



Building DRI Plants

Project Development, Execution
& Continued Operational Support



MIDREX

Designed for Today,
Engineered for Tomorrow™



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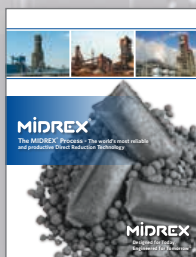
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ENVIRONMENTAL ASSURANCE

Midrex Technologies, Inc. along with its parent company Kobe Steel, Ltd., recognizes the importance of protecting the environment and conserving natural resources. Through the years we have been proactive in increasing efficiency, productivity, reliability and safety while reducing the environmental impact of our processes.

MIDREX® Plants are designed to minimize water, noise and air pollution.

MIDREX® Plants meet applicable World Bank standards and more importantly, Midrex can and will provide DRI Plants designed to meet any local emissions or environmental standards regardless of location.



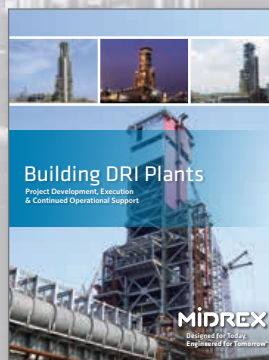
MIDREX® Process



MIDREX NG™



MXCOL®



Building DRI Plants



DRI Products & Applications

DRI IS OUR BUSINESS

FROM DEVELOPING PROJECTS THROUGH PLANT CONSTRUCTION TO SUPPORTING ONGOING OPERATIONS, THE MIDREX NAME IS SYNONYMOUS WITH DIRECT REDUCTION IRONMAKING.

Midrex has championed the worldwide growth of direct reduction ironmaking for more than 40 years with technology innovations, comprehensive project development and unmatched plant performance.

Since our first commercial plants in the early 1970s, **MIDREX® Technology** has raised the standard for DRI products and production by establishing itself as the world's most dependable and productive technology.

As a company, Midrex is known for designing and engineering reliable direct reduction plants as well as for making certain that these plants have a long and successful operating life.

Our involvement with clients goes far beyond supplying technology solutions and developing projects. Our relation-

ship begins even before the contract stage, as we find the right solution specific for each client rather than making one generic technology fit.

Through our in-house capabilities as well as strategic partners, Midrex can help with all aspects of project development from contracting to commissioning. Midrex makes sure that a successful plant start-up is but a first step, as our Technical Services Group continues to support our Process Licensees, guided by the principle that current and future customers should receive the greatest possible value for their investments. We also have a dedicated aftermarket group supported by engineers and process professionals who have worked on **MIDREX® Plants** for decades because at Midrex, **DRI Technology is our Business.**

LGOK II

Gubkin, Russia



Essar Steel I & II

Hazira, India



Qatar Steel II

Mesaieed, Qatar



DRI INNOVATION AND IMPROVEMENTS

MIDREX WAS FOUNDED ON INNOVATION...AND THE DESIRE TO IMPROVE AND INNOVATE IS A CONSTANT MOTIVATION.



Lion DRI
Banting, Malaysia



Jindal Shadeed
Sohar, Oman



ArcelorMittal South Africa
Saldanha Bay, South Africa



OEMK I - IV
Stary Oskol, Russia

Midrex has been advancing the technology standard of the direct reduction industry since introducing the first continuous discharge shaft furnaces in its earliest plants. Through years of development **MIDREX® Technology** has been instrumental in the global expansion of electric arc furnace (EAF) steelmaking by allowing EAFs to expand into new markets or prosper in scrap deficient regions.

From the first breakthroughs in DRI innovation to using coal to provide syngas for direct reduction and even various hot transport options offered today, Midrex continues to provide various solutions tailored to individual steelmakers.

What sets Midrex apart from our competition is the flexibility of our core technology combined with the dedication and experience of our organization. This allows for innovations grounded in the idea that improvements must provide clients with greater benefits of operational flexibility, reliability and performance.

Our innovation exists as a state of continuous technology development, but Midrex does not introduce any technology until it is proven. Our goal is to eliminate risk so our clients do not have to worry. When the basic concept, chemistry and engineering are proven and reliable, overall project risk is reduced, financing is less costly and the investment decision can be made with greater confidence.

KEY MIDREX® TECHNOLOGY DEVELOPMENTS

Technology suppliers are expected to develop new and improved products that keep pace with the quicker, more demanding pace of today's global marketplace. Staying on the leading edge of technology requires a seamless blending of research and operational experience that never loses sight of the goal - to provide customers the performance, flexibility and reliability needed to be successful.

Midrex continually increases the relevance and vitality of its process technology and equipment to assure that technology innovations and improvements benefit new and existing customers alike.

THE FOLLOWING ARE A FEW OF THE MOST SIGNIFICANT INNOVATIONS AND IMPROVEMENTS INTRODUCED OVER THE LAST FOUR DECADES OF MIDREX® DIRECT REDUCTION TECHNOLOGY:

► RAW MATERIAL FLEXIBILITY

MIDREX® Plants have processed iron bearing materials of varying quality from more than 50 sources around the world and have operated reliably and consistently using 70 percent lump ore and combinations of numerous iron oxide pellets. Some companies have successfully used the **MIDREX® Process** to reduce BF-grade pellets when they were unable to obtain DR-grade materials in order to maintain steelmaking operations.

► LARGE CAPACITY PLANTS

MIDREX® Plants are available with guaranteed capacities of 2.5 Mt per year from a single module. A design for a 3 Mt module is being developed.

► LOW ENERGY CONSUMPTION

MIDREX® Plants incorporate multiple stages of heat recovery and consistently achieve the lowest natural gas

consumption in the industry. These achievements are based on actual annual performance data.

► REDUCTANT OPTIONS

MXCOL® Plants can be designed to use syngas from **COREX® Plants**, coal gasifiers, coke oven gas (COG), and other coal-based sources. Modules utilizing coal reductant options are operating in South Africa and in India.

► HOT TRANSPORT OPTIONS*

Midrex offers three proven options for transporting hot DRI from the shaft furnace to one or more electric arc furnaces at temperatures up to 650° C: hot transport conveyor, hot transport vessels, and **HOTLINK®**. Numerous modules incorporating hot transport containers or a hot transport conveyor are in operation. Additional modules with **HOTLINK®** systems and/or a hot transport conveyor are under construction.

** The **HOTLINK®** system transports and directly charges hot DRI by gravity into the EAF*

HADEED MODULE E SURPASSES 2 MILLION TONS

Annual production record for a single DRI Module set in 2013

Design capacity 1,760,000 tpy

The **MIDREX® DRI Module E** at Hadeed is the first, and currently only plant, to have produced 2 million tons within a single calendar year.

2,000,458 TONS



DEVELOPING PROJECTS CONTRACTING TO COMMISSIONING

A DIRECT REDUCTION PROJECT TAKES YEARS TO BE TRANSFORMED FROM IDEA TO REALITY. MIDREX HAS THE EXPERIENCE, KNOW-HOW AND PARTNERS TO DEVELOP AND COMPLETE PROJECTS ON-TIME AND ON-BUDGET.

SULB

Hidd, Bahrain



Nu-Iron

Point Lisas, Trinidad & Tobago



A DRI project typically involves four phases to move from concept to completion: **Study, Planning, Contracting** and **Implementation**. Midrex is actively engaged every step of the way.

Beginning with the **study phase**, Midrex works with potential clients to identify the basic concept of the project and perform a pre-feasibility study. Based on the outcome of this study, the clients can choose to proceed to the next stage of development.

Next, in the **planning phase**, Midrex performs a feasibility study that focuses in much more detail on the client's needs and the project scope. Examined are the best choice for each individual client including selecting the most effective technology configuration, executing the basic design, evaluating project economics and risks and determining the preliminary financial structure of the project. Midrex assigns a project manager for each client to organize the project team, select a financial advisor (if required), and prepare the project schedule. At the end of this stage, a final decision to proceed is made.

In the **contracting phase**, the pace picks up. Midrex performs preliminary engineering, writes equipment specifications and sends out bid packages. Based on the bids received, the best quality and priced contractors are selected. Schedules for utilities and raw materials consumption are developed and contracts for them are negotiated. Meanwhile, the client investigates the market and prepares a preliminary marketing plan. This is especially important in the case of a merchant HBI or DRI plant. Midrex assists the client in preparing the documentation required for project financing and in obtaining loan commitments from lenders. At this point, Midrex, the selected construction partner and the client sign the project contracts and agreements.

The **implementation phase** opens with Midrex and the construction partner performing the basic and detailed engineering and procuring the key plant equipment. In parallel, the marketing plan is refined, additional off-take commitments are signed (in the case of a merchant plant), product delivery schedules are established and financing is finalized. The construction partner installs the plant and a start-up and commissioning team of Midrex and construction partner personnel puts the plant into operation.

BEYOND COMMISSIONING

What happens after the plant begins operation further separates Midrex from other technology suppliers. The MIDREX® Process Licensing program brings together the collective experience and expertise of more than 50 operating plants and the ongoing technology development efforts of Midrex in a cooperative sharing of innovations and improvements to the MIDREX® Process (see pages 11-12, MIDREX® Process Licensing program).

Midrex clients have access to the industry's most comprehensive support services from Midrex Technical Services and Midrex Global Solutions, which specialize in spare parts procurement, maintenance, repair, and operation (MRO) services, engineered solutions and field services.

voestalpine Texas

Texas, USA



Cleveland-Cliffs

Ohio, USA
(Under construction start-up 2020)



GLOBAL OFFICES

Midrex operates offices in strategic locations to assist customers with preliminary and detailed feasibility studies used to evaluate project economics and risks, select technology and perform basic design, and determine preliminary financial structure for projects. The London office specializes in sourcing and arranging project financing for global projects.



OFFICE LOCATIONS

MIDREX TECHNOLOGIES, INC.
Corporate offices and Technology Center
Charlotte, NC, USA

MIDREX TECHNOLOGIES INDIA PRIVATE, LTD.
Sales and support for Indian projects
New Delhi, India

MIDREX METALLURGY TECHNOLOGY SERVICES (SHANGHAI) LTD.
Sales, support, and engineering for Chinese projects
Shanghai, Peoples Republic of China

MIDREX UK LTD.
Project financing and support for global projects
London, United Kingdom

PROJECT FINANCING

ONE OF THE MOST CHALLENGING ASPECTS OF PROJECT DEVELOPMENT IS ARRANGING FOR FINANCING. CUSTOMERS OFTEN WANT TO BORROW MONEY TO FINANCE PROJECTS RATHER THAN TO FUND THEM FROM THEIR OWN RESOURCES. FINANCING ALLOWS A CUSTOMER TO DEFER PAYING FOR A PROJECT UNTIL IT IS CONSTRUCTED SO EARNINGS FROM THE PROJECT CAN BE USED TO REPAY THE LOAN.

EXPORT CREDIT FINANCING

The United Kingdom has excellent Export Credit Agency (ECA) financing support known as the Export Credit Guarantee Department (ECGD). There are two critical pre-requisites to access ECGD financing: the exporter must be a UK registered company and the exporter must source a minimum scope of supply from the UK. Midrex UK Ltd. was established in London to provide customers access to this valuable project development resource.

Midrex UK was most recently instrumental in arranging financing for the LGOK HBI 3 contract with Metalloinvest of Russia and is available to assist other Midrex customers in locating financing for projects throughout the world.



There are a number of sources of project financing: commercial banks, development banks, investment or merchant banks and export credit agencies.

CONDITIONS FOR PROJECT FINANCING		CONSIDERATIONS FOR PROJECT FINANCING		
<ul style="list-style-type: none">▪ Market for the product Is there sufficient demand at the price necessary to service the debt and provide a reasonable return on investment?▪ Access to raw materials Is there an adequate supply of labor and sufficient transportation or delivery systems for iron ore, reductant (fuel), electricity and water?▪ Debt service capacity Are the projected cash flows enough to service the debt?▪ Accuracy of cost estimates Have all cost been identified and verified?		Risks	Strategy	
		Completion	Select a competent general contractor; insist on completion guarantees	
		Production	Select a commercially proven technology; hire competent management and operating staff	
		Input	Obtain guaranteed supply contracts with longest term possible	
		Market	Sign product off-take contracts that cover cash flow, operating costs, and debt servicing	
		Political	Obtain host government support with licenses, taxes, etc.; involve national companies as project shareholders, investors or suppliers	
Regardless of the source, the more manageable the risks, the easier it is to secure project financing.				

STRONG GLOBAL CONSTRUCTION PARTNERS

MIDREX CONCENTRATES ON WHAT IT DOES BEST...DESIGNING AND ENGINEERING DIRECT REDUCTION PLANTS, SOURCING PROJECT FINANCING, AND PROCURING KEY PROPRIETARY EQUIPMENT.

From its earliest days, Midrex has been the technology partner of various international companies which have built plants based on the MIDREX® Direct Reduction Process. These companies, known as MIDREX® Construction Licensees, are selected for their particular expertise in project and construction management, process design and engineering, and often project financing.

In their own right, MIDREX® Construction Licensees are acknowledged leaders in their fields, from design and supply of iron and steelmaking furnaces to the production of steel products.

Each MIDREX® Construction Licensee exhibits the technical competence, adherence to completion schedule, and performance excellence that are the hallmarks of MIDREX® Plant projects. This makes for a strong and mutually supportive technical team and assures the utmost customer value.

MIDREX® CONSTRUCTION LICENSEES



• KOBELCO LTD.



• PRIMETALS
TECHNOLOGIES
(Formerly Siemens VAI
Metals Technologies)



• SMS GROUP
(Represented by
Paul Wurth S.A.)

KEY SUPPLIER RELATIONSHIPS

SPECIALIZED EQUIPMENT PLAYS AN IMPORTANT ROLE IN THE SUCCESS OF A THRIVING MIDREX® PLANT. WE RECOGNIZE THAT CLOSE RELATIONSHIPS WITH KEY EQUIPMENT SUPPLIERS ARE INDISPENSABLE TO HELP FACILITATE OPTIMUM PERFORMANCE AND SMOOTH START-UPS.

Midrex has active improvement and development programs with leading suppliers and makers of specialized equipment for hot briquetting and hot transport of DRI.

Maschinenfabrik Köppern GmbH & Co. KG

Midrex has worked for three decades with Köppern to develop the system for producing hot briquetted iron (HBI) from a MIDREX® Shaft Furnace and continues to cooperate with Köppern in technical matters related to HBI.

Aumund Fördertechnik GmbH

Midrex collaborates exclusively with Aumund to provide conveyors for efficiently transporting hot DRI (HDRI) and other materials.



START-UP & COMMISSIONING

MIDREX® PLANTS ARE KNOWN FOR BEING COMPLETED ON-TIME AND ON-BUDGET AND FOR QUICKLY ACHIEVING PRODUCTION AND PERFORMANCE GUARANTEES.

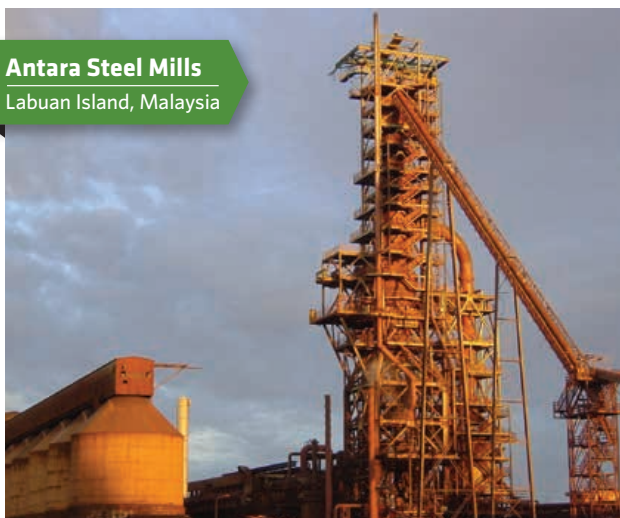
Following mechanical completion of the plant, each piece of equipment and the associated instrumentation and controls are inspected to verify the functionality of the total system.

All plant systems are verified during heat up and hot conditions, then process gas is introduced to initiate reforming into reducing gas. This begins the initial production phase.

Once into the production phase, the plant undergoes performance testing according to parameters established in the plant supply contract. The customer's personnel who will operate the plant are teamed with their counterparts in the Midrex/ Construction Licensee team for technology transfer, hands-on training and continued support. Upon successful completion of the performance tests, the plant is officially turned over to the customer in a commissioning ceremony.



Hadeed Modules A & B
Al-Jubail, Saudi Arabia



Antara Steel Mills
Labuan Island, Malaysia



FMO
Puerto Ordaz, Venezuela

TECHNOLOGY TRANSFER

TO SUSTAIN A SUCCESSFUL DRI OPERATION, EFFECTIVE TECHNOLOGY TRANSFER AND CONTINUED SUPPORT & ADVICE ARE REQUIRED.

Commissioning of a DRI Plant and successful technology transfer are just the beginning of our relationship with our clients. Providing plant owners the knowledge, assistance and benefits of continuing technological advancement is how **MIDREX® Plants** continue to advance and exceed client expectations.

The Midrex approach to technology transfer begins well in advance of the start-up and commissioning of a **MIDREX® Plant**. Awareness of and focus on the effective transfer of **MIDREX® Direct Reduction Technology** starts when plant systems and process equipment are being designed and continues throughout the life of the plant.

Midrex was one of the first U.S. iron and steel industry companies to embrace the concept of providing technical knowledge, training and manufacturing know-how to promote industrial self-reliance through local ownership, operation, and management. The four basic principles of **MIDREX®** technology transfer embody this philosophy.

BASIC PRINCIPLES OF MIDREX TECHNOLOGY TRANSFER

- **KEEP EQUIPMENT DESIGNS AND PLANT OPERATIONS AS SIMPLE AND UNCOMPLICATED AS POSSIBLE –**
One of the greatest accomplishments by Midrex engineers has been maintaining the basic simplicity of the **MIDREX® Process** while increasing its efficiency and productivity.
- **TAILOR TRAINING TO SPECIFIC OPERATIONAL AND PRODUCTION GOALS –**
Midrex training programs stress hands-on experience and are designed according to the background of those to be trained and the performance objectives of the plant management.
- **PROVIDE ONGOING OPERATIONAL SUPPORT AND TECHNICAL ASSISTANCE –**
Midrex offers a number of post-commissioning services intended to help clients get the most from their plants (see **MAINTENANCE AND OPERATIONS**, on page 13).
- **EXCHANGE TECHNICAL IMPROVEMENTS MADE BY MIDREX AND OTHER MIDREX® LICENSEES –**
The key to meaningful technology improvements is firsthand experience (see **MIDREX® PROCESS LICENSING PROGRAM**, on page 11).



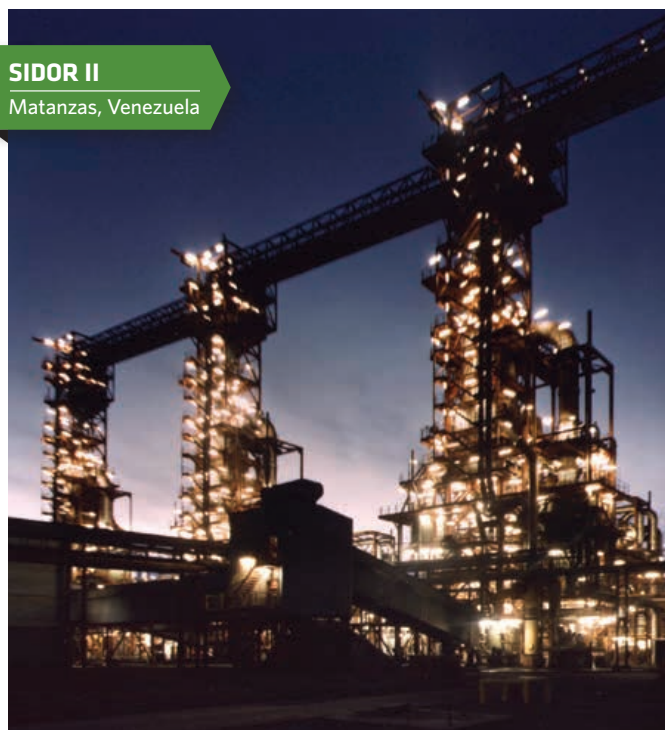
MIDREX® PROCESS LICENSING PROGRAM

CONTINUOUS IMPROVEMENT

IN ORDER FOR TECHNOLOGY TO FLOURISH, IT MUST BE DYNAMIC. MIDREX AND KOBE STEEL LIMITED (KSL), OWNER OF THE **MIDREX® PROCESS**, PLACE GREAT EMPHASIS ON TECHNOLOGY LICENSING. KEY TO THE SUCCESS OF THIS LICENSING APPROACH IS THE COMMITMENT OF MIDREX AND KSL TO MAINTAIN AN ONGOING RELATIONSHIP WITH PROCESS LICENSEES THAT IS BENEFICIAL TO ALL **MIDREX® PROCESS LICENSEES**.

Technology sharing is at the heart of the MIDREX® Process Licensing Program. As a MIDREX® Process Licensee, MIDREX® Plants benefit from the knowledge and experience of not only our staff but of the continually expanding group of operating MIDREX® Plants worldwide.

The close cooperation between Midrex and its plant operators, construction partners and proprietary equipment suppliers supported by an ongoing research and development program are key to the continued commercial success and technical leadership of MIDREX® Direct Reduction Technology. A vital part of this cooperation is the MIDREX® Process Licensing Program.



SUPPLYING TECHNOLOGY - THE MIDREX WAY

Midrex was one of the first US companies to embrace the concept of technology sharing as the way to transfer technology. Rather than the traditional method of direct investment and retention of management control, Midrex chose to train and empower its clients to be successful in managing and operating their plants and encouraged them to come up with innovations and improvements.

By providing its clients the knowledge, training, and assistance to successfully manage and operate their plants, Midrex broadens its network of technical information, operating data, and hands-on experiences that keeps MIDREX® Direct Reduction Technology on the leading edge.

HOW THE PROCESS LICENSING PROGRAM WORKS

Each client who purchases a **MIDREX® Direct Reduction Plant** enters into a Process License Agreement, which grants the right to use the body of patented know-how and technical expertise, collectively known as **MIDREX® Technology**, to operate and maintain the plant and to produce and use and/or sell the plant's product(s). In conjunction with the Process License Agreement, Midrex provides its licensees access to future process improvements and technology enhancements, as well as operational data and know-how received from all **MIDREX® Licensees**.

For their part, licensees agree to respect and protect the proprietary nature of **MIDREX® Technology** and to make improvements and optimizations available to Midrex and all other licensees.

In order to further promote technology sharing, Midrex hosts an annual plant operations seminar. Representatives of each Process Licensee, along with the Construction Licensees and key equipment suppliers gather to exchange ideas and experiences and to make or renew acquaintances.

Members of the Midrex customer services and technical staff are in frequent contact with licensees and regularly visit the operating plants to offer spare parts and materials procurement assistance, engineered solutions, field services and MRO (maintenance, repair and operation) services, and field services (*see page 13, CONTINUED SUPPORT & SOLUTIONS*).



LEGACY OF THE PROCESS LICENSING PROGRAM

Plants from each of the five decades the **MIDREX® Process** has been available are in operation today. This is a testimony to the basic design of the **MIDREX® Process** and the effectiveness of the **MIDREX® Process Licensing Program**. Midrex clients have access to the latest innovations and improvements and the experience and expertise of more than 50 other licensees.

Through the years, countless numbers of Midrex and licensee personnel have been trained in the plants of fellow licensees. Shared experiences have resulted in improvements of equipment designs, optimization of plant operations, and the introduction of new products including hot briquetted iron (HBI).

The **MIDREX® Process Licensing Program** is in touch with the wants and needs of the market. It provides the means to develop and perfect "the next great idea" while maintaining the vitality of existing ones. It is based on the Midrex approach to technology transfer...technology sharing, a two-way street to technology excellence and operational success.

CONTINUED SUPPORT AND SOLUTIONS

MAINTENANCE AND OPERATIONS

THE SECRET OF THE BEST OPERATING **MIDREX® PLANTS** IS A SIMPLE ONE – A GOOD MAINTENANCE AND OPERATIONS PROGRAM. MIDREX CAN ASSIST WITH THIS VIA OUR DEDICATED AFTERMARKET SPARE PARTS AND SUPPORT GROUP – MIDREX GLOBAL SOLUTIONS.

SPARE PARTS AND MATERIALS PROCUREMENT

Midrex is able to provide cost-effective and timely supply of necessary spares and materials by maintaining relationships with a large number of equipment manufacturers and vendors worldwide. These parts are specifically designed and manufactured for use in **MIDREX® Plants** and include technical support and the latest technological improvements along with expert packaging and export shipping methods and procedures.

ENGINEERED SOLUTIONS

Midrex Global Solutions is a group dedicated to working with **MIDREX® Process Licensees** to develop engineered solutions and equipment designs that increase plant productivity, reduce operating costs, and improve overall plant operations. Midrex Global Solutions coordinates and manages small capital projects involving engineering services, equipment designs and supply, and on-site troubleshooting.

MRO SERVICES

Midrex has extensive procurement capabilities for assisting plants with maintenance, repair and operation (MRO) services on an ongoing basis. **MIDREX® Process Licensees** can have Midrex procure all items that must be sourced offshore, which takes advantage of the experience and buying power of Midrex and frees up plant personnel for other operational and administrative tasks.

FIELD SERVICES

Midrex can provide highly skilled and experienced contract workers for plant support functions including operations, maintenance, plant expansions and improvements, and purchasing. These technical personnel have extensive experience in various disciplines in the start-up, commissioning, operation, and maintenance of **MIDREX® Plants**.



PROVIDING IRONMAKING SOLUTIONS FOR STEELMAKERS

MIDREX® DIRECT REDUCTION TECHNOLOGY REPRESENTS THE BEST VALUE FOR THE INVESTMENT...BUT TECHNOLOGY ALONE IS NOT THE ANSWER.

It takes innovation, insight and a passion for excellence to harness the potential of DRI technology. It also takes experience, expertise and pride in providing DRI solutions to successfully deliver a project on time and on spec, while continuing to support it and its operators for years after.

MIDREX® DRI technologies deliver the best investment value. Midrex offers the most reliable, flexible and productive direct reduction plants in the world. These plants are designed, supplied and serviced by dedicated employees and experienced technology and construction partners, who collectively represent the best the direct reduction industry has to offer.

Midrex is constantly challenging itself and encouraging its partners and plant operators to find the next breakthrough ... the next improvement or innovation to provide sustainable ironmaking solutions for steelmakers.



2016. The world's largest single module HBI plant, **voestalpine Texas**, begins operations with production capacity of 2.0 Million tons per year.



1969. First MIDREX® Plants built at **Oregon Steel Mills** in Portland, Oregon, USA.





www.midrex.com

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