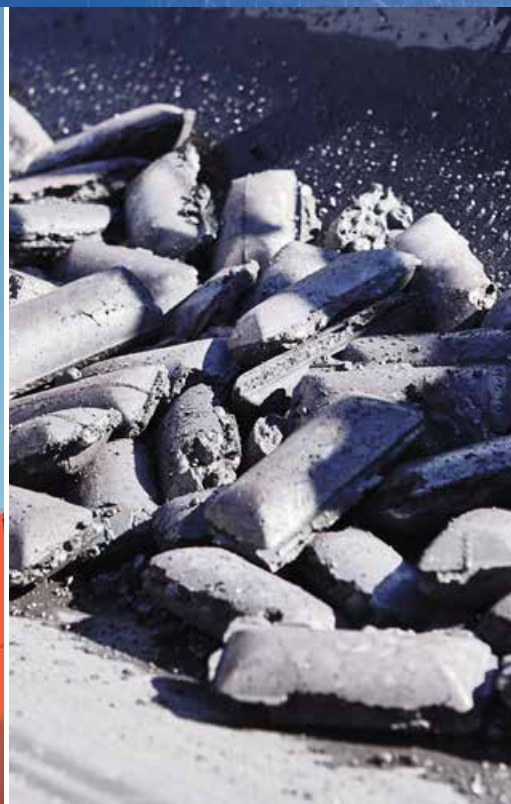


# DIRECT FROM **MIDREX**

4TH QUARTER 2017



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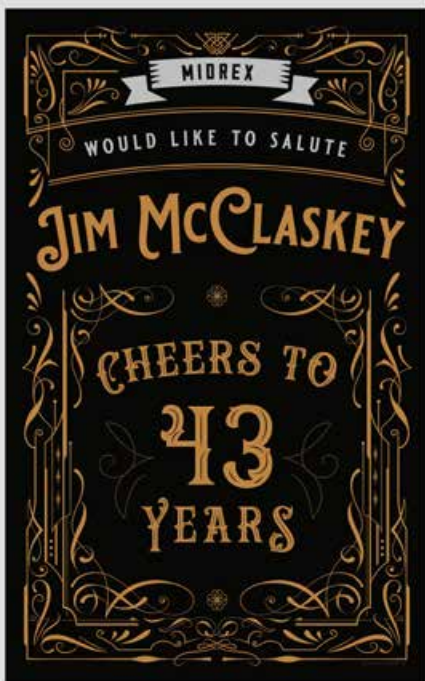
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## COMMENTARY

# THANKS FOR THE MEMORIES!

By Jim McClaskey  
President & CEO Emeritus



**T**his will be my final column in *Direct from Midrex*, as I have now officially retired after 43 years of service. During my tenure as President & CEO of Midrex Technologies, Inc., I have had the opportunity to speak to you through these commentaries about ten or so times, and I have always enjoyed communicating with all of you. To be truthful, it's easy to come up with words

for these articles when you are working for a company that has the best DRI Technology in the world – a company with great people to work with both at home and abroad, and continues to be the leader year after year after year in our niche industry.

As I succeeded Winston Tennies in becoming President and CEO of Midrex in 2004, Stephen Montague has succeeded me, and I'm sure Midrex and the MIDREX® Technology will continue to grow and prosper under his leadership. He too started on the "old drawing board" just like I did back in 1974 when I began my career at Midrex.

During my 43 years, I have seen a lot of "ups and downs" in our industry. I have seen new technologies come and go and I have seen some barely manage to exist. What I also have seen is DRI and HBI grow to unbelievable heights.

I had the privilege of working on the very first HBI plant in the world in the early 80s. Back then, it was called Sabah Gas Industries but today it is called Antara Steel Mills. That was exciting. I can remember Midrex people spending months and months on the tiny island of Labuan, Malaysia, "fine tuning" the equipment to finally make that project ultimately successful. Now there are 16 MIDREX® HBI Modules located throughout the world, which represent more than 124 million metric tons per year (t/y) of production to date.

I've seen the Project Design Capacity grow in size from a mere 400,000 t/y to 2.5 million t/y. That's what I call real progress!

I've seen some of our oldest plants

continue to operate for more than 40 years after they started up, and to this day, continue to operate well.

I've seen our Research and Development Center go from a modest test facility to a state-of-the-art technology development center.

I've seen our core technology expand its potential year after year with new innovations continuing to give DRI producers and steelmakers more and more control of their raw materials.

I've seen Midrex expand its office presence into China, Great Britain, India, Russia and Venezuela.

And most of all, because I was an employee of Midrex, I have been able to see so much of this wonderful world, meet people from all walks of life, and make friends with people of so many different cultures. I have been truly blessed to have had such a wonderful career, which has afforded my wife and children the opportunity to see some of this fascinating world, as well.

Will I miss it? You bet I will. And in the words of that very famous personality Bob Hope, thanks to all of you for the memories!

To all my friend and colleagues, I don't like saying goodbyes, so let's just leave it at...



See you later,  
Jim McClaskey





## FROM DRAWING BOARD TO BOARD ROOM

# THE CAREER & ACCOMPLISHMENTS OF JIM MCCLASKEY



"Here I was a fresh, new engineer from a humble small town in West Virginia who moved to the 'big city' to work for an international technology company, and within a few years I was traveling the world and working with so many talented people in developing the very first evolutionary technology like hot briquetting."

**James D. McClaskey**

*James D. McClaskey joined Midrex Corporation (now Midrex Technologies, Inc.) in 1974, after graduating from West Virginia Institute of Technology (now part of West Virginia University) with degrees in civil engineering and business. At the end of October 2017, McClaskey retired after dedicating his professional life to establishing the MIDREX brand and expanding its technical and commercial leadership in the worldwide direct reduction industry.*

*This article looks back over his 43-year career and traces his lasting influence on Midrex and the direct reduction industry.*

### FORGING A VISION

**M**cClaskey held numerous leadership and management positions within the Midrex Group during his 43-year career, beginning as a drawing board design engineer and ultimately serving as President and Chief Executive Officer of Midrex Technologies, Inc. He also founded several Midrex Group companies and related industrial enterprises including Professional Services International, Inc. (PSI), a multi-faceted procurement and support services business, for which he served as president from 1990-2002.

His ability to organize technical tasks and manage engineering teams became evident early in his Midrex career. Soon



*Professional Services International, Inc. (PSI), 1995*

“Creating a company from scratch is something I will never forget (reflection on establishing PSI in Pittsburgh, PA, in 1990). However, what is most gratifying is seeing that concept and approach to doing business embodied in the way Midrex goes about its business today.”

**James D. McClaskey**

after joining the company, McClaskey served as assistant project engineer for the Sidbec-Dosco II plant (now ArcelorMittal Long Products Canada) and soon thereafter was promoted to group leader. In 1981-82, he headed the engineering team based in the Linz, Austria, offices of Midrex Construction Licensee voestalpine Industrienlagenbau (now Primetals Technologies) involved in the design and engineering of the first plant based on the world's most successful hot briquetted iron (HBI) technology.

In April 1985, McClaskey was promoted to Manager – Project Services and began focusing on the project and plant services business sector. Twenty-one MIDREX® Modules had been started up by then and another 10 were added from 1986-90. Each of these was equipped with hundreds of alloy tubes filled with catalyst materials for gas reforming, thousands of refractory bricks lining the reduction furnaces and reformers and various pieces of proprietary equipment – all of which would need replacement or repair over the operating life of the plant module.

McClaskey recognized an opportunity to provide a valuable service to plant owners and operators that would complement the plant engineering and sales activities of Midrex and became the driving force for transforming purchasing from a support function into a procurement and technical services business. As a result, he founded Professional Services International, Inc. (PSI), a Midrex Group company, established its offices in Pittsburgh, PA, and served as its president from 1990-2002. When

PSI was rolled back into Midrex in 2003, it had annual sales of \$20-25 million and had developed and expanded relationships with a number of strategic equipment and materials suppliers.



*Winston L. Tennies, Henry Gaines, James D. McClaskey - 1980s*

## BUILDING ON SUCCESS

As Midrex owner, Kobe Steel Ltd., began looking for someone to replace Midrex pioneer Winston Tennies as president in 2003, McClaskey emerged as the natural choice. He symbolized the spirit and determination of the start-up company with a promising technology that was Midrex Corporation in 1974 and possessed the vision and business acumen to position the





“We could have continued producing just DRI plants, but our goal has been to provide the best technology solutions to make the industry more competitive and better position it for the next generation of steelmakers and consumers. Basically, everything we have done and will continue to do is to help steelmakers achieve better results and better economics.”

**James D. McClaskey**

Midrex Group for success in the 21st century. In January 2003, McClaskey was named President and Chief Operating Officer, and President and Chief Executive Officer when Tennessees retired in July 2004.

As President and CEO, McClaskey oversaw many industry firsts along with the steadfast commercial development of new MIDREX® DRI Plants. These included: the building of bigger MIDREX® Plants that would dependably produce above rated capacity (such as Hadeed E – the first DRI plant to produce more than 2.0 million tons within in a single year); the evolution of combo plants (producing multiple DRI products simultaneously); and overseeing reliable commercial hot transport of DRI bringing tremendous results to steelmaking operations. During this period, Midrex also experienced its most profitable year in its history.

Throughout his career, McClaskey remained committed to his belief in the importance of maintaining relationships and providing aftermarket solutions. As a result, Midrex Global Solutions was established in 2007 from the successful PSI business model to consolidate and focus the various customer support services. Midrex also launched satellite offices in strategic locations outside the USA – Gubkin, Russia (2007), London (2009), Shanghai (2011) and Delhi (2012).

Research and development has been central to development of direct reduction technology since its earliest days.

Many of the advances in MIDREX® Technology were developed and pilot-tested in the company’s technical center over the years. A world-class minerals processing laboratory was added in 2005 and a multi-million dollar renovation of the entire facility was completed in 2015, and now serves as the principal facility for ferrous and non-ferrous reduction technology for Midrex and Kobe Steel. According to McClaskey, “If you are going to be the leader, you need to look the part.”



*McClaskey with Ronald Ashburn, President of AIST, at a steel industry event (circa 2010).*



## A LASTING INFLUENCE

Throughout his long career, McClaskey regularly represented Midrex around the world, meeting with heads of state and conducting business with many of the most powerful and influential figures in the global steel industry. He was passionate about his company and his colleagues ... fiercely loyal and genuinely devoted. He led from the front and asked nothing of anyone he would not do himself. He challenged convention when it was needed but was open to the ideas of others.

Perhaps what reveals the most about the character of Jim McClaskey is that he counts serving as chairman-of-the-board for a non-profit organization dedicated to recognizing the contributions of first responders in the Greater Charlotte area among his most memorable accomplishments.

Forty-three years ago, McClaskey made a choice between working for an established engineering firm in Raleigh, NC, or a start-up company in Charlotte, NC, with a promising but relatively unproven technology in the topsy-turvy steel industry. Those who have learned from his example that hard work, self-confidence and determination can take you from “drawing board to board room” are awfully glad he did. ■



*Kobe Steel CEO, Hiroya Kawasaki with James D. McClaskey*



*James D. McClaskey with current President & CEO Midrex Technologies, Stephen Montague*



# Jim McClaskey Career Timeline

**Joined Midrex:**  
September 1974

**Positions held:**  
(Midrex unless otherwise indicated)

**Design Engineer**  
(September 1974-July 1977)

**Group Leader**  
(July 1977-March 1979)

**Mechanical Staff Engineer**  
(March 1979-October 1980)

**Project Engineer**  
(October 1980-November 1983)

**Manager, Project Engineering & Planning** (November 1983-April 1985)

## Memorable Midrex Milestones

### 1970-74

- (1971-73)
  - First commercial MIDREX® Plants started-up – Georgetown Steel, Hamburger Stahlwerke, Sidebec-Dosco 1
- (1971)
  - Alternate flowsheet for high sulfur ores
- (1974)
  - Midrex Corporation established in Charlotte



### 1975-80

- Nine MIDREX® Modules started-up
- (1971-79)
  - Five million tons of MIDREX® capacity
- (1979)
  - MIDREX® Plants first produce more than 50% of global DRI
- MIDREX® innovations
  - Larger diameter shaft furnace (from 4.9 meters to 5.5 meters)
  - Larger capacity reformer (from 120 tubes to 360 tubes)
  - Production capacity rating (from 400,000 t/y to 600,000 t/y)
  - In-situ reforming
  - Process gas preheating
  - Heat recovery
  - Cold briquetting



### 1981-85

- Nine MIDREX® Modules started-up
- (1982)
  - MIDREX® Hot Briquetted Iron Process announced
- (1983)
  - Investigation and initial development of RHF ironmaking (forerunner of FASTMET® Process and ITmk3® Process)
- (1983)
  - Kobe Steel acquires assets of Midrex Corporation
- (1984)
  - First MIDREX® HBI Plant started-up







## Jim McClaskey Career Timeline *(cont'd.)*

### Positions held:

*(Midrex unless otherwise indicated)*

**Manager, Project Services**  
(April 1985-March 1987)

**Manager, Technical Support**  
(March 1987-January 1988)

**Director, Projects & Procurement**  
(January 1988-January 1990)

**Vice President, Projects & Procurement**  
(January 1990-September 1990)

**President, Professional Services International, Inc.**  
(September 1990-December 2002)

### 1986-90

- Ten MIDREX® Modules started-up
  - MIDREX® innovations:
    - Larger diameter shaft furnace (from 5.5 meters to 6.5 meters)
    - Larger capacity reformer (from 360 tubes to 450 tubes)
    - Production capacity rating (from 600,000 t/y to > 1 million t/y)
    - Five stages of heat recovery
    - Use of high % of lump ore (up to 70%)
  - Increased productivity (oxide coating and oxygen injection)

(September 1990)

- Professional Services International, Inc. (PSI) established in Pittsburgh, PA as Midrex procurement and field services subsidiary



### 1991-95

- Nine MIDREX® Modules started-up (1992-95)
- Demonstration of FASTMET® Process at Midrex R&D Center
- Multiple product discharge options – cold DRI (CDRI), hot DRI (HDRI) and hot briquetted iron (HBI)
- (1993)
  - Use of HBI in the blast furnace
- (1993)
  - Hot charging options
- (1995)
  - PSI relocates to Charlotte



### 1996-2005

- Nine MIDREX® Modules started-up
  - MIDREX® innovations:
    - Larger diameter shaft furnace (from 6.5 meters to 7.5 meters)
    - Production capacity rating (from > 1 million t/y to > 2 million t/y)
    - Use of syngas from COREX® Plant (Saldanha Steel and Hanbo Steel) (1998)
    - HOTLINK® System developed (1996-98)
- ITmk3® demonstration plant in Charlotte started up (1999-2000)
- Kobe Steel Kakogawa Works pilot plant started up and operated







## Jim McClaskey Career Timeline *(cont'd.)*

### Positions held:

*(Midrex unless otherwise indicated)*

**President, Professional Services International, Inc.**  
(September 1990-December 2002)

**President & COO, Midrex Technologies, Inc.**  
(January 2003-July 2004)

**President & CEO, Midrex Technologies, Inc.**  
(July 2004-December 2014)

(2000)  
▪ First commercial FASTMET® Plant started-up at Nippon Steel Hirohata Works

(2001)  
▪ FASTMET® Plant started-up to process zinc-bearing steel mill waste at Kobe Steel Kakogawa Works

(2001-03)  
▪ ITmk3® demonstration plant built in Silver Bay, MN for Mesabi Nugget

(2001)  
▪ Midrex Solutions launched to concentrates solely on existing plants and their individual commercial needs when executing small capital projects requiring engineering and new equipment designs

(2004)  
▪ Midrex celebrates 30th anniversary

(2005)  
▪ Mineral processing lab added in renovation of R&D Technical Center



### 2006-2011

- Fifteen MIDREX® Modules started-up (2007)
- Midrex Global Solutions established (2007)
- First MIDREX® Combination Plant started-up, Hadeed E (2007)
- Midrex opens office in Gubkin, Russia (2007)
- Midrex opens office in London (2009)
- First MIDREX HOTLINK® Plant started-up, Jindal Shadeed (2011)
- Midrex opens office in Shanghai (2011)

### 2012-2017

- Nineteen MIDREX® Modules started-up (2012)
- Ten MIDREX® Modules under construction (2012)
- Midrex opens office in Delhi (2012)
- Midrex Global Logistics established with Jim McClaskey as president (2013)
- McClaskey Finalist for Lifetime Achievement Award and Innovative Technology of the Year Award in inaugural Platts Global Metals Awards (2013)
- Midrex R&D Technology Center upgraded and remodeled (2015)
- ACT™ System announced (2017)





## DRI AND ITS EFFECTS ON THE SCRAP STEEL MARKET IN THE US

### The U.S. to use **MORE** scrap steel not less

by Robert Hunter,  
*Raw Materials Consultant*

#### INTRODUCTION

Not that long ago, direct reduced iron (DRI) industry and steel scrap were locked in a struggle reminiscent of the famous Cold War-era shoe-pounding pronouncement by former USSR premier Nikita Khrushchev ... "We will bury you!" A lot has changed in a relatively short time in steel industry years. Today, DRI exerts significant influence on the scrap market but in a way that those metallics industry combatants of yester-years never imagined.

#### LET'S TALK METALLICS

We use the word "metallic" to mean a material typically containing at least 60% iron (Fe), which is used either in ironmaking or steelmaking. This includes the following shown in the right column.

DRI, in its various forms - cold DRI (CDRI), hot DRI (HDRI) and HBI, and pig iron are collectively known as ore-based metallics (OBMs) because they are derived from naturally-occurring iron ore. OBMs are particularly valuable for electric arc furnace (EAF) steelmaking because they are extremely low in copper and other residual metals and steel made with OBMs contains much less nitrogen and hydrogen. These qualities allow EAF steelmakers to produce steels that are malleable, ductile and formable... you can shape the steel without it tearing or marring.

Any amount of DRI/HBI can be used in an EAF, from 0-100%; yes, there are melt shops that use only DRI because scrap is difficult and expensive to source. Remember, the main goal is to meet the chemical specification of the steel. Therefore, it pays to have the ability to blend DRI/HBI, scrap and even pig iron to accomplish the goal at the lowest cost.



#### IRON ORE

Iron oxide, usually  $\text{Fe}_2\text{O}_3$ .



#### HOT METAL

Molten iron from a blast furnace (BF) that has been slagged to remove the gangue (non-iron containing rock).



#### PIG IRON

BF hot metal that has been allowed to cool in the size and shape of the molds in which it cooled; known as merchant pig iron (MPI) when traded.



#### DRI (as either HOT or COLD DIRECT REDUCED IRON)

Iron ore that has been "soaked" in hot carbon monoxide and hydrogen to remove the oxygen; thereby, boosting iron percentage by 25-30% without melting (but no slagging effect).



#### HBI (HOT BRIQUETTED IRON)

DRI that has been discharged hot and compressed into dense, pillow-shaped briquettes, primarily to make DRI easier and safer to ship; however, increasingly being used to boost hot metal production in the BF.



#### STEEL SCRAP

Recyclable materials left over from product manufacturing and consumption, such as parts of vehicles and appliances having a monetary value when recovered for its Fe content and reused in steel production.





## FROM OH TO BOF TO EAF

Once upon a time, in a steel industry nearly forgotten, steel was made primarily in an open hearth (OH) furnace. The OH was big and not very efficient by modern standards. However, its big selling point in its day was the energy savings due to its regenerative stoves.

In the 1960s and 1970s, the OH was replaced by the basic oxygen furnace (BOF), a far more efficient way to make steel. The last OH in the USA closed in 1991. Today, there are only a handful of open hearths still operating in Ukraine, Russia and India... and they will close soon.

The electric arc furnace (EAF) was widely used during World War II to produce alloy steels. However, it was years later, around the time when the BOF overtook the OH, that the low capital cost mini-mill concept was introduced and the EAF came into its own as a steelmaking furnace.

## KEEPING COPPER IN CHECK

Up until recently, the steel market was clearly divided. Integrated steelmakers, with their blast furnaces making hot metal would make the low residual steel grades in the basic oxygen furnace (BOF). The EAF-based mini-mills made the higher residual, commodity grades using scrap steel. All that changed in the 1990s with the advent of the thin slab caster. The marriage of the EAF mini-mill and thin slab casting has resulted in the building of a dozen of these mills in the US, having a cumulative annual capacity of 20-25 million tons of high quality flat products.

One of the primary factors was and continues to be protecting the steel from contamination by residual metals, especially copper. Hot metal, like the other OBMs contains virtually no copper or other residual metals (typically below 0.005% Cu, which on the scale where a point of copper is 0.01%, is "zero points").

For example, let's make a heat of steel in an EAF with a copper specification of 18 points (0.18% Cu content). For the sake of easy math, let's make the numbers simple. We have scrap with an average copper of 0.20%, ranging from about 0.18% up to nearly 0.25% and DRI/HBI or pig iron with zero points of copper (< 0.005%).

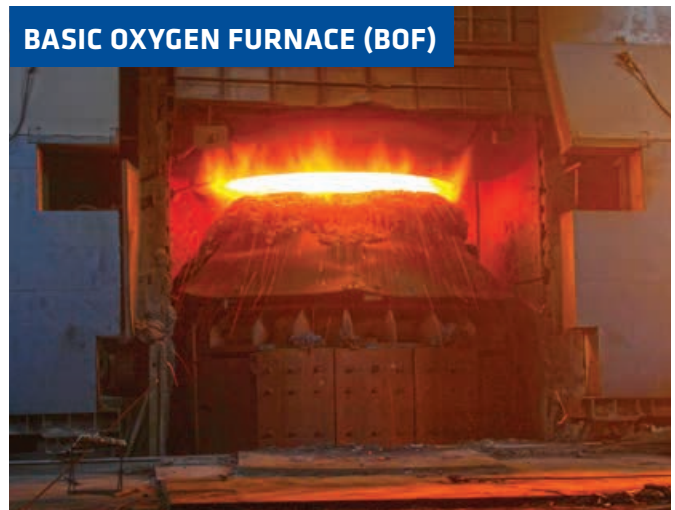
Because the scrap varies over a range and we cannot afford to miss the steel specification, we must be careful. So, we will aim for 15 points Cu (0.15%) and use 25% OBMs and 75% scrap ... and make the specification better than 99.99% of the time.

By using 75% scrap steel for the Fe charge, costs are kept

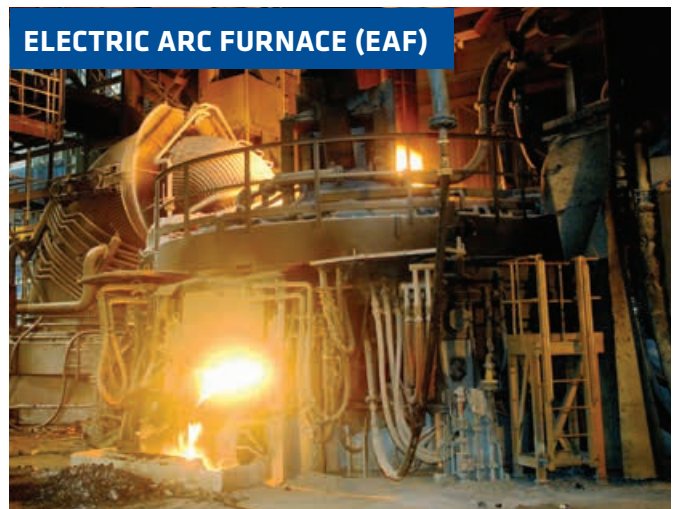
### OPEN HEARTH FURNACE (OH)



### BASIC OXYGEN FURNACE (BOF)



### ELECTRIC ARC FURNACE (EAF)





75% OF 0.20% PLUS 25% OF 0.00%  
EQUALS 0.15% IN THE STEEL.

75% of scrap  
containing  
0.20% of copper

25% of DRI, HBI,  
MPI containing  
0.00% of copper

melt them together  
and refine them  
to make steel

and they form a mix  
containing 0.15%  
copper

0.15% of copper

low. A BF-BOF mill cannot do this because BOF scrap usage cannot be adjusted to levels above 20% ... so the EAF takes market share away from the BF-BOF.

#### A DOSE OF (SCRAP) REALITY

As the number of EAF flat products mills increases, the need for prime scrap mounts, and no one is going to manufacture additional cars, refrigerators, washing machines just to produce more prime scrap. Therefore, it could be said that were it not for OBMs, most of the EAF-based flat products mills could not have been built. So, even though scrap suppliers must compete with OBMs, at least half of this market would not even exist if not for DRI/HBI and merchant pig iron (MPI).

In other words, the existence of the DRI/HBI and MPI enables the consumption of an additional 5-10 million tons per year of scrap steel in the US alone. ■

*Based on presentation by Robert Hunter at ISRI Ferrous workshop,  
April 5, 2016, Mandalay Bay Hotel, Las Vegas*







## MIDREX News & Views

# LGOK HBI-3 Plant Launch Named Most Important Event of the Russian Steel Industry in 2017



Metalloinvest

**T**he third hot briquetted iron production facility (HBI-3 Plant) at Metalloinvest's Lebedinsky GOK has won the "Main Event in the Russian Steel Industry 2017" competition. The HBI plant was launched in July 2017.

The Lebedinsky GOK HBI-3 Plant, one of the most powerful HBI production facilities in the world with an annual capacity of 1.8 million tons, was awarded highly supportive assessments by independent experts, including managers of sector unions and associations within the steel, mechanical engineering and construction industries, as well as scientific and research organizations. Over 400 jobs for highly-qualified professionals have been created at the HBI-3 Plant.

In order to support production volumes of the three HBI plants now operated by LGOK in Gubkin, Russia, the Company has carried out modernization of its beneficiation plant and pelletization plants. This will enable Metalloinvest to increase high-quality concentrate and pellet production volumes.

Andrey Varichev, CEO, Management Company Metalloinvest, commented, "The HBI-3 Plant is Metalloinvest's most important investment project. The launch of the facility is strengthening the Company's position as the leading global supplier of HBI, the premium metallized raw material for high-quality steel production."



"The increase in HBI usage in the iron and steel industries also serves to reduce the sector's environmental impact," Varichev said. "HBI production is the most environmentally-friendly method of producing iron from ore."

The "Main Event in the Russian Steel Industry" competition was founded in 2011, and aims to support and publicize innovative projects within the industry. The largest investment projects implemented in the industry are nominated for the competition. Earlier this year, the HBI-3 Plant received the "Investment Project of the Year" prize at the Russian Mining Excellence Awards 2017. ■

**"THE HBI-3 PLANT IS METALLOINVEST'S MOST IMPORTANT INVESTMENT PROJECT."**

**ANDREY VARICHEV, CEO,  
Management Company  
METALLOINVEST**



*(Based on Metalloinvest press release by Dmitry Kravchenko, Corporate Communications Director)*



## News & Views



**E**ach year, Midrex invites plant operators to come together for a week to share their expertise and experiences with their counterparts and to interact with Midrex engineers and technologists. The 2017 International Conference on MIDREX® Technology was held September 24-28 in Paris, France, with participants coming from 17 countries. The conference was hosted by Midrex Technologies, Inc. and was attended by 36 Process Licensees from 14 MIDREX® Plants, as well as personnel from Midrex Construction Partners, Kobe Steel, Ltd., Primetals Technologies and Paul Wurth.

## 2017 International Conference on MIDREX® Technology held in Paris, France



Christopher M. Ravenscroft: Editor

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