65	61.67	0.03	2454.60	2467.50	2498.00	0.00	254.56	383.39	10.00	0.03	2579.10	3276.70	2498.00
11:51 AM	1933.10	0.00	486.64	726.77	61.77	0.03	2450.80	2463.70	2498.00	0.00	253.74	345.93	10.00	0.03	2578.50	3276.70	2498.00
11:52 AM	1935.10	0.00	486.22	718.16	61.56	0.03	2450.90	2466.00	2498.00	0.00	254.48	348.11	10.00	0.03	2578.80	3276.70	2498.00
11:53 AM	1935.30	0.00	489.81	718.91	62.42	0.03	2447.70	2460.10	2498.00	0.00	254.64	422.26	10.00	0.03	2577.80	3276.70	2498.00
11:54 AM	1926.70	0.00	493.51	740.01	64.03	0.03	2446.50	2458.70	2498.00	0.00	253.99	400.87	10.00	0.03	2579.70	3276.70	2498.00
11:55 AM	1926.20	0.00	490.02	739.51	63.18	0.03	2448.00	2461.10	2498.00	0.00	254.80	364.81	10.00	0.03	2581.80	3276.70	2498.00
11:56 AM	1925.40	0.00	490.44	745.88	62.84	0.03	2448.70	2458.50	2498.00	0.00	254.23	348.42	10.00	0.03	2581.60	3276.70	2498.00
11:57 AM	1924.40	0.00	481.70	733.27	62.26	0.03	2450.50	2460.10	2498.00	0.00	255.21	351.39	10.00	0.03	2582.70	3276.70	2498.00
11:58 AM	1919.30	0.00	474.31	720.78	60.28	0.03	2455.00	2463.70	2498.00	0.00	255.21	409.62	10.00	0.03	2582.50	3276.70	2498.00
11:59 AM	1915.30	0.00	485.70	720.53	61.75	0.03	2450.80	2459.80	2498.00	0.00	254.88	406.96	10.00	0.02	2582.90	3276.70	2498.00
12:00 PM	1912.80	0.00	480.03	722.90	62.47	0.03	2448.90	2458.70	2498.00	0.00	254.15	366.06	10.00	0.02	2582.60	3276.70	2498.00
12:01 PM	1909.70	0.00	478.73	721.53	60.71	0.03	2453.10	2460.90	2498.00	0.00	255.21	358.41	10.00	0.02	2584.50	3276.70	2498.00
12:02 PM	1906.10	0.00	482.84	718.91	61.72	0.03	2450.10	2460.90	2498.00	0.00	255.04	339.06	10.00	0.02	2586.00	3276.70	2498.00
12:03 PM	1902.10	0.00	476.71	724.03	59.87	0.03	2454.60	2462.40	2498.00	0.00	255.37	419.76	10.00	0.02	2587.00	3276.70	2498.00
12:04 PM	1898.90	0.00	469.94	709.79	59.37	0.03	2455.10	2465.00	2498.00	0.00	255.61	412.11	10.00	0.02	2589.60	3276.70	2498.00
12:05 PM	1899.30	0.00	469.32	704.55	58.09	0.03	2456.00	2466.10	2498.00	0.00	255.61	422.26	10.00	0.03	2590.00	3276.70	2498.00
12:06 PM	1893.60	0.00	473.33	710.91	58.95	0.03	2454.10	2463.20	2498.00	0.00	253.99	384.17	10.00	0.03	2588.30	3276.70	2498.00
12:07 PM	1894.00	0.00	470.52	710.41	58.49	0.03	2454.60	2465.00	2498.00	0.00	254.07	366.22	10.00	0.03	2588.90	3276.70	2498.00
12:08 PM	1889.00	0.00	465.78	703.17	56.84	0.03	2457.60	2467.70	2498.00	0.00	255.53	390.26	10.00	0.03	2589.00	3276.70	2498.00
12:09 PM	1887.00	0.00	465.00	700.30	56.54	0.03	2457.20	2466.80	2498.00	0.00	254.64	410.08	10.00	0.03	2588.00	3276.70	2498.00
12:10 PM	1887.10	0.00	453.46	694.18	55.14	0.03	2459.30	2467.70	2498.00	0.00	255.53	363.25	10.00	0.03	2589.50	3276.70	2498.00
12:11 PM	1890.80	0.00	447.58	668.96	53.24	0.03	2462.20	2470.90	2498.00	0.00	255.78	402.59	10.00	0.03	2590.60	3276.70	2498.00
12:12 PM	1893.00	0.00	449.35	675.07	52.61	0.03	2461.90	2469.80	2498.00	0.00	254.80	412.43	10.00	0.03	2588.00	3276.70	2498.00
12:13 PM	1886.20	0.00	439.57	660.96	52.32	0.03	2460.60	2468.80	2498.00	0.00	254.48	353.73	10.00	0.03	2590.10	3276.70	2498.00
12:14 PM	1885.00	0.00	438.68	653.47	51.43	0.03	2461.00	2469.50	2498.00	0.00	256.18	371.84	10.00	0.02	2590.30	3276.70	2498.00
12:15 PM	1884.00	0.00	443.26	663.96	52.95	0.03	2455.80	2463.40	2498.00	0.00	254.64	394.01	10.00	0.02	2589.00	3276.70	2498.00
12:16 PM	1880.80	0.00	447.94	673.83	52.63	0.03	2455.60	2460.60	2498.00	0.00	254.15	412.89	10.00	0.02	2588.00	3276.70	2498.00
12:17 PM	1880.80	0.00	435.35	667.46	51.33	0.03	2457.80	2461.40	2498.00	0.00	256.18	382.30	10.00	0.03	2590.50	3276.70	2498.00
12:18 PM	1881.30	0.00	446.17	667.33	52.76	0.03	2453.20	2460.50	2498.00	0.00	254.56	344.36	10.00	0.03	2589.50	3276.70	2498.00
12:19 PM	1876.20	0.00	441.65	662.09	52.95	0.03	2452.20	2461.30	2498.00	0.00	255.86	356.23	10.00	0.03	2587.90	3276.70	2498.00
12:20 PM																	

Single Briquette Layer with High Volatile Bituminous Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer Anthracite, per	Briquette P269, per cart	Cover Layer Anthracite, per car	Number of Sample Carts	Start Time	Stop Time
4/26/2011	1121	6.0	144 g/min	2000 g	1850 g	1530 g	4	11:27 AM	12:20 AM

Air Flow Measurements

Time	Flow (ft/min)	Temp (degF)	Notes
11:05 AM	123	154	No Sample
11:55 AM	147	151.7	With Sample
12:10 PM	138	151	Sample (all in Zone 3)

LGA Data

	Port 1								Port 2								Port 3				
	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen
11:27 AM	16.35	20.81	0.06	0.00	13.10	23.55	8.51	0.00	9.76	20.81	0.07	0.00	9.41	19.03	28.81	0.00	8.72	20.81	0.07	0.00	8.30
11:28 AM	17.57	20.81	0.06	0.00	13.83	23.43	6.32	0.00													
11:29 AM									10.08	20.81	0.07	0.00	9.68	19.28	27.61	0.00	8.84	20.81	0.06	0.00	8.44
11:30 AM	17.90	20.81	0.06	0.00	14.39	22.92	5.16	0.01	10.40	20.81	0.06	0.00	9.85	19.43	26.75	0.00					
11:31 AM																	8.90	20.81	0.06	0.00	8.59
11:32 AM	18.00	20.81	0.06	0.00	14.99	23.13	3.52	0.10	10.54	20.81	0.06	0.00	10.00	19.40	26.16	0.00	8.93	20.81	0.06	0.00	8.66
11:33 AM	18.35	20.81	0.06	0.00	15.83	22.67	2.64	0.17													
11:34 AM									10.43	20.81	0.06	0.00	10.09	19.17	26.54	0.00	8.88	20.81	0.06	0.00	8.74
11:35 AM	18.71	20.81	0.06	0.00	16.55	22.06	1.47	0.26	10.44	20.81	0.06	0.00	10.21	18.82	27.07	0.00					
11:36 AM																	9.14	20.81	0.06	0.00	8.94
11:37 AM	18.80	20.81	0.06	0.00	17.35	21.56	0.46	0.37	10.64	20.81	0.06	0.00	10.35	19.00	26.09	0.00	9.23	20.81	0.06	0.00	8.97
11:38 AM	19.34	20.81	0.06	0.00	18.16	20.84	0.00	0.46													
11:39 AM									10.68	20.81	0.06	0.00	10.39	18.76	26.45	0.00	9.18	20.81	0.06	0.00	9.07
11:40 AM	19.36	20.81	0.05	0.00	18.10	20.19	0.61	0.45	10.85	20.81	0.06	0.00	10.37	19.13	25.63	0.00					
11:41 AM																	9.18	20.81	0.06	0.00	9.05
11:42 AM	19.59	20.81	0.06	0.00	18.06	19.95	0.57	0.41	10.71	20.81	0.06	0.00	10.34	18.94	26.04	0.00	9.16	20.81	0.06	0.00	9.10
11:43 AM	19.56	20.81	0.06	0.00	17.47	19.68	2.11	0.35													
11:44 AM									10.74	20.81	0.06	0.00	10.37	18.98	26.02	0.00	9.22	20.81	0.06	0.00	9.14
11:45 AM	19.46	20.81	0.06	0.00	16.98	19.38	3.66	0.33	10.71	20.81	0.06	0.00	10.31	18.91	26.12	0.00					
11:46 AM																	9.19	20.81	0.06	0.00	9.02
11:47 AM	19.92	20.81	0.06	0.00	17.12	19.11	2.97	0.29	10.74	20.81	0.06	0.00	10.43	18.94	25.91	0.00	9.30	20.81	0.06	0.00	9.09
11:48 AM	19.49	20.81	0.06	0.00	16.51	19.32	4.37	0.21													
11:49 AM									10.88	20.81	0.06	0.00	10.37	18.99	25.88	0.00	9.38	20.81	0.06	0.00	9.07
11:50 AM	19.70	20.81	0.06	0.00	16.31	19.61	4.39	0.14	10.75	20.81	0.06	0.00	10.43	18.69	26.19	0.00					
11:51 AM																	9.33	20.81	0.06	0.00	9.20
11:52 AM	19.45	20.81	0.06	0.00	16.06	20.40	3.89	0.09	10.79	20.81	0.06	0.00	10.53	18.52	26.09	0.00	9.30	20.81	0.06	0.00	9.16
11:53 AM	20.03	20.81	0.06	0.00	16.16	20.18	3.25	0.05													
11:54 AM									10.97	20.81	0.06	0.00	10.68	18.50	25.87	0.00	9.29	20.81	0.06	0.00	9.18
11:55 AM	19.88	20.81	0.06	0.00	16.18	20.79	2.73	0.03	11.10	20.81	0.06	0.00	10.75	18.48	25.55	0.00					
11:56 AM																	9.33	20.81	0.06	0.00	9.24
11:57 AM	19.53	20.81	0.06	0.00	15.86	21.24	2.65	0.01	11.15	20.81	0.06	0.00	10.77	18.52	25.54	0.00	9.31	20.81	0.06	0.00	9.19
11:58 AM	19.36	20.81	0.06	0.00	15.93	21.21	3.09	0.01													
11:59 AM									10.97	20.81	0.06	0.00	10.63	18.34	26.06	0.00	9.33	20.81	0.06	0.00	9.17
12:00 PM	18.88	20.81	0.06	0.00	15.40	21.58	4.26	0.00	10.83	20.81	0.06	0.00	10.34	18.41	26.55	0.00					
12:01 PM																	9.25	20.81	0.06	0.00	8.95
12:02 PM	18.32	20.81	0.06	0.00	14.91	21.77	5.43	0.00	10.79	20.81	0.06	0.00	10.22	18.45	26.96	0.00	9.18	20.81	0.06	0.00	8.92
12:03 PM	18.18	20.81	0.06	0.00	14.80	21.85	5.47	0.00													
12:04 PM									10.43	20.81	0.06	0.00	10.10	18.17	28.06	0.00	9.15	20.81	0.06	0.00	8.83
12:05 PM	17.19	20.81	0.06	0.00	13.75	21.53	8.97	0.00	10.31	20.81	0.06	0.00	10.02	18.22	28.33	0.00					
12:06 PM																	9.03	20.81	0.06	0.00	8.77
12:07 PM	17.16	20.81	0.07	0.00	13.64	21.98	8.96	0.00	10.35	20.81	0.06	0.00	9.83	18.48	27.85	0.00	9.02	20.81	0.06	0.00	8.68
12:08 PM	17.72	20.81	0.06	0.00	14.13	22.43	6.66	0.00													
12:09 PM									10.34	20.81	0.06	0.00	9.88	18.60	27.68	0.00	8.98	20.81	0.06	0.00	8.71
12:10 PM	18.09	20.81	0.06	0.00	14.61	22.64	5.42	0.00	10.47	20.81	0.06	0.00	9.93	18.92	27.05	0.00					
12:11 PM																	8.92	20.81	0.06	0.00	8.67
12:12 PM	17.93	20.81	0.06	0.00	14.56	22.63	5.42	0.00	10.49	20.81	0.06	0.00	9.95	19.12	26.73	0.00	8.94	20.81	0.06	0.00	8.70
12:13 PM	17.68	20.81	0.06	0.00	14.40	22.95	5.54	0.00													
12:14 PM									10.32	20.81	0.06	0.00	9.93	18.94	27.24	0.00	8.90	20.81	0.06	0.00	8.64
12:15 PM	17.80	20.81	0.06	0.00	14.41	22.82	5.49	0.00	10.20	20.81	0.06	0.00	9.78	18.99	27.64	0.00					
12:16 PM																	8.81	20.81	0.06	0.00	8.54
12:17 PM	17.47	20.81	0.06	0.00	13.94	22.90	6.38	0.00	9.99	20.81	0.06	0.00	9.63	19.01	27.81	0.00	8.68	20.81	0.06	0.00	8.32
12:18 PM																					
12:19 PM	16.79	20.82	0.06	0.00	13.41	22.86	8.51	0.00	11.56	20.82	0.06	0.00	10.30	21.84	21.40	0.00					
12:20 PM																	8.91	20.82	0.06	0.00	8.37

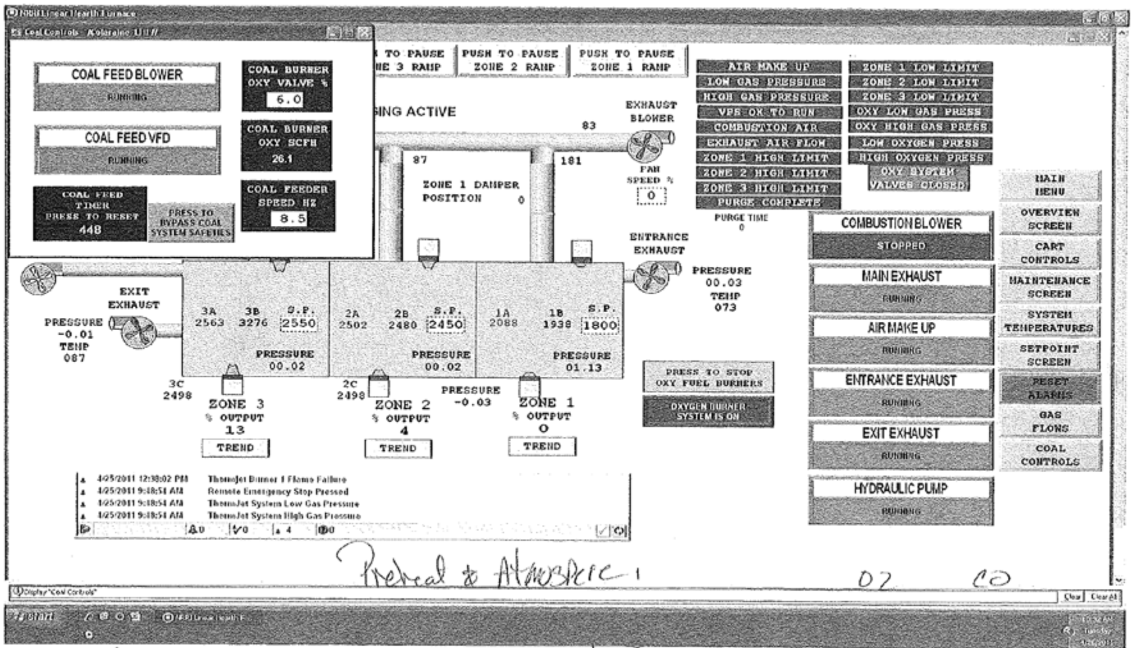
Single Briquette Layer with High Volatile Bituminous Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer Anthracite, per cart	Briquette (P269, per cart)	Cover Layer thracite, per c	Number of Sample Carts	Start Time	Stop Time
4/26/2011	1121	6.0	144 g/min	2000 g	1850 g	1530 g	4	11:27 AM	12:20 AM

Air Flow Measurements			
Time	**Flow (ft/min)**	**Temp (degF)**	**Notes**
11:05 AM	123	154	No Sample
11:55 AM	147	151.7	With Sample
12:10 PM	138	151	h Sample (all in Zone 3)

				Port 4								Testo Emission Data				
	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% O2	ppm CO	ppm NOx	ppm SO2	% CO2
11:27 AM	15.31	36.02	0.00									3.33	109324	752	319	10.45
11:28 AM				7.62	20.81	0.07	0.00	7.92	16.49	36.69	0.00	11.47	51270	555	0	5.36
11:29 AM	15.33	35.73	0.00	7.73	20.81	0.07	0.00	8.05	16.49	36.42	0.00	2.16	77024	610	0	10.86
11:30 AM												0.90	94081	611	0	11.26
11:31 AM	15.20	35.28	0.00	7.90	20.81	0.07	0.00	8.21	16.44	36.03	0.00	0.46	72492	633	0	11.45
11:32 AM	15.03	35.21	0.00									0.40	93765	652	0	11.52
11:33 AM				7.96	20.81	0.06	0.00	8.27	16.34	35.71	0.00	0.50	106688	664	0	11.44
11:34 AM	14.86	35.16	0.00	8.02	20.81	0.06	0.00	8.38	16.29	35.55	0.00	1.37	65553	653	35	10.79
11:35 AM												1.49	119989	553	31	11.28
11:36 AM	15.02	35.03	0.00	8.12	20.81	0.06	0.00	8.52	16.29	35.58	0.00	-0.61	76386	602	149	11.64
11:37 AM	15.00	34.74	0.00									-1.00	0	645	367	11.47
11:38 AM				8.18	20.81	0.06	0.00	8.54	16.22	35.22	0.00	-1.00	0	703	387	11.32
11:39 AM	14.82	34.78	0.00	8.20	20.81	0.06	0.00	8.59	16.24	35.17	0.00	-0.88	0	733	381	11.17
11:40 AM												-0.88	0	757	376	11.09
11:41 AM	14.83	34.64	0.00	8.24	20.81	0.06	0.00	8.63	16.29	35.14	0.00	-0.89	0	765	367	10.95
11:42 AM	14.77	34.52	0.00									-0.87	0	774	354	10.77
11:43 AM				8.26	20.81	0.06	0.00	8.61	16.28	35.12	0.00	-0.84	0	819	342	10.74
11:44 AM	14.85	34.59	0.00	8.26	20.81	0.06	0.00	8.55	16.29	35.13	0.00	-0.83	0	817	330	10.65
11:45 AM												-0.83	0	768	329	10.39
11:46 AM	14.86	34.48	0.00	8.25	20.81	0.06	0.00	8.61	16.33	35.00	0.00	-0.82	0	775	328	10.31
11:47 AM	14.92	34.64	0.00									-0.80	0	789	320	10.31
11:48 AM				8.28	20.81	0.06	0.00	8.69	16.41	35.19	0.00	-0.79	0	778	308	10.25
11:49 AM	14.98	34.47	0.00	8.28	20.81	0.06	0.00	8.63	16.43	35.07	0.00	-0.78	0	791	302	10.25
11:50 AM												-0.76	0	807	297	10.39
11:51 AM	14.94	34.47	0.00	8.21	20.81	0.06	0.00	8.67	16.40	35.18	0.00	-0.74	0	809	293	10.58
11:52 AM	14.88	34.42	0.00									-0.72	24440	814	256	10.66
11:53 AM				8.25	20.81	0.06	0.00	8.57	16.38	35.14	0.00	-0.67	37106	824	0	10.77
11:54 AM	14.90	34.41	0.00	8.27	20.81	0.06	0.00	8.54	16.42	35.05	0.00	-0.65	39265	797	0	10.83
11:55 AM												-0.64	40601	781	0	10.79
11:56 AM	14.88	34.35	0.00	8.23	20.81	0.06	0.00	8.48	16.44	35.17	0.00	-0.63	41792	790	0	10.88
11:57 AM	14.91	34.44	0.00									-0.61	42554	797	0	11.06
11:58 AM				8.19	20.81	0.06	0.00	8.49	16.40	35.23	0.00	-0.60	42939	797	0	11.15
11:59 AM	14.82	34.47	0.00	8.13	20.81	0.06	0.00	8.45	16.40	35.41	0.00	-0.43	19899	791	120	11.21
12:00 PM												-0.18	0	795	224	11.26
12:01 PM	14.90	34.81	0.00	8.11	20.81	0.06	0.00	8.33	16.38	35.77	0.00	-0.15	0	798	234	11.34
12:02 PM	14.93	35.05	0.00									-0.25	0	799	235	11.40
12:03 PM				8.00	20.81	0.06	0.00	8.13	16.38	35.97	0.00	-0.28	0	800	226	11.42
12:04 PM	14.95	35.49	0.00	7.84	20.81	0.06	0.00	8.05	16.40	36.50	0.00	-0.29	0	790	209	11.31
12:05 PM												-0.31	0	796	209	11.42
12:06 PM	14.91	35.62	0.00	7.78	20.81	0.07	0.00	7.93	16.36	36.63	0.00	-0.30	0	811	208	11.64
12:07 PM	14.96	35.39	0.00									-0.29	0	815	214	11.89
12:08 PM				7.77	20.81	0.06	0.00	8.00	16.47	36.48	0.00	-0.28	0	809	218	11.97
12:09 PM	14.98	35.21	0.00	7.88	20.81	0.06	0.00	7.99	16.50	36.19	0.00	-0.28	0	783	220	11.96
12:10 PM												-0.27	0	762	221	12.00
12:11 PM	14.98	35.20	0.00	7.91	20.81	0.06	0.00	8.05	16.52	36.01	0.00	-0.27	0	758	216	11.95
12:12 PM	15.14	35.35	0.00									-0.26	0	774	213	12.02
12:13 PM				7.90	20.81	0.06	0.00	8.16	16.62	35.94	0.00	-0.26	0	794	205	12.08
12:14 PM	15.21	35.35	0.00	7.85	20.81	0.06	0.00	7.96	16.63	35.96	0.00	-0.25	0	780	203	12.12
12:15 PM												-0.25	0	766	201	12.06
12:16 PM	15.18	35.64	0.00	7.74	20.81	0.06	0.00	7.98	16.63	36.31	0.00	-0.25	0	742	195	11.93
12:17 PM	15.27	35.86	0.00									-0.24	0	732	186	11.73
12:18 PM				7.64	20.81	0.06	0.00	7.70	16.65	36.61	0.00	-0.23	0	744	180	11.70
12:19 PM												-0.22	0	753	174	11.76
12:20 PM	16.85	32.41	0.00	7.95	20.82	0.06	0.00	7.78	18.11	34.56	0.00	-0.21	0	776	173	11.96

Tuesday, April 26, 2011 10:33:01 AM



Preheat & Atmosphere   O2   CO

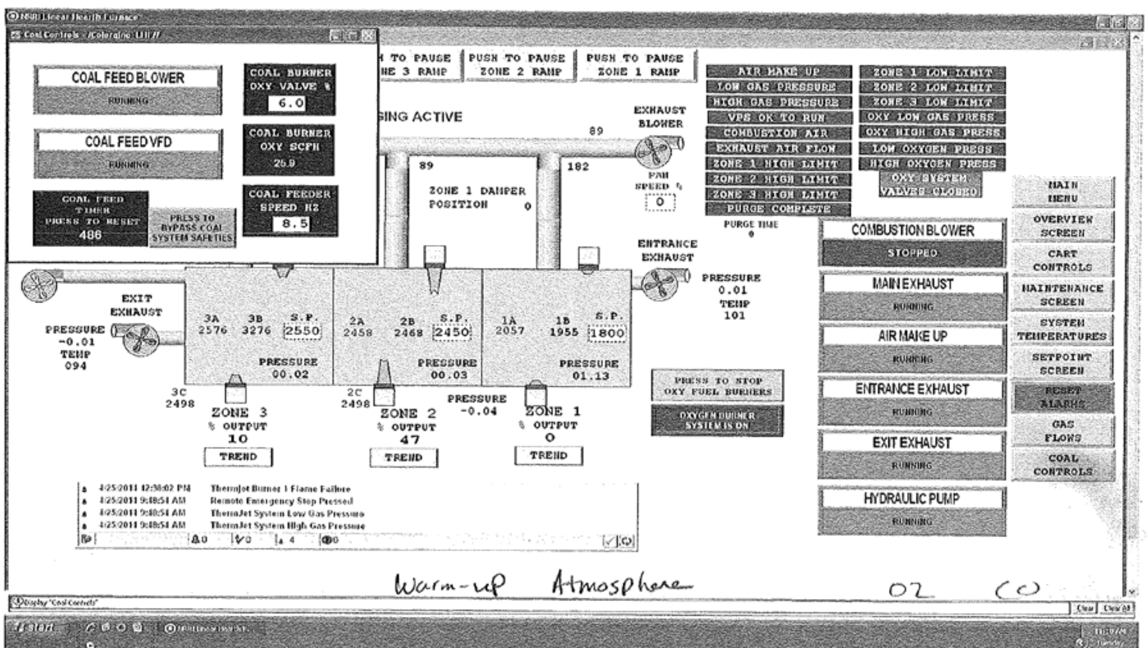
Test # N/A   Test # 1121
CAR SPEED 7
MIX N/A
INT. S/I

Convey 5.0 | 9.0
Prime 1.0 | 8.0

Feed-Rate. 72 Grams @ 30 Sec

O2	CO
0.000	4.8647
	6.3945
	5.2895
	3.4576

Tuesday, April 26, 2011 11:10:25 AM



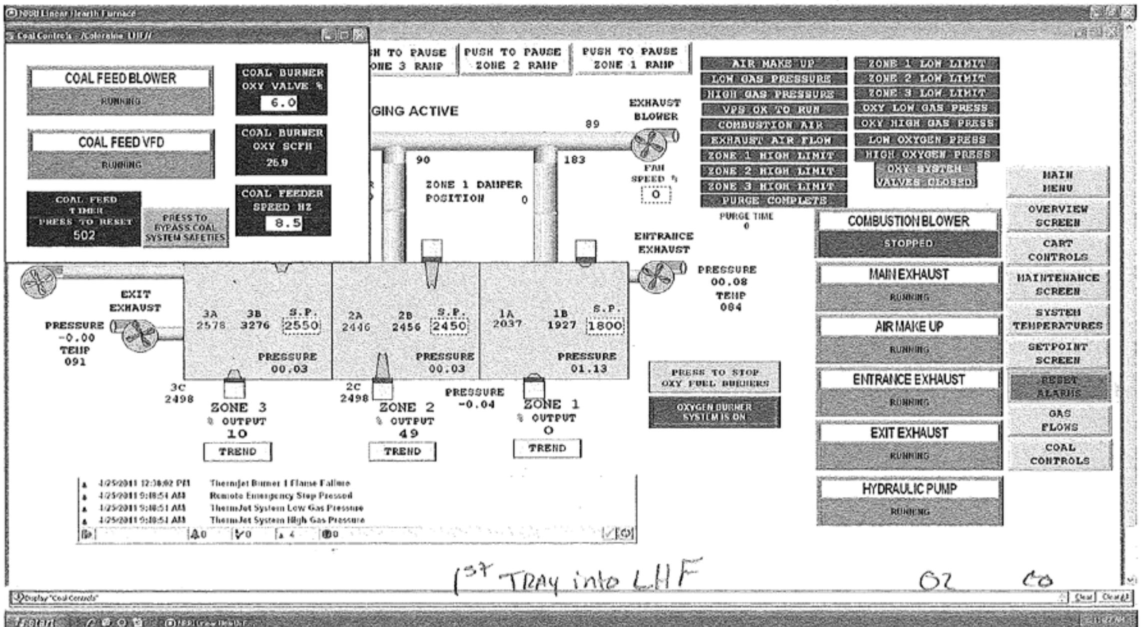
Warm-up Atmosphere   O2   CO

Test # N/A   Samples soon
CAR SPEED 6
MIX N/A
INT. S/I

Convey 5.5 | 10.0 ← Jeff Chang to 5.0
Prime 1.0 | 8.0

O2	CO
0.000	15.7412
	9.1520
	8.1325
	6.9580

Tuesday, April 26, 2011 11:27:14 AM

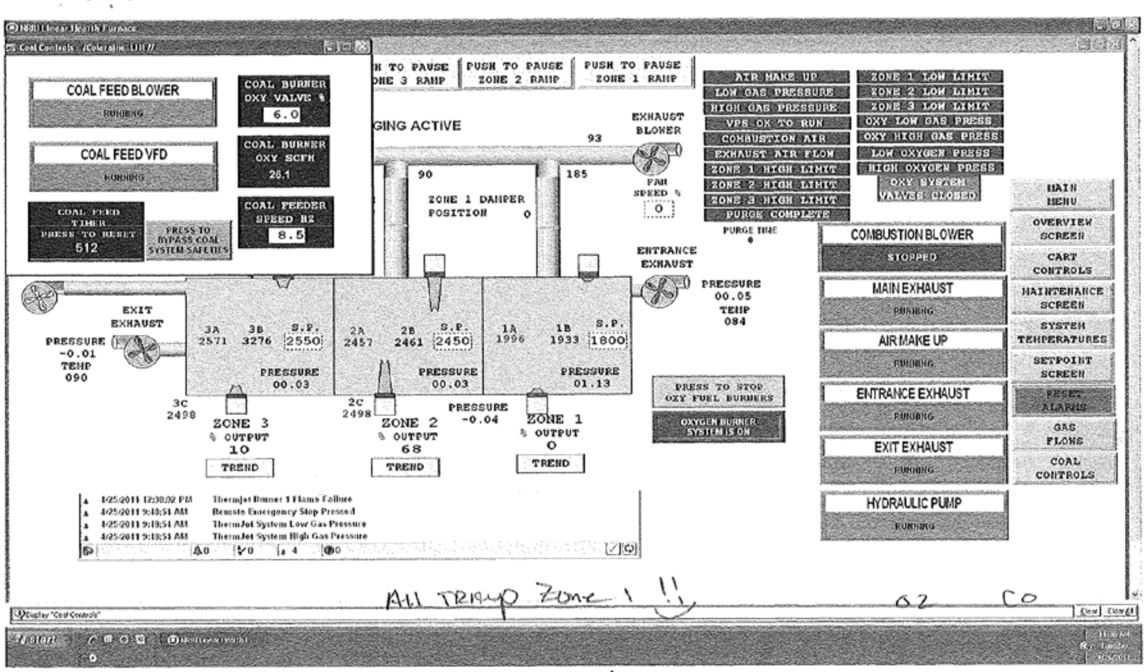


Test # 1121
CAR SPEED 6
MIX P269 w Teco
INT. S.G.

Convey 5.0 | 9.5
Prime 1.0 | 8.0

0.000 17.5685
10.6827
8.8415
7.7293

Tuesday, April 26, 2011 11:36:49 AM

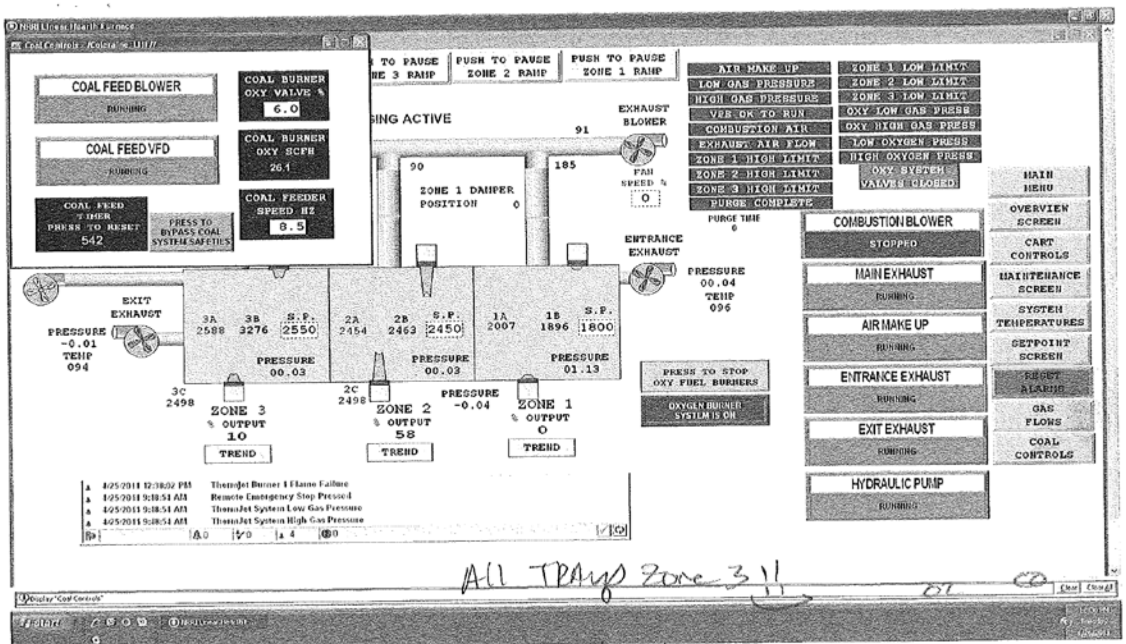


Test # 1121
CAR SPEED 6
MIX P269 Teco 4 TRAY
INT. S.G.

Convey 5.0 / 9.5
Prime 1.0 / 8.0

0.000 19.3358
10.6794
9.1811
8.2050

Tuesday, April 26, 2011 12:06:44 PM



Test # 112

CAR SPEED 16

MIX 8769 4 TRAYS TCOD

INT 5½

Convey 5.0 | 9.5

Prime 1.0 | 8.0

Total Time 44:20

0.000 17.7245
10.3421
8.9797
7.8794

Single Briquette Layer with Bio-Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer (Anthracite, per cart)	Briquette (P269, per cart)	Cover Layer (Anthracite, per cart)	Number of Sample Carts	Start Time	Stop Time
7/14/2011	1125	6.0	111 g/min	2000 g	1850 g	1530 g	4	8:52 AM	9:46 AM

Air Flow Measurements		
Zone	Flow (ft/min)	Temp (degF)
1	132	150.8
2	140	148.7
3	122	141.3

	LHF Data												
	Cart Pressure	Entrance Exhaust Output	Entrance Pressure	Exhaust Pressure	Exit Exhaust Output	OI Inches per Minute	Zone 1 Exhaust Output	Zone 1 Gas Flow	Zone 1 Oxygen Flow	Zone 1 PID CV	Zone 1 Pressure	Zone 1 Temp A	Zone 1 Temp B
8:52 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	159.78	246.25	0.00	1.13	2087.30	2000.30
8:53 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	166.34	273.50	0.00	1.13	2080.80	1995.80
8:54 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	173.47	269.75	0.00	1.13	2075.30	1988.20
8:55 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	176.91	306.63	0.00	1.13	2072.70	1982.10
8:56 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	179.10	239.00	0.00	1.13	2069.40	1977.60
8:57 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	183.57	266.13	0.00	1.13	2061.20	1966.70
8:58 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.63	283.13	0.00	1.13	2053.50	1958.30
8:59 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	176.60	284.13	0.00	1.13	2051.70	1958.00
9:00 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	180.55	261.50	0.00	1.13	2044.30	1948.20
9:01 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	179.62	264.63	0.00	1.13	2041.70	1945.90
9:02 AM	-0.04	100.00	0.07	0.00	100.00	6.00	0.00	175.76	289.75	0.00	1.13	2041.70	1945.30
9:03 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	189.98	235.75	0.00	1.13	2038.40	1941.20
9:04 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	185.97	245.50	0.00	1.13	2036.80	1938.30
9:05 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.00	283.38	0.00	1.13	2041.70	1942.30
9:06 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	174.83	279.63	0.00	1.13	2043.10	1946.60
9:07 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	169.78	247.63	0.00	1.13	2048.20	1951.50
9:08 AM	-0.04	100.00	0.07	0.00	100.00	6.00	0.00	197.37	246.38	0.00	1.13	2053.60	1959.30
9:09 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	174.46	251.50	0.00	1.13	2049.90	1957.50
9:10 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	186.80	267.75	0.00	1.13	2050.90	1962.80
9:11 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	180.60	246.75	0.00	1.13	2049.60	1962.80
9:12 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	175.45	266.38	0.00	1.13	2048.50	1962.40
9:13 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	180.55	265.88	0.00	1.13	2045.60	1961.70
9:14 AM	-0.04	100.00	0.06	0.00	100.00	6.00	0.00	174.62	283.13	0.00	1.13	2048.90	1962.60
9:15 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	182.95	272.63	0.00	1.13	2052.30	1966.90
9:16 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	193.67	294.38	0.00	1.13	2047.70	1961.70
9:17 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	184.09	305.13	0.00	1.13	2048.60	1962.50
9:18 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	188.99	305.88	0.00	1.13	2053.40	1966.10
9:19 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	194.66	285.63	0.00	1.13	2050.40	1961.30
9:20 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	186.96	255.13	0.00	1.13	2048.90	1962.10
9:21 AM	-0.04	100.00	0.08	0.00	100.00	6.00	0.00	173.63	282.13	0.00	1.13	2051.00	1964.90
9:22 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	170.82	276.63	0.00	1.13	2051.60	1962.70
9:23 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	185.97	283.13	0.00	1.13	2057.00	1965.80
9:24 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	173.94	260.25	0.00	1.13	2063.10	1974.40
9:25 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	170.50	303.38	0.00	1.13	2065.20	1973.90
9:26 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	171.34	235.00	0.00	1.13	2068.00	1978.60
9:27 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	177.32	270.00	0.00	1.13	2073.80	1983.90
9:28 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	176.02	238.63	0.00	1.13	2080.80	1989.90
9:29 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	182.01	295.88	0.00	1.13	2088.20	1996.40
9:30 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	185.55	247.75	0.00	1.13	2095.10	2004.10
9:31 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	170.87	310.50	0.00	1.13	2103.00	2011.40
9:32 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	185.92	272.63	0.00	1.13	2104.30	2013.00
9:33 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	178.16	294.38	0.00	1.13	2106.50	2018.30
9:34 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	180.81	287.75	0.00	1.13	2109.20	2018.70
9:35 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	174.46	242.88	0.00	1.13	2105.30	2017.50
9:36 AM	-0.04	100.00	0.04	0.00	100.00	6.00	0.00	180.08	246.13	0.00	1.13	2105.80	2017.20
9:37 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	176.18	242.25	0.00	1.13	2108.50	2020.40
9:38 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	181.85	279.00	0.00	1.13	2103.10	2015.30
9:39 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	183.21	254.25	0.00	1.13	2103.20	2017.70
9:40 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	179.36	263.25	0.00	1.13	2106.20	2021.20
9:41 AM	-0.04	100.00	0.01	0.00	100.00	6.00	0.00	180.29	253.50	0.00	1.13	2100.80	2015.50
9:42 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	176.75	244.00	0.00	1.13	2103.10	2017.50
9:43 AM	-0.04	100.00	0.02	0.00	100.00	6.00	0.00	190.70	235.75	0.00	1.13	2102.70	2017.60
9:44 AM	-0.04	100.00	0.00	0.00	100.00	6.00	0.00	178.00	276.38	0.00	1.13	2104.20	2017.20
9:45 AM	-0.04	100.00	0.03	0.00	100.00	6.00	0.00	192.06	276.00	0.00	1.13	2100.30	2013.40
9:46 AM	-0.04	100.00	0.05	0.00	100.00	6.00	0.00	176.28	283.38	0.00	1.13	2101.40	2016.30

Single Briquette Layer with Bio-Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Layer nthracite, per ca	Briquette (P269, per cart)	Cover Layer ınthracite, per ca	Number of Sample Carts	Start Time	Stop Time
7/14/2011	1125	6.0	111 g/min	2000 g	1850 g	1530 g	4	8:52 AM	9:46 AM

Air Flow Measurements		
Zone	Flow (ft/min)	Temp (degF)
1	132	150.8
2	140	148.7
3	122	141.3

	LHF Data															
	Zone 2 Exhaust Output	Zone 2 Gas Flow	Zone 2 Oxygen Flow	Zone 2 PID CV	Zone 2 Pressure	Zone 2 Temp A	Zone 2 Temp B	Zone 2 Temp C	Zone 3 Exhaust Output	Zone 3 Gas Flow	Zone 3 Oxygen Flow	Zone 3 PID CV	Zone 3 Pressure	Zone 3 Temp A	Zone 3 Temp B	Zone 3 Temp C
8:52 AM	0.00	315.67	472.03	26.76	0.03	2445.70	2442.10	2498.00	0.00	246.51	356.54	10.00	0.02	2593.50	3276.70	2498.00
8:53 AM	0.00	324.20	490.51	29.66	0.03	2439.60	2435.70	2498.00	0.00	246.35	321.11	10.00	0.02	2593.30	3276.70	2498.00
8:54 AM	0.00	331.43	492.63	30.71	0.03	2438.70	2434.40	2498.00	0.00	243.43	330.47	10.00	0.02	2591.00	3276.70	2498.00
8:55 AM	0.00	342.77	507.62	32.54	0.03	2436.50	2433.30	2498.00	0.00	243.75	360.29	10.00	0.02	2591.60	3276.70	2498.00
8:56 AM	0.00	354.32	527.35	35.58	0.03	2431.50	2431.90	2498.00	0.00	244.64	413.21	10.00	0.02	2591.60	3276.70	2498.00
8:57 AM	0.00	450.23	685.19	56.54	0.03	2434.70	2432.70	2498.00	0.00	243.43	369.34	10.00	0.02	2591.10	3276.70	2498.00
8:58 AM	0.00	453.72	678.07	57.16	0.03	2443.30	2444.60	2498.00	0.00	242.45	321.57	10.00	0.02	2590.10	3276.70	2498.00
8:59 AM	0.00	372.63	646.10	38.19	0.03	2448.80	2451.60	2498.00	0.00	244.56	331.88	10.00	0.02	2585.70	3276.70	2498.00
9:00 AM	0.00	382.09	561.94	41.33	0.03	2441.90	2444.40	2498.00	0.00	244.73	404.78	10.00	0.02	2581.90	3276.70	2498.00
9:01 AM	0.00	387.19	572.68	42.56	0.03	2440.30	2442.90	2498.00	0.00	243.26	391.35	10.00	0.02	2583.70	3276.70	2498.00
9:02 AM	0.00	386.77	588.29	41.68	0.03	2443.70	2443.60	2498.00	0.00	245.05	396.35	10.00	0.02	2588.30	3276.70	2498.00
9:03 AM	0.00	388.18	583.92	42.17	0.03	2443.70	2441.50	2498.00	0.00	244.24	367.62	10.00	0.02	2592.70	3276.70	2498.00
9:04 AM	0.00	391.25	587.91	42.99	0.03	2442.80	2441.00	2498.00	0.00	242.53	405.09	10.00	0.02	2591.70	3276.70	2498.00
9:05 AM	0.00	388.18	569.18	38.90	0.02	2453.70	2439.60	2498.00	0.00	241.31	356.70	10.00	0.02	2591.50	3276.70	2498.00
9:06 AM	0.00	393.28	575.05	43.82	0.02	2443.10	2442.90	2498.00	0.00	243.67	316.42	10.00	0.02	2594.00	3276.70	2498.00
9:07 AM	0.00	393.64	594.16	44.21	0.03	2442.30	2443.10	2498.00	0.00	242.78	380.11	10.00	0.02	2595.80	3276.70	2498.00
9:08 AM	0.00	393.85	589.54	43.12	0.03	2446.00	2446.40	2498.00	0.00	243.34	414.30	10.00	0.02	2597.20	3276.70	2498.00
9:09 AM	0.00	393.48	586.54	44.11	0.03	2444.40	2443.00	2498.00	0.00	244.24	404.62	10.00	0.02	2598.80	3276.70	2498.00
9:10 AM	0.00	401.08	595.03	45.68	0.03	2441.00	2442.90	2498.00	0.00	240.34	364.50	10.00	0.02	2595.30	3276.70	2498.00
9:11 AM	0.00	400.56	607.89	45.25	0.03	2444.00	2446.20	2498.00	0.00	242.94	394.32	10.00	0.02	2591.20	3276.70	2498.00
9:12 AM	0.00	403.47	592.91	47.19	0.03	2440.30	2443.70	2498.00	0.00	244.81	381.83	10.00	0.02	2594.60	3276.70	2498.00
9:13 AM	0.00	407.58	609.27	47.72	0.03	2440.50	2442.60	2498.00	0.00	241.15	350.14	10.00	0.02	2587.90	3276.70	2498.00
9:14 AM	0.00	503.65	749.50	68.46	0.03	2444.40	2446.50	2498.00	0.00	239.44	316.42	10.00	0.02	2586.10	3276.70	2498.00
9:15 AM	0.00	405.55	588.91	46.84	0.03	2454.70	2457.10	2498.00	0.00	243.67	332.81	10.00	0.02	2591.80	3276.70	2498.00
9:16 AM	0.00	417.83	619.38	49.65	0.03	2447.60	2449.10	2498.00	0.00	242.45	349.36	10.00	0.02	2592.60	3276.70	2498.00
9:17 AM	0.00	433.48	654.85	52.74	0.03	2441.10	2447.40	2498.00	0.00	242.29	311.74	10.00	0.02	2590.40	3276.70	2498.00
9:18 AM	0.00	427.76	659.59	51.93	0.03	2444.20	2448.80	2498.00	0.00	243.02	312.21	10.00	0.02	2588.30	3276.70	2498.00
9:19 AM	0.00	428.70	653.47	51.74	0.03	2445.60	2446.20	2498.00	0.00	242.69	371.37	10.00	0.02	2589.10	3276.70	2498.00
9:20 AM	0.00	429.11	652.22	53.36	0.03	2443.20	2448.30	2498.00	0.00	243.59	401.97	10.00	0.02	2592.50	3276.70	2498.00
9:21 AM	0.00	437.75	647.73	53.06	0.03	2444.30	2447.90	2498.00	0.00	242.04	384.64	10.00	0.02	2595.90	3276.70	2498.00
9:22 AM	0.00	440.09	645.60	53.90	0.03	2443.40	2445.70	2498.00	0.00	240.50	375.90	10.00	0.02	2598.80	3276.70	2498.00
9:23 AM	0.00	438.22	643.61	53.60	0.03	2445.00	2449.50	2498.00	0.00	241.15	326.10	10.00	0.02	2597.90	3276.70	2498.00
9:24 AM	0.00	434.73	642.36	51.73	0.03	2450.10	2454.50	2498.00	0.00	242.86	361.07	10.00	0.02	2598.20	3276.70	2498.00
9:25 AM	0.00	424.85	641.73	50.46	0.03	2453.10	2453.60	2498.00	0.00	240.18	388.54	10.00	0.02	2597.60	3276.70	2498.00
9:26 AM	0.00	415.43	623.63	49.51	0.03	2454.70	2456.30	2498.00	0.00	242.21	415.86	10.00	0.02	2596.90	3276.70	2498.00
9:27 AM	0.00	417.67	615.51	47.64	0.03	2458.30	2459.20	2498.00	0.00	243.26	418.20	10.00	0.02	2596.50	3276.70	2498.00
9:28 AM	0.00	411.06	625.87	48.41	0.03	2455.30	2456.00	2498.00	0.00	242.61	351.23	10.00	0.02	2599.50	3276.70	2498.00
9:29 AM	0.00	408.31	617.26	47.12	0.03	2456.20	2459.00	2498.00	0.00	242.45	303.62	10.00	0.02	2599.20	3276.70	2498.00
9:30 AM	0.00	399.67	609.77	44.80	0.03	2461.80	2464.40	2498.00	0.00	242.94	327.04	10.00	0.02	2596.80	3276.70	2498.00
9:31 AM	0.00	397.59	592.28	44.85	0.03	2459.70	2463.30	2498.00	0.00	243.43	332.19	10.00	0.02	2598.90	3276.70	2498.00
9:32 AM	0.00	393.74	589.29	42.87	0.03	2462.80	2464.90	2498.00	0.00	243.75	406.65	10.00	0.02	2595.90	3276.70	2498.00
9:33 AM	0.00	383.29	580.54	40.18	0.03	2467.20	2469.60	2498.00	0.00	244.08	352.33	10.00	0.02	2595.60	3276.70	2498.00
9:34 AM	0.00	368.57	554.07	37.35	0.03	2471.10	2471.40	2498.00	0.00	241.48	339.37	10.00	0.02	2598.80	3276.70	2498.00
9:35 AM	0.00	358.37	542.46	35.05	0.03	2473.20	2470.50	2498.00	0.00	242.13	356.54	10.00	0.02	2597.40	3276.70	2498.00
9:36 AM	0.00	352.34	520.98	33.66	0.03	2472.90	2469.80	2498.00	0.00	243.43	418.83	10.00	0.02	2596.60	3276.70	2498.00
9:37 AM	0.00	337.88	508.74	30.16	0.03	2476.50	2470.80	2498.00	0.00	242.21	403.84	10.00	0.02	2599.20	3276.70	2498.00
9:38 AM	0.00	327.95	498.25	28.98	0.03	2476.20	2466.50	2498.00	0.00	242.94	315.49	10.00	0.02	2606.50	3276.70	2498.00
9:39 AM	0.00	316.40	475.40	26.23	0.03	2478.50	2467.70	2498.00	0.00	245.38	364.19	10.00	0.02	2608.60	3276.70	2498.00
9:40 AM	0.00	299.13	443.81	22.59	0.02	2482.40	2471.10	2498.00	0.00	246.35	409.77	10.00	0.02	2608.60	3276.70	2498.00
9:41 AM	0.00	295.23	435.31	21.40	0.02	2480.30	2463.30	2498.00	0.00	245.21	395.10	10.00	0.02	2607.00	3276.70	2498.00
9:42 AM	0.00	283.79	405.47	18.92	0.03	2481.30	2465.50	2498.00	0.00	245.05	381.99	10.00	0.02	2610.00	3276.70	2498.00
9:43 AM	0.00	277.55	423.45	17.68	0.02	2479.10	2466.80	2498.00	0.00	246.59	347.96	10.00	0.02	2609.70	3276.70	2498.00
9:44 AM	0.00	285.97	422.08	20.50	0.02	2468.10	2456.60	2498.00	0.00	244.16	345.77	10.00	0.02	2611.10	3276.70	2498.00
9:45 AM	0.00	289.25	431.44	22.00	0.03	2461.70	2453.60	2498.00	0.00	244.81	404.00	10.00	0.02	2611.40	3276.70	2498.00
9:46 AM	0.00	293.93	434.32	21.52	0.02	2461.10	2454.50	2498.00	0.00	243.67	351.39	10.00	0.02	2613.30	3276.70	2498.00

Single Briquette Layer with Bio-Coal in Coal Feeder

Date	Sample Number	Run Speed	Coal Feeder Throughput	Hearth Laye hracite, per	Briquette P269, per cart	Cover Layer Anthracite, per car	Number of Sample Carts	Start Time	Stop Time
7/14/2011	1125	6.0	111 g/min	2000 g	1850 g	1530 g	4	8:52 AM	9:46 AM

Air Flow Measurements		
Zone	Flow (ft/min)	Temp (degF)
1	132	150.8
2	140	148.7
3	122	141.3

	LGA Data																	
	Port 1								Port 2								Port 3	
	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor
8:52 AM																	1.95	20.51
8:53 AM	10.60	20.51	0.06	0.00	7.96	29.50	17.12	0.00	3.11	20.51	0.06	0.00	3.77	17.56	47.31	0.00	2.04	20.51
8:54 AM	10.84	20.51	0.06	0.00	8.32	28.61	17.30	0.00										
8:55 AM									3.19	20.51	0.05	0.00	3.93	17.56	46.97	0.00	2.10	20.51
8:56 AM	11.95	20.51	0.06	0.00	8.92	29.12	14.44	0.00	3.31	20.51	0.05	0.00	3.97	17.63	46.56	0.00		
8:57 AM																	2.12	20.51
8:58 AM	12.48	20.51	0.06	0.00	9.53	28.67	13.25	0.00	3.38	20.51	0.06	0.00	4.11	17.76	46.45	0.00	2.17	20.51
8:59 AM	13.41	20.51	0.06	0.00	10.50	28.56	10.85	0.06										
9:00 AM									3.51	20.51	0.06	0.00	4.23	17.84	46.15	0.00	2.24	20.51
9:01 AM	14.27	20.51	0.06	0.00	11.52	27.95	8.71	0.13	3.65	20.51	0.06	0.00	4.35	17.89	45.57	0.00		
9:02 AM																	2.41	20.51
9:03 AM	15.92	20.51	0.05	0.00	13.18	26.69	5.29	0.24	3.86	20.51	0.06	0.00	4.60	17.86	44.82	0.00	2.54	20.51
9:04 AM	15.02	20.51	0.05	0.00	12.57	26.70	7.29	0.18										
9:05 AM									3.90	20.51	0.06	0.00	4.76	17.80	44.66	0.00	2.68	20.51
9:06 AM	14.67	20.51	0.05	0.00	12.40	25.83	9.10	0.22	4.00	20.51	0.06	0.00	4.77	17.66	44.55	0.00		
9:07 AM																	2.73	20.51
9:08 AM	13.14	20.51	0.06	0.00	11.26	25.82	12.71	0.22	4.03	20.51	0.06	0.00	4.84	17.50	44.61	0.00	2.73	20.51
9:09 AM	12.36	20.51	0.05	0.00	10.57	24.99	16.08	0.23										
9:10 AM									4.03	20.51	0.06	0.00	4.81	17.44	44.78	0.00	2.79	20.51
9:11 AM	12.28	20.51	0.06	0.00	10.12	25.84	15.89	0.16	4.08	20.51	0.06	0.00	4.94	17.45	44.73	0.00		
9:12 AM																	2.84	20.51
9:13 AM	12.67	20.51	0.05	0.00	10.02	25.89	15.61	0.13	4.14	20.51	0.06	0.00	4.88	17.41	44.75	0.00	2.89	20.51
9:14 AM	13.39	20.51	0.06	0.00	10.18	26.24	14.24	0.09										
9:15 AM									4.25	20.51	0.05	0.00	5.03	17.53	44.32	0.00	2.98	20.51
9:16 AM	14.17	20.51	0.06	0.00	10.75	26.55	11.79	0.05	4.34	20.51	0.06	0.00	5.07	17.52	43.89	0.00		
9:17 AM																	3.05	20.51
9:18 AM	15.46	20.51	0.05	0.00	11.66	27.21	7.95	0.02	4.55	20.51	0.06	0.00	5.19	17.80	43.22	0.00	3.27	20.51
9:19 AM	16.07	20.51	0.06	0.00	12.18	27.09	6.30	0.00										
9:20 AM									4.72	20.51	0.06	0.00	5.40	17.81	42.58	0.00	3.36	20.51
9:21 AM	16.69	20.51	0.06	0.00	12.47	27.67	4.13	0.00	4.98	20.51	0.06	0.00	5.58	17.78	42.10	0.00		
9:22 AM																	3.58	20.51
9:23 AM	16.64	20.51	0.06	0.00	12.83	27.71	3.72	0.00	5.09	20.51	0.06	0.00	5.71	17.88	41.80	0.00	3.61	20.51
9:24 AM	16.85	20.51	0.06	0.00	13.00	27.52	3.71	0.00										
9:25 AM									5.11	20.51	0.06	0.00	5.74	17.81	41.70	0.00	3.77	20.51
9:26 AM	15.00	20.51	0.06	0.00	12.03	27.27	7.68	0.00	5.16	20.51	0.06	0.00	5.78	17.63	41.87	0.00		
9:27 AM																	3.78	20.51
9:28 AM	14.95	20.51	0.06	0.00	11.82	27.56	7.86	0.00	5.15	20.51	0.06	0.00	5.80	17.52	41.87	0.00	3.76	20.51
9:29 AM																		
9:30 AM	14.28	20.51	0.05	0.00	11.46	28.38	7.87	0.00	6.60	20.51	0.06	0.00	6.40	20.88	35.00	0.00		
9:31 AM																	4.27	20.51
9:32 AM	13.04	20.51	0.06	0.00	10.34	27.07	13.11	0.00	5.37	20.51	0.06	0.00	5.94	18.52	40.18	0.00	3.74	20.51
9:33 AM	11.88	20.51	0.06	0.00	9.12	27.00	16.50	0.00										
9:34 AM									5.07	20.51	0.05	0.00	5.65	18.16	41.48	0.00	3.70	20.51
9:35 AM	11.37	20.51	0.06	0.00	8.79	27.14	17.62	0.00	4.91	20.51	0.06	0.00	5.45	18.06	42.04	0.00		
9:36 AM																	3.61	20.51
9:37 AM	11.24	20.51	0.06	0.00	8.64	27.55	17.60	0.00	4.84	20.51	0.06	0.00	5.38	18.00	42.42	0.00	3.56	20.51
9:38 AM	10.47	20.51	0.06	0.00	8.11	27.80	18.86	0.00										
9:39 AM									4.70	20.51	0.06	0.00	5.24	17.97	42.60	0.00	3.55	20.51
9:40 AM	10.03	20.51	0.06	0.00	7.86	28.10	19.53	0.00	4.72	20.51	0.06	0.00	5.24	18.00	42.72	0.00		
9:41 AM																	3.51	20.51
9:42 AM	8.85	20.51	0.06	0.00	7.15	28.16	21.91	0.00	4.62	20.51	0.06	0.00	5.12	18.00	43.02	0.00	3.29	20.51
9:43 AM	7.75	20.51	0.06	0.00	6.50	28.87	23.33	0.00										
9:44 AM									4.23	20.51	0.05	0.00	4.82	18.23	43.56	0.00	2.84	20.51
9:45 AM	6.85	20.51	0.06	0.00	5.83	28.90	25.12	0.00	3.84	20.51	0.06	0.00	4.44	18.21	44.59	0.00		
9:46 AM																	2.45	20.51

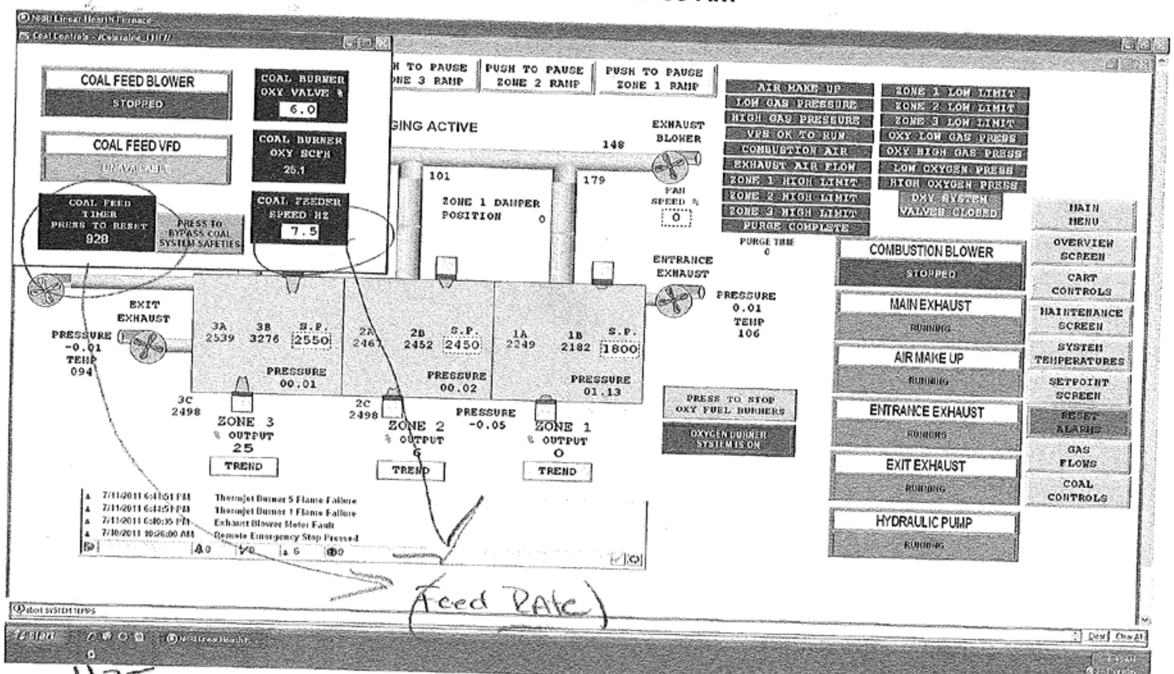
Single Briquette Layer with Bio-Coal in Coal Feeder

Date	Sample Numb	Run Speed	Coal Feeder Throughput	Hearth Layer Anthracite, per car	Briquette P269, per car	Cover Layer Anthracite, per car	Number of Sample Carts	Start Time	Stop Time
7/14/2011	1125	6.0	111 g/min	2000 g	1850 g	1530 g	4	8:52 AM	9:46 AM

Air Flow Measurements		
Zone	Flow (ft/min)	Temp (degF)
1	132	150.8
2	140	148.7
3	122	141.3

	Port 3						Port 4								Testo Emission Data			
	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% Carbon Monoxi	% Water Vapor	% Ammonia	% Oxygen	% Hydrogen	% Carbon Dioxid	% Nitrogen	% Hydrocarbons	% O2	ppm CO	ppm NOx	% CO2
8:52 AM	0.06	0.00	2.50	19.51	48.21	0.00	0.63	20.51	0.06	0.00	1.37	21.15	49.50	0.00	-0.03	0	135	40.43
8:53 AM	0.06	0.00	2.61	19.57	47.76	0.00									-0.04	0	135	41.45
8:54 AM							0.67	20.51	0.06	0.00	1.42	21.33	49.17	0.00	-0.03	0	134	41.16
8:55 AM	0.06	0.00	2.75	19.54	47.64	0.00	0.74	20.51	0.06	0.00	1.47	21.38	48.98	0.00	-0.02	0	129	40.86
8:56 AM															-0.02	0	124	41.16
8:57 AM	0.06	0.00	2.67	19.48	47.50	0.00	0.79	20.51	0.06	0.00	1.48	21.29	48.81	0.00	-0.03	0	116	40.48
8:58 AM	0.06	0.00	2.71	19.55	47.63	0.00									-0.04	0	110	39.91
8:59 AM							0.84	20.51	0.06	0.00	1.51	21.40	48.77	0.00	-0.03	0	106	40.25
9:00 AM	0.06	0.00	2.78	19.56	47.46	0.00	0.89	20.51	0.06	0.00	1.53	21.55	48.41	0.00	-0.05	0	103	38.92
9:01 AM															-0.05	0	102	38.00
9:02 AM	0.06	0.00	2.95	19.42	47.18	0.00	0.99	20.51	0.06	0.00	1.70	21.90	47.69	0.00	-0.05	0	103	38.19
9:03 AM	0.06	0.00	3.08	19.51	46.52	0.00									-0.05	0	103	37.28
9:04 AM							1.08	20.51	0.06	0.00	1.76	21.90	47.50	0.00	-0.07	0	103	36.25
9:05 AM	0.06	0.00	3.19	19.58	46.22	0.00	1.16	20.51	0.06	0.00	1.86	21.76	47.29	0.00	-0.06	0	102	36.46
9:06 AM															-0.07	0	101	36.30
9:07 AM	0.06	0.00	3.29	19.49	46.07	0.00	1.18	20.51	0.06	0.00	1.86	21.71	47.33	0.00	-0.07	0	100	35.27
9:08 AM	0.06	0.00	3.29	19.44	46.16	0.00									-0.09	158000	99	35.52
9:09 AM							1.15	20.51	0.06	0.00	1.89	21.71	47.40	0.00	-0.08	0	100	36.25
9:10 AM	0.06	0.00	3.35	19.40	46.19	0.00	1.16	20.51	0.06	0.00	1.84	21.64	47.53	0.00	-0.08	0	102	36.29
9:11 AM															-0.08	0	104	36.19
9:12 AM	0.06	0.00	3.32	19.29	46.12	0.00	1.23	20.51	0.06	0.00	1.83	21.62	47.35	0.00	-0.07	0	109	37.49
9:13 AM	0.06	0.00	3.32	19.26	46.11	0.00									-0.07	0	111	37.99
9:14 AM							1.30	20.51	0.06	0.00	1.96	21.60	47.37	0.00	-0.07	0	112	38.16
9:15 AM	0.06	0.00	3.41	19.24	45.92	0.00	1.38	20.51	0.06	0.00	2.01	21.75	46.84	0.00	-0.07	0	111	38.48
9:16 AM															-0.05	0	113	38.91
9:17 AM	0.06	0.00	3.49	19.14	45.54	0.00	1.47	20.51	0.06	0.00	2.03	21.88	46.51	0.00	-0.06	0	116	39.21
9:18 AM	0.06	0.00	3.71	19.15	45.24	0.00									-0.05	0	118	39.97
9:19 AM							1.62	20.51	0.06	0.00	2.18	22.12	45.93	0.00	-0.04	0	118	39.97
9:20 AM	0.06	0.00	3.73	19.14	44.87	0.00	1.65	20.51	0.06	0.00	2.19	22.19	45.80	0.00	-0.05	0	116	39.50
9:21 AM															-0.03	0	121	40.63
9:22 AM	0.06	0.00	3.93	19.16	44.64	0.00	1.81	20.51	0.06	0.00	2.31	22.10	45.30	0.00	-0.03	0	133	40.77
9:23 AM	0.06	0.00	3.95	19.06	44.45	0.00									-0.03	0	132	39.13
9:24 AM							1.82	20.51	0.06	0.00	2.32	22.10	45.33	0.00	-0.03	0	134	39.39
9:25 AM	0.06	0.00	4.00	19.01	44.30	0.00	1.92	20.51	0.06	0.00	2.39	22.02	45.34	0.00	-0.04	0	138	39.69
9:26 AM															-0.04	0	132	38.88
9:27 AM	0.06	0.00	4.09	18.98	44.21	0.00	1.95	20.51	0.06	0.00	2.41	21.88	45.48	0.00	-0.05	0	129	39.88
9:28 AM	0.06	0.00	4.01	18.97	44.14	0.00									-0.04	0	129	40.46
9:29 AM							1.90	20.51	0.06	0.00	2.44	21.64	45.72	0.00	-0.05	0	126	38.69
9:30 AM															-0.07	0	127	37.98
9:31 AM	0.06	0.00	4.26	20.59	41.29	0.00	2.19	20.51	0.06	0.00	2.51	23.83	42.51	0.00	-0.05	0	139	39.06
9:32 AM	0.06	0.00	3.99	19.58	43.36	0.00									-0.06	0	137	38.68
9:33 AM							1.91	20.51	0.06	0.00	2.41	22.17	45.04	0.00	-0.06	0	127	38.13
9:34 AM	0.06	0.00	3.94	19.46	43.80	0.00	1.90	20.51	0.06	0.00	2.38	21.83	45.64	0.00	-0.07	0	130	38.91
9:35 AM															-0.06	0	129	38.85
9:36 AM	0.06	0.00	3.83	19.45	44.18	0.00	1.88	20.51	0.06	0.00	2.40	21.71	45.78	0.00	-0.05	111000	132	38.96
9:37 AM	0.06	0.00	3.89	19.48	44.14	0.00									-0.06	0	133	38.99
9:38 AM							1.86	20.51	0.06	0.00	2.34	21.56	45.86	0.00	-0.05	0	131	38.93
9:39 AM	0.06	0.00	3.85	19.52	44.21	0.00	1.89	20.51	0.06	0.00	2.40	21.58	45.88	0.00	-0.06	138000	145	39.42
9:40 AM															-0.06	156000	178	40.50
9:41 AM	0.06	0.00	3.90	19.64	44.12	0.00	1.91	20.51	0.06	0.00	2.46	21.55	45.93	0.00	-0.04	140000	211	41.84
9:42 AM	0.06	0.00	3.65	19.58	44.53	0.00									-0.04	140000	241	42.05
9:43 AM							1.59	20.51	0.06	0.00	2.22	21.61	46.16	0.00	-0.02	101000	244	42.31
9:44 AM	0.06	0.00	3.25	19.69	45.46	0.00	1.22	20.51	0.06	0.00	1.96	21.63	47.16	0.00	-0.02	125000	216	43.05
9:45 AM															-0.03	115000	184	42.36
9:46 AM	0.06	0.00	3.00	19.73	46.40	0.00	0.93	20.51	0.06	0.00	1.73	21.55	48.02	0.00	-0.03	119000	155	42.58

Thursday, July 14, 2011 6:45:33 AM



Test # 1125

CAR SPEED 6.0 = 44:20

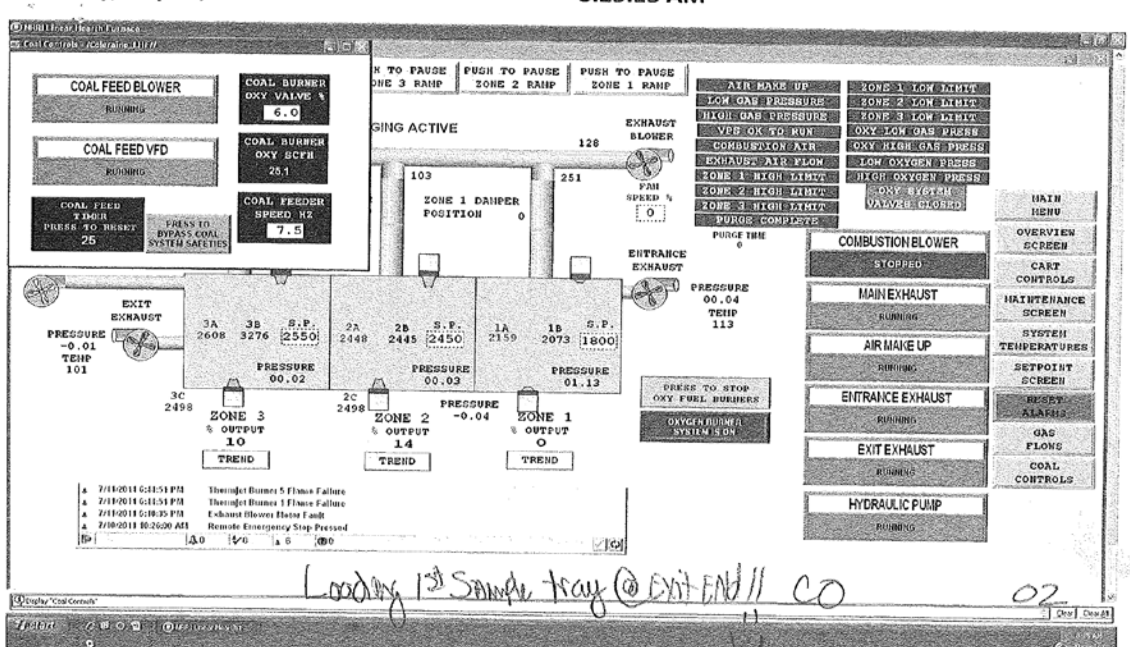
MIX ________

INT. ________

Convey____________

Prime____________

Thursday, July 14, 2011 8:25:13 AM



Test # N/A.

CAR SPEED 6

MIX N/A

INT. SG.

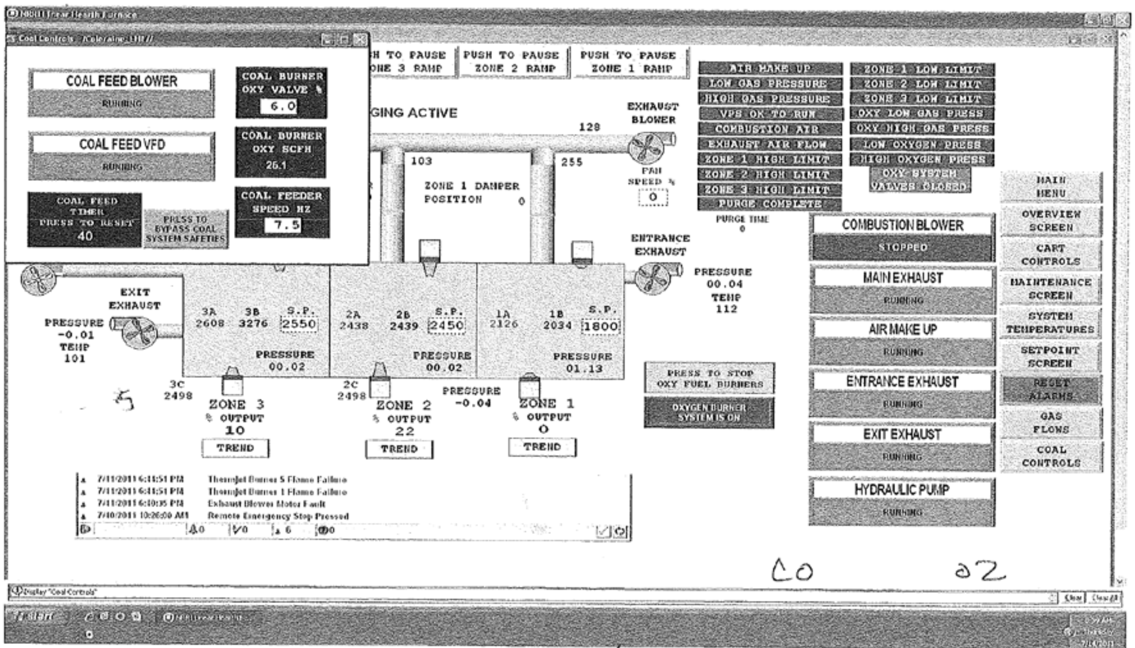
Vibrator is on Also under Coal Burner Feed Tube.

Convey 3.5 / 5.D

Prime 1.D / 8.D

8.2948	0.0000
2.5471	0.0000
1.5107	0.0000
0.2333	0.0000

Thursday, July 14, 2011 8:40:05 AM



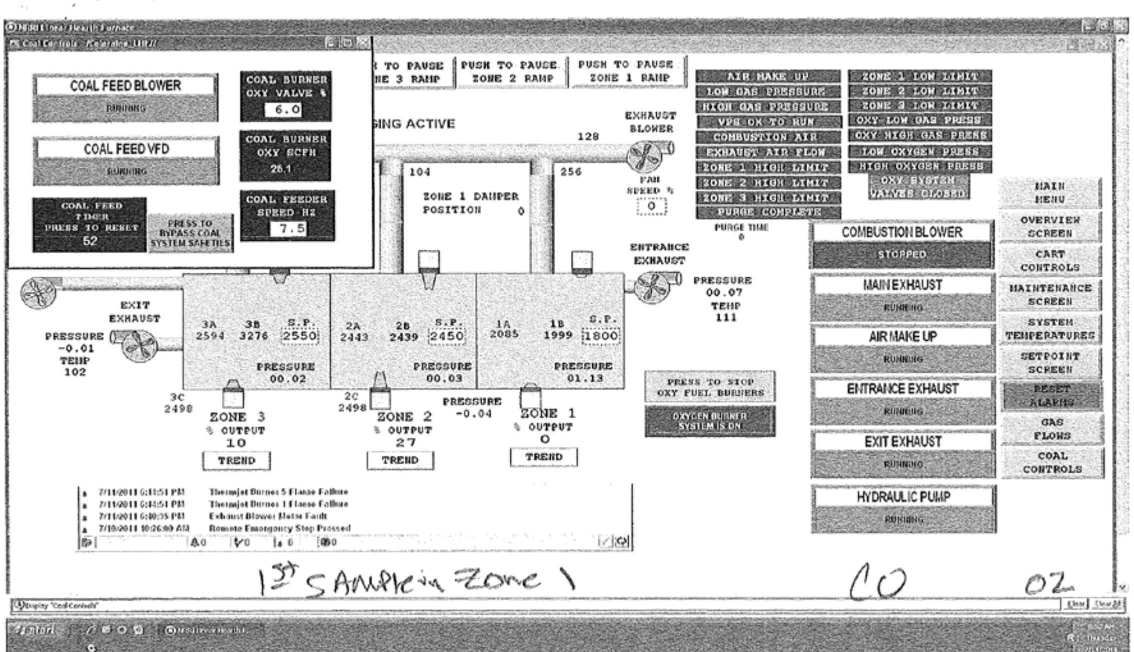
Test # ________
CAR SPEED _______
MIX _______
INT. ________

Convey 3.5 / 5.0
Prime 1.0 / 8.0

7.8611
2.8988
1.8403
0.5103

0.000

Thursday, July 14, 2011 8:52:40 AM



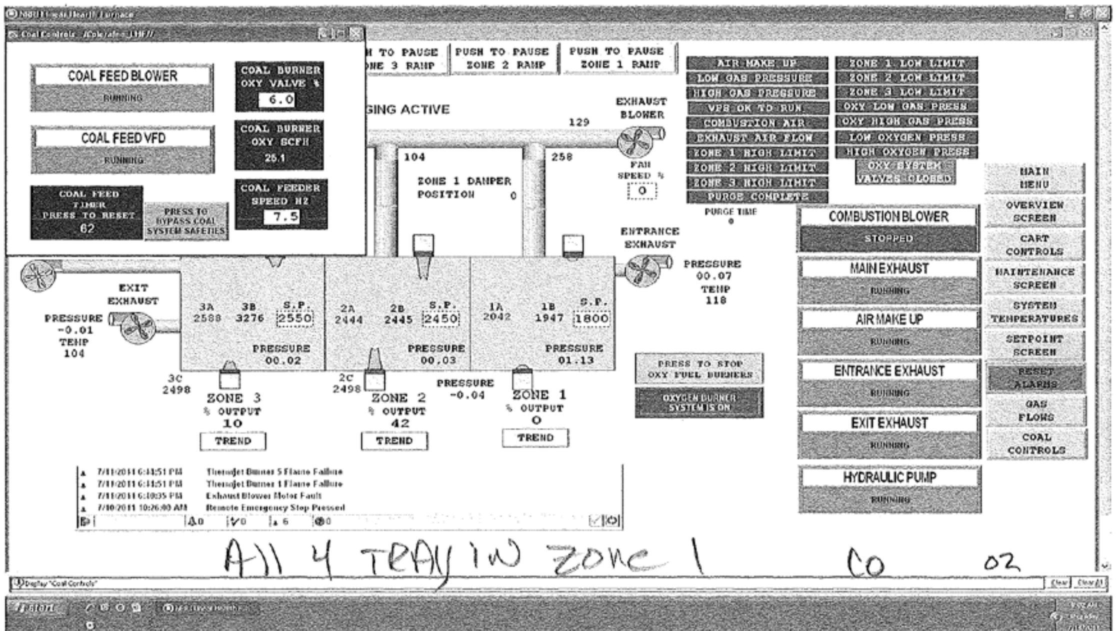
Test # 1125
CAR SPEED 6
MIX R269 / Torified Coal burner
INT. SW.

Convey 3.5 / 5.0
Prime 1.0 / 8.0

11.9521
3.3074
3.1226
8.7917

0.000

Thursday, July 14, 2011 9:02:17 AM



Test # 1125 A,B,C,D

CAR SPEED 6

MIX P7C9

INT. S/ri

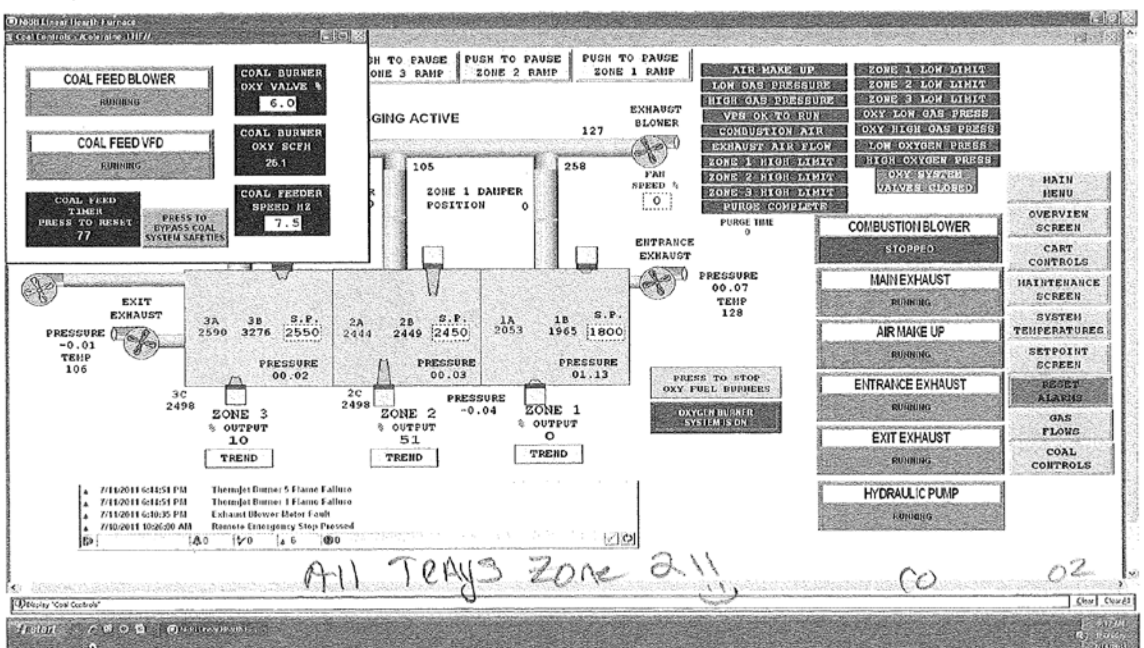
Convey 3.5 | 5.0

Prime 1.0 | 8.0

14.6655
3.9990
2.7312
1.1823

0.0000

Thursday, July 14, 2011 9:18:01 AM



Test # 1125

CAR SPEED 6

MIX P7C9

INT. S/9

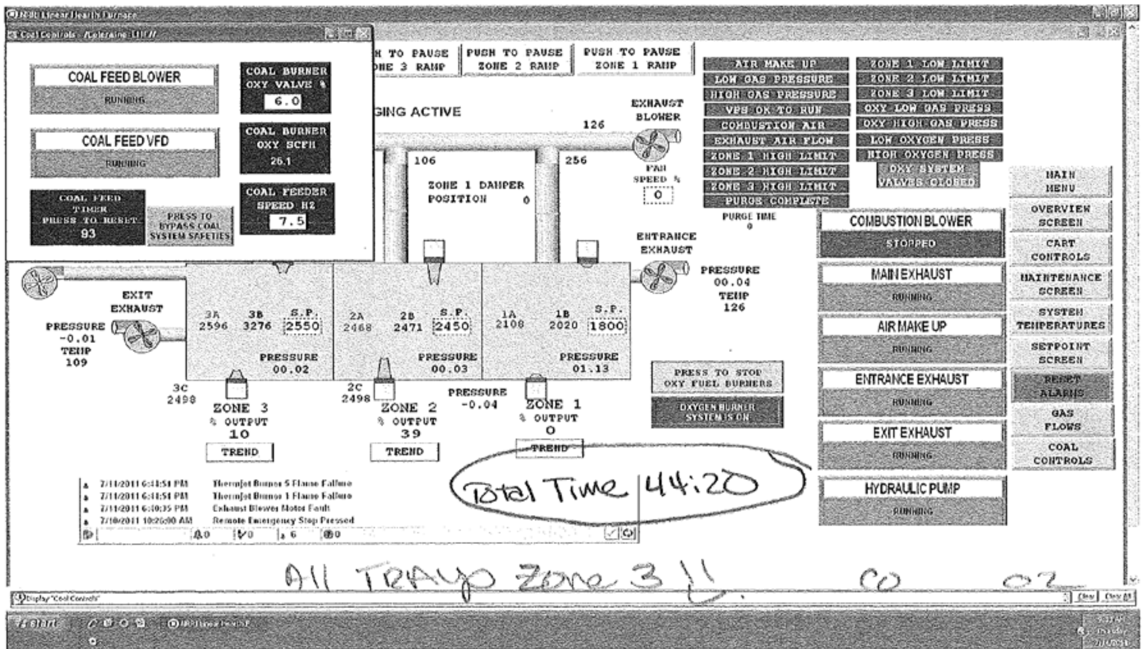
Convey 3.5 | 5.0

Prime 1.0 | 8.0

16.6942
4.9825
3.5785
1.8056

0.0000

Thursday, July 14, 2011 **9:33:31 AM**



Test # 1125 A,B,C,P

CAR SPEED 6

MIX D769 w/Torified Injected Thro. Coal burner

INT. SG.

Convey 3.5/5.0

Prime 1.0/8.0

11.2389
4.8356
3.5650
1.8640

0.0000