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PHASE II CALDERON PROCESS TO PRODUCE
DIRECT REDUCED IRON
RESEARCH AND DEVELOPMENT PROJECT

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Principal Author(s): ALBERT CALDERON

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Submitting
Organization(s)

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QUARTERLY TECHNICAL PROGRESS REPORT
PHASE II CALDERON PROCESS TO PRODUCE DIRECT REDUCED IRON
RESEARCH AND DEVELOPMENT PROJECT

CALDERON ENERGY COMPANY
COOPERATIVE AGREEMENT NO. DE-FC22-95PC92638

Reporting Period: 7-01-05 to 9-30-05

Date of Report: 10-14-05;

Phase II Award Date: 6-23-00; Anticipated Completion Date: 12-03-06

Total Project: \$ 14,732,316.00 Total DOE Share This Action: \$6,457,000.00

Contracting Officer's Representative (COR): John Stipanovich;

Project Director: Albert Calderon

Assistant Project Director: Reina Calderon

Abstract

This project was initially targeted to the making of coke for blast furnaces by using proprietary technology of Calderon in a phased approach, and Phase I was successfully completed. The project was then re-directed to the making of iron units. In 2000, U.S. Steel teamed up with Calderon for a joint effort which will last 42 months to produce directly reduced iron with the potential of converting it into molten iron or steel consistent with the Roadmap recommendations of 1998 prepared by the Steel Industry in cooperation with the Department of Energy by using iron ore concentrate and coal as raw materials, both materials being appreciably lower in cost than using iron pellets and coke.

The project was extended by 12 months, and a request was recently submitted for an additional year.

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Executive Summary

The commercialization path of the Calderon technology for making a feedstock for steelmaking with assistance from DOE initially focused on making coke and work was done which proved that the Calderon technology is capable of making good coke for hard driving blast furnaces. U.S. Steel which participated in such demonstration felt that the Calderon technology would be more meaningful in lowering the costs of making steel by adapting it to the making of iron - thus obviating the need for coke.

U.S. Steel and Calderon teamed up to jointly work together to demonstrate that the Calderon technology will produce in a closed system iron units from iron concentrate (ore) and coal competitively by eliminating pelletizing, sintering, coking and blast furnace operation. If such process steps could be eliminated, a huge reduction in polluting emissions and greenhouse gases (including CO₂) relating to steelmaking would ensue. Such reduction will restructure the steel industry away from the very energy-intensive steelmaking steps currently practiced and drastically reduce costs of making steel.

The development of a technology to lower U.S. steelmaking costs and become globally competitive is a priority of major importance. Therefore, the development work which Calderon is conducting presently under this Agreement with the U.S. Department of Energy becomes more crucial than ever.

During the 3rd quarter of 2005 which the present report covers, virtually all the effort to advance the Calderon technology to make iron units was concentrated towards forming a team with a steelmaker who needs both iron units in the form of hot metal and a substitute for natural gas (SNG), both being major contributors to higher costs in steelmaking. Calderon felt that a very good candidate would be Steel Dynamics (SDI) by virtue that it operates a rotary

hearth facility in Butler, Indiana that uses large amounts of natural gas to reduce briquettes made from ore and coal that they subsequently melt in a submerged arc furnace that is a large consumer of electric power. This facility is operated as a division of SDI under the name of Iron Dynamics (IDI). It is no secret that IDI has had and still has a great number of operational problems, including high cost for natural gas.

Experimental

During the quarter only one test run relating to making iron units was conducted and this run was a dry run in preparation for a test run for IDI's representatives to observe a test run of making hot metal. Because of conflicts in their schedules, postponements occurred. The Test Run was finally conducted on October 4th.

Results and Discussion:

On April 28, 2005 Calderon wrote a letter to Keith Busse, President of SDI regarding its technology for making hot metal from iron ore concentrate and coal without the formation of pellets or briquettes, and without using natural gas. Mark Millett, vice President and General Manager, contacted Calderon and a meeting was arranged for the 25th of August for Calderon to make a presentation of its technology in Butler, Indiana to David Bednarz, Plant Manager, and to Steve Rutherford, Manager of Engineering and Services.

The meeting which lasted 2 hours, went well by virtue that interest was shown in both ironmaking as well as the production of SNG, and Steve Rutherford was appointed as the contact person. On September 15, Steve Rutherford accompanied by Paul Wierzbowski, Operations Engineer, visited Calderon's facility. The visit lasted one-half a day covering

ironmaking and gasmaking and taking detailed notes of Calderon's unique operation, which also included the observation of the production of gas from high sulfur coal in Calderon's pilot.

At the end of the meeting, it was concluded that

- (i) a secrecy agreement be entered into;
- (ii) steps be taken to set up the Calderon pilot for a test run for making iron/carbon intermediate, homogenizing it into hot metal and casting the hot metal into pigs. IDI representatives would be present and samples would be taken to Butler for analysis. Calderon would be informed as to the date that IDI would make it.

- (iii) IDI would review the notes taken and if additional information were needed Calderon would be informed.

On September 20, Calderon received the e-mail (marked Attachment "A") requesting clarification to nine items of which one item related to the quality of gas, seven items related to making iron, and one item related to an administrative issue. The response to Attachment "A" was prepared and submitted to the attention of Rutherford on September 29, a copy of which is attached and marked as Attachment "B".

Developments With Respect to U.S. Steel:

During the Quarter which this Report covers, there were several contacts with U.S. Steel. At U.S. Steel Research, there have been changes in personnel. Fortunately, our main contact, David Rohaus, has not changed. He informed Calderon that the Research Department is being relocated; also, that he and his superiors, Messrs. Fortini and Serrano, would plan to visit Calderon after the 17th of October at which time Calderon would demonstrate the operation of its process of using ore concentrate and steam coal. Because of conflicts in schedules, the date was changed to the 27th of October by U.S. Steel.

Unfortunately, Albert Calderon will be out of town on that date. Arrangements are currently being made to meet at an early date suitable to both U.S. Steel and Calderon based on several dates that Calderon submitted to U.S. Steel. During this forthcoming meeting, Calderon's plan is to explain in detail its technology to Messrs. Fortini and Serrano, and its potential benefits to U.S. Steel by means of actually converting iron ore concentrate to hot metal using steam coal in its pilot. These two representatives from U.S. Steel have not previously observed the Calderon technology practiced. Calderon will also explain the relationship between SDI and Calderon, and invite U.S. Steel to join the team which Calderon is working towards forming with SDI.

Conclusion

During the forthcoming Quarter Calderon will concentrate on forming the team with SDI and hopefully with U.S. Steel joining such team. Once this team is formed, Calderon intends to take its technology to a higher level towards commercialization by presenting to the U.S. Department of Energy the next phase of this much needed development.

Submitted by:

Albert Calderon
Project Director

References

Burke, T., Osiniak, R. and Li, M., Ajax Magnethermic Corp. "Channel Induction Melt/Hold Technology at Nippon Steel Corp." Iron and Steel Magazine, November, 2000, pp. 51-54.

U.S. Steel, The Making, Shaping and Treating of Steel, Ninth Edition. Pittsburgh, Pennsylvania: Herbick & Held. 1971, p. 503.

Patty Ballard

From: <Steve.Rutherford@stld.com>
To: <CalBook@bghost.net>
Sent: Tuesday, September 20, 2005 10:28 AM

Patty,

Please forward list of questions to Albert.

1. What are the specifications for "lean" gas? Primary concern here is btu value and gas volumes required.
2. What are the specifications for ore, coal and lime:
3. What are the specifications for the iron product?
4. The current pro-forma is a million ton per year iron plant. Please forward a pro-forma for a 500, 000 ton per year iron plant?
5. The iron plant pro-forma does not include the following cost items that were listed in the channel furnace patent. Please explain?
 - a. electrical power
 - b. lime/dolo
 - c. oxygen
 - d. refractory
 - e. gas/oil
6. What reference information do you have on the pigging machine shown in Photo #15 i.e. capital, operating and maintenance costs?
7. What are the expected environmental emissions for the "Calderon Process"?
 - a. Nox
 - b. Sox
 - c. PM10
8. Please send copy of November 2000 article regarding channel furnace.
9. Please forward secrecy agreement and video presentation.

Best Regards,
Steve

10/05/2005

Attachment "A"

September 29, 2005

Mr. Steve Rutherford
Manager, Engineering and Services
Steel Dynamics, Inc.
4500 County Road 59
Butler, Indiana 46721

Re: Responses to Questions

Dear Steve:

In answer to the 9 items contained in your e-mail communication of 9/20/05, please find the following:

(1) Item 1: Specification of the Lean Gas

Analysis of Lean Gas

	H ₂	1.69%
	O ₂	0.99%
	N ₂	54.77%
	CO	40.33%
	CO ₂	1.23%
	<u>CH₄</u>	<u>0.99%</u>
Total		100.00%

Discussion: We have looked into the issue of your concern regarding the low Btu value of the lean gas and the large gas volumes required. The way to overcome this concern is to maintain the separation of the rich gas produced that is devolatilized from the coal and not to mix it with the lean gas produced in the air-blown char gasifier. This rich gas is similar to a coke oven gas whose hydrocarbons have been cracked; it yields a much hotter gas with low volume by virtue of the very low content of N₂.

Analysis of H₂ Rich Gas

H ₂	58.2%
O ₂	--
N ₂	0.6%
CO	19.4%
CO ₂	7.1%
CH ₄	13.0%
C ₂ H ₆	1.5%
C ₃ H ₈	0.2%
	<u>100.0%</u>

It is quite easy to keep the rich gas separated from the lean gas; see Exhibit 1. However, a provision must be made to furnish two complete and separate gas clean-up systems instead of a common one. In so doing the composite price for the gas would increase by 90 cents/mm Btu from \$3.60 to \$4.50/mm Btu and still be based on \$30/ton at the mine-mouth as a coal cost plus transportation as previously quoted. The decrease of the coal cost to \$23/mm Btu @ mine-mouth which was quoted to you, will help reduce the high cost of transportation.

The increase to \$4.50/mm Btu is to cover the cost of the additional gas cleanup system that is required and also for a discount that would be incurred from the \$3.60/mm Btu base price which is necessary to enable the sale of the very lean gas having only about 100 Btu/cu ft. Such very lean gas is similar to blast furnace gas. It can be used to raise steam and even used in combined cycle to generate power.

Item 2 – Specification for ore, coal, and limestone (i.e. size, moisture, etc.)

(i) Specification for ore:

See Exhibit 2 attached.

Size: < 300 mesh (estimate)

Moisture: 10% (estimate)

Specification for coal:

See Exhibit 3

Size: -1/4" crushed

Moisture: 7% (estimated)

Specification for limestone (dolomite):

See Exhibit 4.

Size: -3/4" x +1/2" crushed

Moisture: 4% (estimate)

Item 3 – Specification of iron product:

The results of three tests conducted by U.S. Steel on the Calderon iron/carbon product prior to homogenization are shown in Exhibit 5, pages 1, 2 and 3.

Discussion: Many years ago, when we approached U.S. Steel regarding our process to interest its forming a team with Calderon, the objective was to make hot metal, rather than a directly reduced iron (DRI) as known in the industry. U.S. Steel, however, wished to see whether the process could be applied to make DRI as an alternate to a rotary hearth. The iron product produced from the gasifier/metallizer/agglomerator (GMA) of Calderon turns out to be a non-uniform metallized iron/carbon product, and is not a DRI; some is steel, some is iron, some is semi-reduced material, and some is unreduced material. It must be "homogenized" prior to use.

In our development work, we have been gauging metallization on-the-fly by taking four samples from the product discharged hourly and grinding each sample at six different locations. By observing the characteristics of the sparks of the grind we conclude metallization. This test procedure allows us to gauge metallization in a crude way during test operations to make adjustments and to overcome the delays of sending samples out for wet chemistry, which can

take up to four weeks to obtain results. When we get 20 out of 24 grinds to spark (Exhibit 6) we assume that we achieved 80% metallization; when we get 24 out of 24 grinds to spark we assume that we achieved 100% metallization; when we get 12 out of 24 grinds to spark we assume that we achieved 50% metallization.

It is important to emphasize that the product we get from the GMA is only an intermediate product that needs to be homogenized by melting it to make hot metal. The product does contain excess carbon intertwined in the “chunky” product, making it an iron/carbon product having an ample reductant in close proximity to the unreduced iron oxide that insures complete metallization upon melting, rather than having loose FeO which attacks the lining of the melter. The carbon in the product yields large amounts of CO as an off-gas (Exhibit 7). The combustion of the CO above the bath is very beneficial particularly with respect to the reflective heat that radiates onto the bath.

When work on this technology with U.S.Steel as a teammate began, the objective was to make DRI, as U.S. Steel had recommended. But soon thereafter, it was found that our process was not suited to make DRI but an intermediate iron/carbon product which must be homogenized via melting to produce hot metal which was Calderon’s objective even before approaching U.S. Steel. This hot metal via the Calderon process when desulfurized makes hot metal comparable to blast furnace iron; see Exhibit 8 and 9 (previously submitted in our letter to Mr. Busse).

Since the ultimate objective from day 1 was to make hot metal from ore concentrate (fines) and coal, of blast furnace quality, we have investigated for many years as to what type of melter would be most suitable to homogenize the Calderon iron/carbon product produced from a GMA. My association with the steel industry began in the open hearth steelmaking which dealt with large area molten bath furnaces and hot metal mixers; see Exhibit 10. I approached Ed

Jennings, V.P. of Ajax Magnethermic in view of the announced work Ajax had done at Iscor; he recommended a channel furnace. Because of the developments at Iscor and Nippon Steel relating to the application of channel furnace technology, and the poor performance of the submerged arc furnace, we are more convinced than ever that the channel furnace is the best candidate for the homogenization of our product. We think that when the channel furnace is accompanied by our proprietary dunkers and supplemented by thermal energy released from post-combustion above the molten bath of the copious amounts of hot CO off-gas generated from the excess carbon contained in the iron/carbon product formed in our GMA's, we have an excellent chance of producing low cost hot metal in an elegant process that is environmentally benign as well as efficient.

Item 4: Pro-Forma for a 500,000 ton per year iron plant

See Exhibit 11 attached.

Item 5: Cost of sub-items (a through e) that were not included in the submitted pro-forma that were listed in the channel furnace patent of ISCOR

By referring to the NOTES at the bottom of the pro forma in your possession (and which was prepared for 1 million tons/y), you will find that NOTE #1 which represents 5% of the plant cost (\$10 million) was allocated for maintenance to cover as follows: \$5 million for power (sub-item (a)), and \$5 million for sub-items (b) through (d). As to sub-item (e)--since gas is generated internally from the coal, and oil is not used, an allowance for sub-item (e) was omitted. In the Exhibit 11 pro forma for 500,000 tons/y of hot metal production, we have included \$6 million under its NOTE #3 that would be similarly divided at \$3.0 million for power (sub-item (a)) and \$3.0 million for sub-items (b) through (d).

Discussion: In 2000, when we began to seriously consider the use of a channel furnace in conjunction with our technology, we asked Ajax Magnathermic that if we were able to deliver an iron/carbon product at 2100°F to the channel furnace how much power would we need to feed to the inductors to produce hot metal; the answer was 114 kWh/ton of hot metal at 100% metallization of the product from the GMA.

Since the Calderon GMA produces a product that is not 100% metallized, the additional power that would be required to bring it to 100% metallization must be accounted for. Such accountability is more than made-up by the thermal credit derived from the secondary energy input at the melting end from the combustion of the CO released above the bath. The bath in a channel furnace covers quite a large area; it offers an expansive heat transfer surface. The thermal energy release from the combustion of the CO should be more than adequate to compensate for the extra energy required to make-up for the GMA product that is not 100% metallized based on the disclosure of Iscor's patent; see Column 6 lines 39 through 45. In our estimate we provided 3.6 cents/kWh for power and when multiplied by 114 kWh/ton of hot metal, the yearly expense equals to about \$2 million. Adding \$1.0 million for other miscellaneous power requirements in the facility, results in \$3.0 million which accounts for 50% of the total maintenance cost of \$6 million in NOTE 3 in the updated pro-forma Exhibit 11.

Item 6 – Reference information with respect to pigging machine shown in Photo #15

We do not have any information. We constructed our small "lazy Susan" in-house. I think Sparrows Point has a pigging machine. They may be able to help.

Item 7 – Environmental Emissions for the Calderon Process

(a) NO_x – (i) From the GMA – virtually none, because of being reducing;

(ii) From the channel furnace by using excess air to combust the CO, the NO_x may be comparable to the combusting of blast furnace gas which is around 10 ppmv.

(b) SO_x – The off-gas from the GMA will be passed through our hot gas clean-up system which averaged 97.3% efficiency in 22 tests that we conducted for Sun Refinery (Sunoco), the oil company; see Exhibit 12.

(c) PM10 – Since we intend to remove mercury through activated carbon as the final cleanup, the gas will be cooled and then followed by a low-temperature baghouse which will satisfy regulation. The collected dust from the baghouse will be recycled with the coal in the gasification island that will be converted together with the ash in the coal to a vitreous, non-leaching slag as a by-product.

Item 8 – Copy of November 2000 article of channel furnace.

See Exhibit 13, attached.

Item 9 – Secrecy Agreement and Video

(a) Secrecy Agreement – submitted, executed and attached.

(b) Video – An updated video will be submitted at a later date.

Item 10 – Engineering, Teaming, and Business Arrangement

Although you sent us a questionnaire which comprised 9 items, we are adding an Item 10, which we recommend. Once SDI and Calderon have entered into a teaming agreement, the next immediate step is to prepare a comprehensive engineering package which is site specific, to the Ironmaking Island of the “Industrial Energy Park”, and be inclusive of a definitive cost estimate for a commercial plant and, also, the running of additional tests as needed.

In FY 2001, Congress appropriated \$6.5 million to our project, in addition to the \$6.5 million it had appropriated in FY 2000. These funds were for applying our process to coke making; see Exhibit 14. Calderon together with U.S. Steel recommended to Congress that our technology would be much more valuable to the steel industry by making iron from ore concentrate and coal instead of making coke. Approval was received from Congress to proceed in making iron. Since we did not need the appropriation of FY 2001 when the approval from Congress was received, this second appropriation was redirected to fuel cell research.

The Assistant Secretary of Fossil Energy, Mr. Robert Kripowicz, communicated to us that, as we progressed, additional monies would be made available. Therefore, we intend to ask Congress for the money that had been appropriated in 2001 and earmarked to our project, and that had been re-directed because at the time we converted our coke-making project to iron-making, our iron-making technology was not as advanced as our coke-making technology and the FY 2001 funds were at that time not needed. We would urge that funds be taken from the \$150 million awarded to the CPICOR iron-making project which was terminated by DOE and Geneva Steel by mutual agreement in 2004; these funds remain unexpended and were originally awarded for iron-making, consistent with the Clean Coal Technology program's 1985 statutory authorization that provided for modernizing facilities through new coal-based technologies, including for industry. However, even after most of the billions in Clean Coal Technology program money have been spent over the years for power industry projects, the "scavengers" in the power industry are after using the \$150 million from CPICOR for a very futuristic power generation project called "FUTURE GEN" that promises a "zero emissions" coal-fired power plant. We, and you as steel-makers (as well as U.S. Steel if it elects to join) should strongly oppose this use of the cancelled CPICOR project's funding as eliminating the last reserve of

existing DOE appropriations large enough to be used for grant-funding a major iron-making/steel-making project, and that were originally awarded to an iron-making team. Once the engineering and definitive cost estimate are completed, we plan to apply to obtain the balance of project funding, if possible through a Congressional re-direction of the entire amount of the CPICOR funds, equivalent new appropriations, and/or loan guarantees.

Since R&D is based on an 80% federal and a 20% private sector cost-share under the applicable energy laws, it means that we need to contribute \$1.6 million to obtain \$6.4 million in federal funds, of which we propose that Calderon contribute \$800,000 and SDI contribute \$800,000. The Department of Energy accepts contribution in-kind; therefore, we would contribute \$400,000 in-kind and \$400,000 in cash, and propose that SDI make whatever portion it elects of its \$800,000 contribution in the form of in-kind and the rest in cash.

This approach will enable Calderon and SDI to execute an action plan that will produce a solid platform from which funding for the 500,000 tons/y "Pioneer Plant" would be available. If U.S. Steel joins the team, then the \$1.6 million private sector cost share will be divided into three parts and an arrangement worked out whereby it becomes equitable to all concerned.

I hope you will find this letter to be responsive to your questions and in accord with what we propose. We look forward to meeting in Bowling Green on Wednesday, October 5th.

Sincerely,

Albert Calderon
President

Enclosures

CALDERON GASIFICATION PROCESS
FOR CO-PRODUCTION OF SNG & ELECTRIC POWER

**H₂ RICH GAS FOR SYNTHESIS
FROM PYROLYSIS
(BEING FLARED)**

**LEAN GAS FOR POWER
FROM CHAR GASIFICATION
(BEING FLARED)**

PHOTOS TAKEN FROM BOWLING GREEN PILOT

USS/USX MINNTAC PLANT MATERIAL SAFETY DATA SHEET

Health	1 *
Flammability	0
Reactivity	0
Personal Protection	-

HMIS Ratings

*See Section VIII.

1	Health
0	Flammability
0	Reactivity
-	Specific Hazard

NFPA Ratings

NFPA 308 Rating: 1

SECTION I

PRODUCT NAME IRON ORE CONCENTRATES, AND FILTER CAKES	INFORMATION TELEPHONE NO. (218) 749-7401
SUPPLIER USS/USX MINNTAC PLANT	24 HR. EMERGENCY TELEPHONE NO. (218) 749-7406
ADDRESS P.O. BOX 417, MT. IRON, MN 55768	DATE 01-16-1998
HAZARDOUS MATERIAL DESCRIPTION, PROPER SHIPPING NAME, HAZARD CLASS, HAZARD ID NO. (49 CFR 172.101) IRON ORE CONCENTRATES, AND FILTER CAKES	
ADDITIONAL HAZARD CLASSES (as applicable) NONE	
CHEMICAL FAMILY IRON ORE	FORMULA MIXTURE

SECTION II - HAZARDOUS INGREDIENTS

CAS REGISTRY NUMBER	%W	CHEMICAL NAME(S)	OSHA PEL	MSHA TLV	Listed as Carcinogen NTP, IARC or OSHA 1910(z) (specify)
1309-37-1	< 65.50	IRON	10 mg/M3 AS Iron Oxide dust and fume.	10 mg/M3 as the fume.	
14808-60-7	< 5.00	SILICA (quartz)	10/(%Silica +2) as Total Respirable Dust	10/(%Silica +2) as Total Respirable Dust	IARC
1305-78-8	< 5.00	CALCIUM OXIDE	5 mg/M3	5 mg/M3	
1309-48-4	< 1.50	MAGNESIUM OXIDE	15 mg/M3 as total particulates	10 mg/M3 as the fume	
1344-28-1	< 1.00	ALUMINUM OXIDE	5 mg/M3 respirable fraction as PNOR*** E	10 mg/M3 as nuisance particulates	
7439-96-5	< .50	MANGANESE	5 mg/M3 (C)* as the fume E	5 mg/M3 (C) *	
13463-67-7	< .030	TITANIUM DIOXIDE	15 mg/M3 as total dust	10 mg/M3 as nuisance particulates	
7446-09-5	< .030	SULFUR	5.0 PPM as sulfur dioxide	5 PPM as sulfur dioxide	
1314-13-2	< .030	ZINC OXIDE	5 mg/M3 as the fume	5 mg/M3 as the fume	

NOTE: All commercial metals contain small amounts of various elements in addition to those specified. These small quantities, frequently referred to as "trace" or "residual" elements, generally originate in the raw materials used. Typical levels of commonly involved trace or residual elements that may be encountered in steel products are provided in Annex I so that their potential hazards may be considered.

NOTE: All exposure limits are based on 8-hour time-weighted average values.

* (C) denotes "Ceiling limit" which should not be exceeded at any time.

** (STEL) denotes "Short Term Exposure Limit" - a 15 minute time weighted average value.

*** PNOR - Particulates Not Otherwise Regulated

E denotes Environmental Hazard (PA)

SECTION III - PHYSICAL DATA

BOILING POINT (Degrees) N.A. F C	SPECIFIC GRAVITY N.E.	MAXIMUM PERCENT VOC BY WEIGHT (%) % 0 Method used THEORETICAL
VAPOR PRESSURE @ N.A. F C mm H psi	PERCENT VOLATILE BY VOLUME (%) 0	
VAPOR DENSITY (AIR = 1) N.A.	EVAPORATION RATE (Butyl Acetate = 1) N.E.	
SOLUBILITY IN WATER N.A.	PH = N.E.	PERCENT SOLID BY WEIGHT (%) 100%
APPEARANCE AND ODOR DARK RED TO BLACK, SOLID		

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT N.A. F C method used	FLAMMABLE LIMITS	LEL N.A.	UEL N.A.
EXTINGUISHING MEDIA N.A.			
SPECIAL FIRE FIGHTING PROCEDURES N.A.			
UNUSUAL FIRE AND EXPLOSION HAZARDS NONE			
WARNING NONE			

N.A. - Not Applicable
N.E. - Not established
N.D. - Not Determined

Premier Elkhorn Coal Company

PO Box 130

Myra, Ky. 41549

Customer	Calderon Energy	Destination	Bowling Green, Oh.
Train Number	547	Order Number	547
Lab No	154253	Shipper Number	547
Sampled By	Plant Crew	Date Shipped	8/23/2004
Received From	Plant Crew	Sample Type	Truck
Units Shipped	1	Date Received	8/23/2004
Conditions	Clear	Total Tons	

	<u>As Received Basis</u>	<u>Dry Basis</u>	<u>MAF BTU</u>
Surface Moisture	2.82		
Residual Moisture	1.60		
Total Moisture	4.37		
Ash	5.40	5.65	
Sulfur	0.73	0.76	
Volatile	36.47	38.14	
Fixed Carbon	53.75	56.21	
BTU	13,585	14,206	
Chlorine	N/A	N/A	
HGI	N/A	Comments	
Lbs SO2/MMBTU 1.07	Lbs Ash/MMBTU 3.98		

<u>Fusion Temperature of Ash (Degrees F)</u>		<u>Ash Mineral</u>	
Temperatures in Reducing Atmosphere		% Ignited Basis	
Initial	N/A	Titanium Dioxide	N/A
Softening	N/A	Aluminum Oxide	N/A
Hemispherical	N/A	Ferric Oxide	N/A
Fluid	N/A	Calcium Oxide	N/A

ISO 9001:2000 - ANSI/ISO/ASQ Q9001-2000
Processing and Shipment of Coal and Synthetic Fuel

Tuesday, August 24, 2004

Keyed By:

Robert Clevinger

Page 1 of 1

E-mailed to J P Norton

JP
8/24

Martin Marietta Magnesia Specialties

755 Lime Road
Woodville, Ohio 43551
Phone (419) 849-4221
Fax (419) 849-4246

Dennis M. Briggs, Ph.D.
Sales Manager - Aggregates
Denny.briggs@martinmarietta.com

The following analysis are typical of the crushed stone produced at our Woodville, Ohio Plant:

Analysis of Raw Dolomite
Magnesium Carbonate 45+ %
Calcium Carbonate 54+ %

Oxide Basis

Silicon Dioxide	0.104%
Aluminum Oxide	0.0161%
Calcium Oxide	30.810%
Magnesium Oxide	21.390%
Strontium Oxide	0.046%
Manganese Oxide	0.009%
Iron as Ferric Oxide	0.12%
Titanium Oxide	0.003%
Phosphorus Pentoxide	0.006%
Carbon Dioxide	47.490%
Water of Mineralization	0.020%
Sulfur Trioxide	0.049%
Sulfide Sulfur	0.020%
	99.723%

Mineralogical Composition

Quartz	0.03%
Kaolinite	0.152%
Dolomite	99.701%
Limonite	0.0152%
Pyrite	0.037%
Celestite	0.082%
Anhydrite	0.022%
Rutile	0.003%
Apatite	0.011%
Rhodochrosite	0.015%
	100.071%

Calderon DRI Sample :						
	Weight, lb.	%				
Uncrushable	34.60	26.59				
+1/4 Inch	9.50	7.30				
- 1/4 Inch	86.00	66.10				
Total	130.10	100.00				
Uncrushable*		*Chemistry Assumed to be that of Feb 18 Test				
Fe Total	95.60					
Fe Met**	95.60					
(**assumed all metallic)						
C	0.022					
S	0.514					
+ 1/4 Inch	+100 Mesh	-100 Mesh	Composite			
%	34.20	65.80	100.00			
Fe Total	95.60	70.81	79.29			
Fe Met	95.60	28.65	51.55			
C	0.022	0.597	0.400			
S	0.514	0.476	0.489			
- 1/4 Inch	+100 Mesh	-100 Mesh	Composite			
%	11.60	88.40	100.00			
Fe Total	95.60	66.78	70.12			
Fe Met	95.60	25.82	33.91			
C	0.022	7.420	6.562			
S	0.514	0.372	0.388			
Overall						
	Wt. Fraction, %	Fe Total	Fe Met	% Met	C	S
Uncrushable	26.59	95.60	95.60	100.00	0.022	0.514
+1/4 Inch	7.30	79.29	51.55	65.01	0.400	0.489
- 1/4 Inch	66.10	70.12	33.91	48.36	6.562	0.388
Composite	100.00	77.56	51.60	66.53	4.37	0.43
Fe Balance						
No. of Pushes	60					
Blend/Push, lb.	3.50					
Tot Blend, lb	210.00					
Tot Fe Charged, lb	94.62	(2.26% Moisture, 46.1% Fet)				
Tot Fe Recovered, lb	100.91	(Tot Wt. X Fet in Composite)				

Calderon DRI Sample : Operation of Apr 28, 03 (72 Hour Test)							
	Drum BCD		Drum EFG		Drum HIJ		Drum KLMN
	Weight, lb.	%	Weight, lb.	%	Weight, lb.	%	Weight, lb.
Uncrushable	40.88	9.60	36.38	9.19	38.3	8.26	115.15
+1/4 Inch	136.78	32.13	116.31	29.39	159.87	34.50	121.83
- 1/4 Inch	248.11	58.27	243.05	61.42	265.28	57.24	286.7
Total	425.77	100.00	395.74	100.00	463.45	100.00	523.68
	Composite						
	Weight, lb.	%					
Uncrushable	230.71	12.76					
+1/4 Inch	534.79	29.57					
- 1/4 Inch	1043.14	57.68					
Total	1808.64	100.00					
Uncrushable*				*Chemistry Assumed to be that of Feb 18 Test			
Fe Total	95.60	C	0.022				
Fe Met**	95.60	S	0.514				
(**assumed all metallic)							
Drum BCD				EFG			
+ 1/4 Inch	+100 Mesh	-100 Mesh	Composite	+ 1/4 Inch	+100 Mesh	-100 Mesh	Composite
%	66.00	34.00	100.00	%	55.20	44.80	100.00
Fe Total	95.60	64.64	85.07	Fe Total	95.60	64.45	81.64
Fe Met	95.60	13.86	67.81	Fe Met	95.60	15.29	59.62
Drum HIJ				KLMN			
+ 1/4 Inch	+100 Mesh	-100 Mesh	Composite	+ 1/4 Inch	+100 Mesh	-100 Mesh	Composite
%	52.90	47.10	100.00	%	64.10	33.90	100.00
Fe Total	95.60	63.64	80.55	Fe Total	95.60	65.35	83.43
Fe Met	95.60	15.61	57.92	Fe Met	95.60	11.50	65.18
Composite of All Drums							
+ 1/4 Inch	Fe Total	Fe Met	% Met				
	82.60	62.47	75.63				

Attn: Mr. Calderon

Calderon DRI Sample :						
	Weight, lb.	%				
Uncrushable	13.50	8.83				
+1/4 Inch	46.50	30.41				
- 1/4 Inch	92.90	60.76				
Total	152.90	100.00				
Uncrushable						
Fe Total	95.60					
Fe Met*	95.60					
(*assumed all metallic)						
C	0.022					
S	0.514					
+ 1/4 Inch						
	+100 Mesh	-100 Mesh	Composite			
%	63.10	36.90	100.00			
Fe Total	95.60	53.90	80.21			
Fe Met	95.60	13.80	65.42			
C	0.022	14.070	5.206			
S	0.514	0.914	0.662			
- 1/4 Inch						
	+100 Mesh	-100 Mesh	Composite			
%	44.90	55.10	100.00			
Fe Total	95.60	59.70	75.82			
Fe Met	95.60	19.70	53.78			
C	0.022	12.870	7.101			
S	0.514	0.822	0.684			
Overall						
	Wt. Fraction, %	Fe Total	Fe Met	% Met	C	S
Uncrushable	8.83	95.60	95.60	100.00	0.022	0.514
+1/4 Inch	30.41	80.21	65.42	81.56	5.206	0.662
- 1/4 Inch	60.76	75.82	53.78	70.93	7.101	0.684
Composite	100.00	78.90	61.01	77.33	5.900	0.662
Fe Balance						
No. of Pushes	70					
Blend/Push, lb.	3.50					
Tot Blend, lb	245.00					
Tot Fe Charged, lb	110.39	(2.26% Moisture, 46.1% Fet)				
Tot Fe Recovered, lb	120.64	(Tot Wt. X Fet in Composite)

Exhibit 6

Exhibit 7

United States Steel Corporation
Research and Technology Center
4000 Tech Center Drive
Monroeville, PA 15146

D. M. Rohaus
Associate Research Consultant
Raw Materials & Ironmaking
Process Technology
412 825 2074
Fax 412 825 2800

December 10, 2004

Albert Calderon, President
Calderon Energy Co.
500 Lehman Avenue
PO Box 126
Bowling Green, OH 43402

Dear Mr. Calderon:

Dr. Defilippi asked me to respond to your request to analyze a sample of metal you provided with a letter addressed to Ms. Lisa Roudabush on November 1, 2004. The sample has been analyzed by Clark Laboratories. In the table below, those results are compared to the typical chemistry of hot metal produced by U. S. Steel. Note that the sulfur content of the material is significantly higher than that of typical hot metal.

ELEMENT	TYPICAL HOT METAL CONCENTRATION RANGE (%)	CLARK ANALYSIS OF SAMPLE PRODUCED BY CALDERON (%)
Carbon	4.3 - 4.7	4.22
Phosphorus	0.04 - 0.09	0.064
Silicon	0.3 - 1.2	0.15
Sulfur	0.03 - 0.06	0.291
Manganese	0.2 - 0.7	0.062
Iron	93.3 - 94.8	95.1 (By Difference)
Copper	<0.1	0.013
Nickel	<0.1	0.032
Molybdenum	<0.1	<0.002
Vanadium	<0.1	0.035
Titanium	<0.1	0.029

Please let me know if you have any questions about the analysis.

Sincerely,

D. M. Rohaus

January 9, 2005

Albert Calderon
Calderon Energy Co.
PO Box 126
Bowling Green, Ohio 43402

Dear Mr. Calderon:

As per your request I have reviewed the hot-metal analysis that you sent me. The analysis is very typical of that found in the steel industry with the exception of the lower silica and the higher sulfur contents. The lower silicon could be a benefit in the steelmaking process if the oxygen blowtime could be reduced, resulting in a higher productivity. Reduction of the sulfur level to the more desired level of .002 to .005 percent required for steelmaking could best be achieved by adjusting the slag chemistry in the melting furnace and enhancing the mixing of the slag and the metal. This would reduce the sulfur level to about the same level as is typical of blast furnace hot-metal. Final desulfurization to the .002 to .005 level could then be achieved in ladles by injecting mag-lime. It would also be possible to do the entire desulfurization in a ladle by injecting mag-lime and adjusting the chemistry as required, but this would be more costly. Reducing the sulfur level would provide an excellent hot-metal for steelmaking.

Yours truly,

Al Terchick,
Consultant-formerly
Tech. Dir. Raw
Materials and
Ironmaking USSteel
Research

FIG. 17—7. Two identical hot-metal mixers, each of 800 tons capacity, installed in a separate mixer building at one end of the charging floor of an open-hearth furnace building. The mixers rotate counter-clockwise to pour molten pig iron into the transfer ladle shown.

determined by metallurgical experience, the drag of molds with their contained ingots are drawn by motive power to the strippers which usually are special electric overhead traveling cranes. With big-end-down molds, the stripper lifts the mold from the ingot car while a plunger forces the ingot down against the ingot stool on the mold car (Figure 17—9). Molds after lifting from the ingots are transferred by the stripper to a parallel drag of cars. With big-end-up molds, it is

necessary to pull or push the ingot up and out of the mold while the latter is held against the stool and car (Figure 17—9). Modern stripper cranes, rated at 200 to 250 tons capacity, usually handle either type of mold.

As discussed in Chapter 11, the facilities for gaseous oxygen will depend upon the quantity of gas required for normal and peak operations, whether or not the plant is isolated or part of a steelmaking complex, and so on.

FIG. 17—8. By manipulating the lever, the pourer opens and closes the nozzle of the ladle to control the flow of molten steel from the ladle to the molds. The operation shown is called "teeming" or "pouring." Recently, an electrically operated hydraulic cylinder has been developed to replace the lever and provide better control of pouring (see Section 5 of this chapter).

PLANT CAPACITY/YEAR - 500,000 TONS¹

PRO-FORMA SUMMARY

<u>REVENUES</u>	<u>MIL. \$/YEAR</u>	<u>MODEL PARAMETERS (IN 2005 DOLLARS)</u>
Hot Metal Sales	125.00	Total Plant Cost - \$120 MIL
Credit from Recovered Recyclable Carbon	<u>10.00</u>	Miscellaneous Exp - \$5 MIL
Total Revenue	135.00	Total Project Investment - \$125 MIL
<u>EXPENSES</u>		Depreciative Capital - \$125 MIL
Ore Concentrate Costs	30.00	Equity @20% - \$ 25 MIL
Coal Costs	38.50	Debt @ 80% - \$100 MIL
Oxygen Costs	<u>1.25</u>	Interest @ 9% (levelized at 4.83%)
Subtotal	69.75	Tax Life - 12 Years
<u>CONVERSION COSTS:</u>		Period To Retire Debt - 20 Years
Maintance ³	6.00	Income Tax Rate - 40%
Operations (Wages) ⁴	1.80	Insurance and Local Taxes - 2%
Benefits ⁴	<u>1.20</u>	Ore Concentrate Cost/Ton - \$40.
Subtotal	9.00	Coal (Non-Metallurgical Steam)/Ton - \$77 (Delivered)
Insurance & Local Taxes	2.50	Oxygen Cost/Ton - \$25
Royalty	6.75	Consumption of Ore Concentrate/Year - 750,000 Tons
Total Operating Costs	88.00	Consumption of Coal/Year - 500,000 Mil Tons ²
Gross Income (Loss) Before Interest, Depreciation and Taxes	47.00	Oxygen Consumed/Year - 0.05 Mil Tons
Interest (Levelized) on Debt	4.83	Sales Price/Ton for Hot Metal - \$250
Depreciation	<u>10.42</u>	Recoverable Carbon from Coal - 60%
Subtotal	15.25	Allowable credit/ton of Carbon - \$40
Income (Loss) Before Taxes	31.75	Royalty - 5%
Income tax @ 40%	12.70	Notes:
Net Income (Loss) After taxes	19.05	¹ The plant has 20% redundancy by adding an extra GMA
Cash Flow (Net Income + Depreciation)	29.47	² Extra coal is added to prevent sticking with excess carbon being recycled in the gasification
Less: Debt Service	5.00	³ At 5% of plant cost = 6 mil: (i) 3.0 mil. for power and (ii) 3.0 mil for other utilities, materials, tools and supplies
Cash Flow After Debt Service	24.47	⁴ 30 people @ 100,000 per person (average/year) for Wages (60%) and Benefits (40%)
Return on Equity After Debt Service & Taxes -- (\$24.47 Mil x 100) / \$25 Mil.	<u>97.88 %</u>	⁵ Ratio of Income to Interest, (before depreciation and taxes), the interest being on a fully loaded basis with the first year of interest being at 9% (\$9.0 million) ⁶ : 47.0 million / 9.0 million = 5.22
		⁶ Debt (\$100 million) x Interest (9%) = \$9.0 million

**Sun Refining and
Marketing Company**
P O Box 920
Toledo OH 43693-0920
419 698 6600

January 15, 1992

FROM: John J. Drummond
Michael B. Wurzel

Michael G. Ruffner

At your request, the Toledo Refinery Laboratory has completed a preliminary evaluation, of the "Calderon Process". The process has several potential applications, at not only the Toledo Refinery, but other Sun refineries, and merits an in depth study by our Environmental and R&D departments. Attached, is a complete report of our findings and recommendations.

JOHN J. DRUMMOND
LABORATORY MANAGER

MICHAEL B. WURZEL
ASSOCIATE SENIOR CHEMIST

L. T. Clere
J. H. Eisenhart
L. R. Sherman
S. L. Thompson
D. L. Verdiani

CALDERON ENERGY (3)

TABLE 6

H₂S CONTENT AND H₂S REMOVAL

<u>RUN</u> <u>#</u>	<u>DATE</u>	<u>TIME</u>	<u>RAW GAS</u> <u>% H₂S</u>	<u>CLEAN GAS</u> <u>PPM H₂S</u>	<u>% REMOVAL</u>	
1	9-19	-	1.5	700	95.3	
1		-	1.5	200	98.7	97.0
2	9-23	1730	4.4	-	-	
		1745	2.0	<3	100.0	
		1800	1.6	10	99.9	
		1815	1.4	225	98.4	
		1830	1.4	225	98.4	
		1845	1.4	300	97.9	
		1900	-	250	-	98.8
3	9-23	1910	3.6	-	-	
		1915	3.8	550	98.6	
		1930	2.4	375	98.4	
		1945	1.6	225	98.6	
		2000	1.6	300	98.1	
		2015	1.2	250	97.9	
		2030	2.8	100	99.6	98.8
4	9-25	1800	5.2	-	-	
		1815	2.2	400	98.2	
		1830	1.2	375	96.9	
		1845	1.0	150	98.5	
		1900	1.1	400	96.4	
		1915	1.1	400	96.4	
		1930	1.1	225	97.7	
5	9-30	1730	4.8	120	99.8	
		1745	1.6	400	97.5	
		1800	1.6	375	97.6	
		1815	1.2	250	97.9	
		1830	1.0	300	97.0	
		1845	0.9	200	97.8	
		1900	0.8	-	-	
6	9-30	1950	6.4	200	99.7	
		2005	2.8	175	99.4	
		2020	1.9	100	99.5	
		2040	1.7	160	99.1	
		2055	1.6	200	98.8	
		2115	1.1	-	-	
		2130	1.3	-	-	99.3
7	10-2	1930	3.8	150	99.6	
		1945	2.2	100	99.5	
		2000	1.6	200	98.8	
		2015	1.6	225	98.6	
		2030	1.6	225	98.6	
		2045	1.0	-	-	99.1
8	10-4	1815	1.0	400	96.0	
		1845	1.2	200	98.3	
		1920	0.8	20	99.8	97.9

<u>RUN #</u>	<u>DATE</u>	<u>TIME</u>	<u>RAW GAS % H2S</u>	<u>CLEAN GAS PPM H2S</u>	<u>% REMOVAL</u>	
9	10-4	2030	3.4	180	99.5	
		2100	1.2	200	98.3	
		2130	1.0	100	99.0	
		2200	0.8	5	99.9	99.2
10	10-4	2230	2.4	300	98.8	
		2305	1.2	100	99.2	
		2330	1.0	35	99.6	99.0
11	10-5	1335	1.9	400	97.9	
		1405	1.5	225	98.5	
		1430	0.8	200	97.5	
		1450	0.8	175	97.8	98.0
12	10-5	1505	2.2	220	99.0	
		1535	1.4	375	97.3	
		1605	0.8	200	97.5	
		1635	0.7	20	99.7	98.4
13	10-5	1700	1.8	400	97.8	
		1730	1.4	400	97.1	
		1740	1.3	400	96.9	
		1815	0.8	60	99.2	97.6
14	10-7	1710	1.8	600	96.7	
		1735	1.4	500	96.4	
		1800	1.2	350	97.0	
		1822	1.0	210	97.9	96.9
15	10-7	1920	4.5	200	99.6	
		1950	2.7	450	98.3	
		2020	1.7	600	96.4	
		2035	1.1	375	96.6	
		2050	1.0	150	98.5	98.4
		1742	7.0	320	99.5	
16	10-9	1800	2.3	400	98.3	
		1815	1.7	600	96.5	
		1835	1.1	575	94.8	
		1850	0.8	500	93.8	
		1905	1.0	400	96.0	
		1915	0.9	150	98.3	97.7
		1530	1.6	800	95.1	
17	10-11	1545	1.3	700	94.6	
		1600	1.0	400	96.0	
		1630	0.9	140	98.4	95.8
		1645	2.6	700	97.3	
18	10-11	1700	1.7	1150	93.2	
		1710	1.6	800	95.0	
		1730	1.6	800	95.0	
		1800	1.3	100	99.2	96.0
		1900	1.6	700	95.6	
19	10-11	1925	1.4	700	95.0	
		1945	1.2	400	96.7	
		2000	1.4	250	98.2	
		2030	1.0	75	99.2	96.8

<u>RUN</u> <u>#</u>	<u>DATE</u>	<u>TIME</u>	<u>RAW GAS</u> <u>% H2S</u>	<u>CLEAN GAS</u> <u>PPM H2S</u>	<u>% REMOVAL</u>
	10-16	1715	1.4	1100	92.1
		1745	1.1	600	94.5
		1815	0.9	200	97.8
21	10-16	1843	1.9	500	97.4
		1910	1.2	875	92.7
		1955	0.8	175	97.8
	10-16	2030	3.8	300	99.2
		2045	2.0	900	95.5
		2115	1.6	750	95.3
		2130	1.3	600	95.4
		2200	1.0	150	98.5
AVERAGE			1.76	342	97.7

Channel Induction Melt/Hold Technology at Nippon Steel Corp.

T. Burke, R. Osiniak and M. Li
Ajax Magnethermic Corp.

Nippon Steel Corp., the world's largest steel producer, explored methods to increase production while avoiding the high cost of relining its two blast furnaces at the Yawata Steelworks in Fukuoka, Japan. While visiting an ISCOR Steel Corp. plant near Johannesburg, South Africa, Nippon officials discovered a possible solution to their problem: a 1,500 metric ton, 13.5 megawatt, large capacity, channel induction furnace used for holding blast furnace iron and melting scrap iron and steel. The furnace was designed and engineered by Ajax Magnethermic Corp., Warren, OH.

Nippon officials concluded that similar induction technologies, though on a larger scale and capacity than that of the ISCOR facility, could be used at its Yawata facility as a melt and hold furnace that would supply molten iron to fulfill the plant's needs.

A single channel induction superheater seemed to present a solution to Nippon's primary considerations. The

After exploring methods to increase production of its blast furnaces at the Yawata facility, Nippon Steel contracted Ajax Magnethermic to design a superheater. Since installation in 1998, the superheater has, among other things, increased steel production levels.

superheater could eliminate the millions of dollars in the cost of relining the refractory of its existing blast furnaces. The superheater could also offset the variation in metal supply and heat loss experienced when transporting molten metal in railway containers over a distance of several kilometers, provide the ability to melt large quantities of scrap metal, possibly eliminate the need of additional on-line blast furnaces and provide the ability to maintain, or even increase, levels of steel production.

Nippon contracted Ajax Magnethermic Co. Ltd., Tokyo, Japan, a subsidiary of Ajax Magnethermic U.S.A., to launch

studies to determine the melt rate, efficiency and economics of the proposed project. Resulting studies indicated that a drum-type channel furnace superheater would accomplish Nippon's objectives of melt rate and efficiency at a fraction of the cost to reline the refractory of its existing blast furnaces.

EFFICIENCIES

Nippon researched different furnace configurations to resolve the mismatch between the existing blast furnaces and production capacity for continuous casting after the converter. In addition, the company hoped to reduce energy consumption and costs for the converter.

Nippon reviewed both the superheater concepts, which were named the iron resolving barrel (IRB), and arc furnace configurations to determine the various advantages of each system (Table I).

Based on the overall efficiency ratings of the compared configurations, Nippon selected the channel furnace superheater configuration for power source capacity and overall efficiency of the unit.

The channel furnace superheater concept would realize additional use of surplus power generated from the Yawata facility's waste mill gas.

Table I Comparison of IRB and Arc Furnaces 1 and 2

	Superheater (IRB)	Arc Furnace 1	Arc Furnace 2
Melt rate	60 tons/hour	70 tons/hour	
Power source capacity	30 MVA	50 MVA	
Overall efficiency	85 percent	65 percent	

EXPERIENCE COUNTS

In addition to the superheater at ISCOR, Ajax Magnethermic also designed and engineered other systems worldwide for metal mixing furnaces and cupola operations based on induction technologies for superheating. Most recently, DaimlerChrysler in the United States has started up two 180-ton Ajax Magnethermic holding furnaces at its Indianapolis, IN, foundry. These duplex-style furnaces are thought to be the largest of their kind in the world.

In January 1997, Nippon contracted with Ajax Magnethermic to design a holding furnace for its Yawata facility. During 1997, Ajax Magnethermic engineers from the company's channel engineering and research and development groups worked in a collaborative effort with Ajax Magnethermic (Japan) to design the Nippon superheater and its inductors.

SUPERHEATER DESIGN

The induction channel furnace superheater design needed to satisfy many considerations of Nippon. The resulting furnace for the Yawata facility was designed to have a capacity of 2,200 metric tons, which is the largest furnace of its kind in the world.

The superheater is a refractory-lined horizontal cylindrical vessel similar in appearance to a conventional hot metal mixer. This furnace has two series of high capacity Ajax Magnethermic jet flow inductors attached to the underside of the vessel (Figure 1). Each inductor operates on a single-phase line-current frequency to meet the 27 megawatt design requirement (Figure 2, Table II).

The Ajax Magnethermic-designed twin-loop jet flow inductors minimize

recirculation of molten metal within the induction channel. In the jet flow inductor, molten metal flows from the main pool down through a center channel and returns up through two exit channels. This permits stirring of the main pool (Figure 3).

PROJECT MANAGEMENT

The size and complexity of the Nippon superheater furnace required that it be fabricated in Japan, based on the Ajax Magnethermic design. Both Ajax locations

Figure 1 The line drawing shows the end view of a furnace with inductors.

Figure 2 Inductor artwork is shown.

supplied the furnace engineering drawings, inductors, inductor technology, electrical power supplies, switchgear and also furnace startup. An aggressive schedule was set for the design and construction of the superheater. The superheater was commissioned as planned in October 1998.

VESSEL CONSTRUCTION

To satisfy the melt capacity requirement, the vessel was designed to accommodate six jet flow inductors rated at 4,500 kW each. The inductors were designed to be capable of 6,000 kW, making them the largest in the world. The design called for three inductors per side to be attached to the underside of the vessel at 45 degrees from center. Steel plates were welded to compose five rings that

Table II Electrical

Inductors	Six Ajax jet flow 4,500 kW nominal rating
Power supply	Three-phase, phase-balanced transformer
Primary voltage	27,500 V
Power control	19 tap, on-load primary tap switch
Leads per inductor	6 water-cooled leads each

Figure 3 The furnace/inductor cross-section, displaying the jet flow concept, is shown.

together form the furnace outer shell with two domed ends. The resulting vessel is 9 m (29.25 feet) in diameter and 20 m (65 feet) long (Figure 4).

The vessel geometry and placement of the inductors required that four pedestals accommodate a total foundation load of 3,880 metric tons.

DRIVE

To permit rotation of the vessel for charging and pouring, the furnace is equipped with a series of drive gears and motors at either end of the furnace. The motors were 110 kW each, inverter driven (Table III).

OPERATION

At Nippon's Yawata facility, the holding furnace will play an important role in the steelmaking process. From the blast furnace, molten metal will be transported via railway transfer car and moved by ladle through desulfurizing and degassing processes before being ladled into the superheater. Steel scrap will be dumped into the back of the holding furnace into one of the three charge doors. Alternating between charge doors was found to even the wear on the refractory.

The holding furnace was designed to superheat blast furnace iron to between 1,300 and 1350°C at the rate of 360 metric tons/hour. The design also permitted 57 metric tons/hour of steel scrap to be melted to 1,350°C.

As an example of the operation, a superheater powered at 36 MW can superheat 14,000 metric tons of hot metal/day

by 220°C. A few basic oxygen furnace (BOF) shops process as much as 14,000 metric tons of hot metal/day. However, instead of superheating blast furnace iron, a 36 MW unit can produce 1,900 metric tons/day of synthetic hot metal (at 1,530°C) by melting low priced steel scrap with added carbon, manganese and silicon. Superheater capacity in tons of hot metal and installed kW can be whatever meets the requirements of individual BOF shops. Retrofitting existing hot metal mixers with high capacity jet flow inductors is also possible.

REFRACTORY

Nippon decided to follow its traditional refractory design for the hearth refractory for the Yawata Steelworks superheater holding furnace by using magnesium oxide (MgO) brick, which Nippon believed was the most economical alternative for the 800-mm-thick hearth (Figure 5). Because MgO bricks expand much more than alumina bricks, traditionally used in the United States, expansion joints were installed between the bricks to maintain stress in the shell at reasonable levels.

As firing procedures were reviewed, Nippon officials realized that once the vessel was under fire and the expansion points compressed, it could not be cooled without collapsing the lining. The

six inductors were eventually mounted with a 900°C furnace, and Nippon's refractory system worked well.

CONTROLS

Programmable logic controllers (PLCs) were installed, and computer interfaces were used for displaying and trending of the superheater data, including water flow and temperatures for the six inductors and throat flanges. More than 70 furnace shell thermocouples were returned for data logging. The PLCs also monitor all inductor power and conductance data.

Sintering, using six thermocouples for each inductor, permitted the prescribed heat-up schedule to be followed.

Nine jet flow inductor assemblies, including six operating and three spares, were completed in December 1997, followed by a demonstration of the inductor lining by Allied Mineral Products in early 1998 for Nippon at the Ajax Magnethermic facility in Warren, OH. The demonstration was videotaped for Nippon personnel. The furnace was installed in June 1998, and inductors were fired on schedule in October and acceptance testing occurred in November.

POWER SUPPLY AND STARTUP FIRING

Ajax Magnethermic (Japan) designed the power supply for the Yawata superheater.

Figure 4 An isometric view of vessel with supports and dimensions is shown.

Table III Mechanical

Diameter	9 m
Length	20 m
Total foundation load	3,880 metric tons
Refractory thickness	800 mm
Main hearth refractory type	MgO brick
Inductor refractory	MgO dri-vibe
Rotation power	220 kW
Rotating mechanism	2× rack and pinion
Number of scrap charge doors	3
Number of ladle charge doors	1
Total molten metal capacity	2,200 metric tons
Total usable capacity	1,500 metric tons

Figure 5 A refractory cutaway is shown.

It consists of a three-phase, phase-balanced system with an on-load primary tap changer for power control.

An eight-hour period was required to mount each inductor because of their large sizes. This included capping the MgO dri-vibe, firing the capping, rigging the inductors and mounting them about 17 meters above the mill floor. Water, power and thermocouple connections were then made.

As the 4,500 kW inductors were mounted on the hot furnace, they were energized. The refractory sinter began when all inductors were on, followed by an average sinter cycle of about 70°C/hour. Several holding periods were used as the prime temperature of 1,150°C was reached. Two ladles provided 600 metric tons of priming metal.

Two gas burners in the ends of the vessel fired the main furnace hearth. These burners also supplemented the furnace hearth by thermocouple control to keep the slag in a molten state and supply above melt line thermal losses. Ajax Magnethermic (Japan) executed the well-run October 1998 startup, made possible to a large extent

by Nippon, through its commitment to a clean and thoughtful installation.

FULL POWER PRODUCTION

During the second half of 1999, in preparation for full power production in 2000, three of the six inductors were changed to gain experience with the procedure and to study the first-year wear. Inductor electrical data indicated that no buildup or erosion was evident in the inductor channels. Physical inspection confirmed that the inductors did not need to be changed.

The final overall operating efficiency of the superheater had been specified by Nippon to be a minimum of 80 percent. The efficiency of the inductors was tested before shipping, and Ajax Magnethermic found that the electrical loss at full power was about 130 kW for coils, 70 kW for bushings and 100 kW for the case. This put the inductor efficiency at 94 percent. Electrical transmission efficiency was measured at about 96 percent. Given the power consumption for steel scrap melting at 340 kWh/metric ton, superheating iron at 4.6 kWh/metric ton and 1,400 kW of loss from the

furnace body, the calculated overall efficiencies were around 81 to 83 percent.

After startup and operation, testing confirmed that operational efficiency was about 85 percent, including furnace radiation loss and all other losses. Cold steel melting rate was about 1 ton/minute at rated power.

STEELMAKING BENEFITS

The superheater technology has proven to be beneficial to Nippon's Yawata Steelworks. Some benefits that can be applied to the steel industry include the following:

- ◆ Steel scrap melting uses excess scrap metal and increases hot metal production.
- ◆ It provides the ability of increasing the temperature of molten metal for transported iron in the steelmaking process.
- ◆ A more continuous flow of metal to the basic oxygen furnace is realized.
- ◆ Surplus electrical energy is better used.
- ◆ It is possible to adjust metallurgy.
- ◆ High metal circulation is provided.

USS Technical Center
4000 Tech Center Drive
Monroeville, PA 15146

October 31, 1997

Albert Calderon
Calderon Energy Co.
500 Lehman Avenue
P. O. Box 126
Bowling Green, Ohio

Dear Mr. Calderon:

During September and October 1997, we have conducted a test program with your personnel and Bethlehem people at the Alliance, Ohio Calderon Process Demonstration Unit. The main purpose of the test was to demonstrate the capability of making high-quality blast-furnace coke using the Calderon Tubular coking reactor while charging coal sequentially at 24-minute intervals into the reactor. Another goal was to determine if a high-coking-pressure (non-traditional) coal blend, which cannot be safely charged into a conventional by-product coke battery, can be charged and pushed through the Calderon reactor. We successfully achieved both goals as indicated by the high coke strength results for cokes produced from the Bethlehem Steel Burns Harbor coal blend and from the U. S. Steel Gary Blue-Tag coal blend and the successful charging of a non-traditional coal blend that contained 50 percent low-volatile, 25 percent medium-volatile, and 25 percent high-volatile coal. ASTM coke stabilities, a measurement of coke strength, exceeded 60 which is the current standard for high-quality blast-furnace coke. In addition to stability, the size and shape of the coke product was similar to conventional by-product oven coke and would be considered acceptable based upon test results to date. The apparent specific gravity was slightly higher and the hardness factor, a measure of abrasability, was less than conventional by-product oven coke, however, it is not certain what if any effect this would have on blast-furnace performance.

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Albert Calderon

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In summary, the results of the coking trial at Alliance, Ohio are very encouraging from a technical standpoint, and we want to make an in-house economic assessment of the Calderon Coking Process. To assist us in this assessment, please expedite the processing of a Secrecy Agreement with your company. Furthermore, we understand that Bechtel has prepared a preliminary Commercial Assessment Study of the Calderon Coking Process for their internal use. If it is possible, please make the necessary arrangements, including any legal documentation, for us to review the Bechtel study which will enable us to make a more rational business decision regarding our participation in the further development in the Calderon Coking Process. We understand further that no portion of the Claderon Cokemaking Assessment Study may be distributed to a third party unless the third party has been invited to and has executed a Non-Disclosure Agreement with Calderon and Bechtel specifically covering the Assessment Study.

Sincerely,

A. A. Terchick
Technical Director
Raw Materials & Ironmaking
Process Technology-Research