

MIDREX^{NG}™

Optimizing DRI production
using natural gas



MIDREX

Designed for Today,
Engineered for Tomorrow™



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ENVIRONMENTAL ASSURANCE

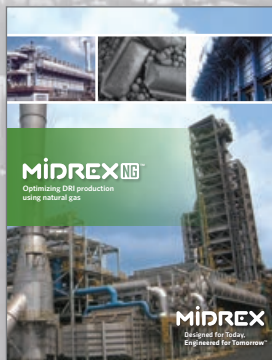
Midrex Technologies, Inc. along with its parent company Kobe Steel, Ltd., recognizes the importance of protecting the environment and conserving natural resources. Through the years we have been proactive in increasing efficiency, productivity, reliability and safety while reducing the environmental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



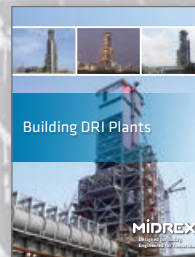
MIDREX® Process



MIDREX NG™



MXCOL®



Building DRI Plants



DRI Products & Applications

MIDREX NG™

NATURAL GAS-BASED IRONMAKING

MIDREX NG™ IS THE NEW NAME AND TRADEMARK USED TO DIFFERENTIATE THE MIDREX® PROCESS OPERATING USING NATURAL GAS FROM THE MIDREX® PROCESS USING COAL BASED FUELS (MXCOL®).

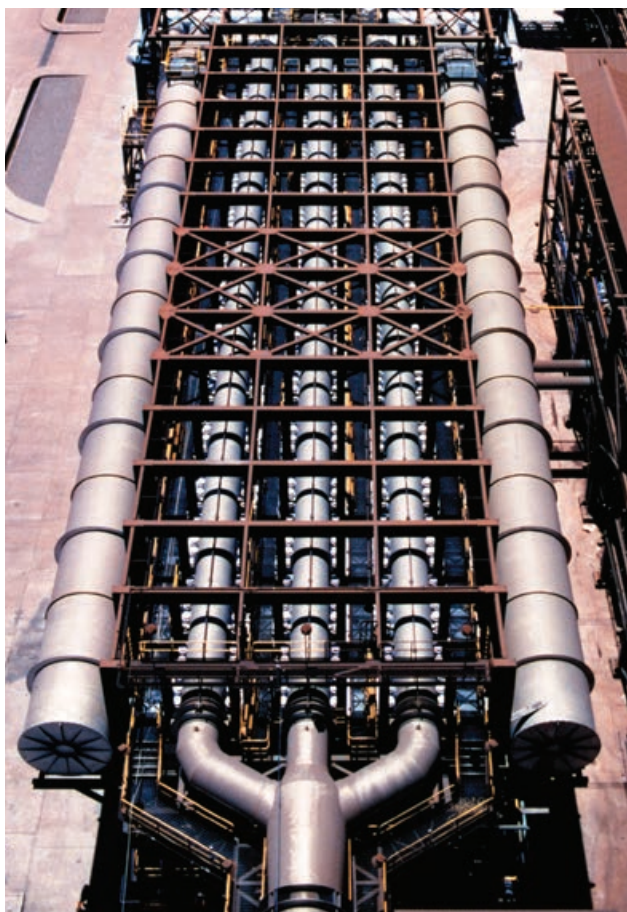
MIDREX NG™, the natural gas-based configuration of the MIDREX® Process, is the most widely-used technology for the production of all forms of direct reduced iron (DRI) products. Each year, MIDREX® Plants produce more than 60% of the entire world's DRI and more than 80% of the DRI produced by all shaft furnace technologies.

NATURAL GAS – THE CLEANEST, GREENEST IRONMAKING FUEL

Natural gas is playing a major factor in helping many industries cut emissions and improve the world's overall air quality. Natural gas is a fossil fuel hydrocarbon gas mixture consisting primarily of methane (CH_4). Shale gas is natural gas trapped within shale formations.

In order to use natural gas for ironmaking, the natural gas needs to be processed, or rather, reformed into a usable reducing gas that is high in hydrogen (H_2) and carbon monoxide (CO) content.

MIDREX NG™, through use of the patented MIDREX® Reformer, cost effectively makes reducing gas for the iron ore reduction reactions that take place in the MIDREX® Shaft Furnace. The MIDREX® Reformer externally generates reducing gas and further optimizes the MIDREX Shaft Furnace performance by converting recycled gas (from the iron reduction reactions) along with fresh natural gas into H_2 and CO to produce additional reducing gas.



THE MIDREX® REFORMER

THE MIDREX® REFORMER HAS BEEN AT THE CORE OF THE MIDREX® PROCESS SINCE ITS INCEPTION. THROUGH THE YEARS IT HAS BEEN IMPROVED AND REMAINS THE STANDARD OF THE INDUSTRY.

In MIDREX NG™, iron oxide is reduced in the MIDREX® Shaft Furnace by using reducing gas externally generated in the high temperature and highly efficient MIDREX® Reformer. It is a closed loop system that minimizes natural gas consumption as well as minimizes the number of moving parts within the plant.

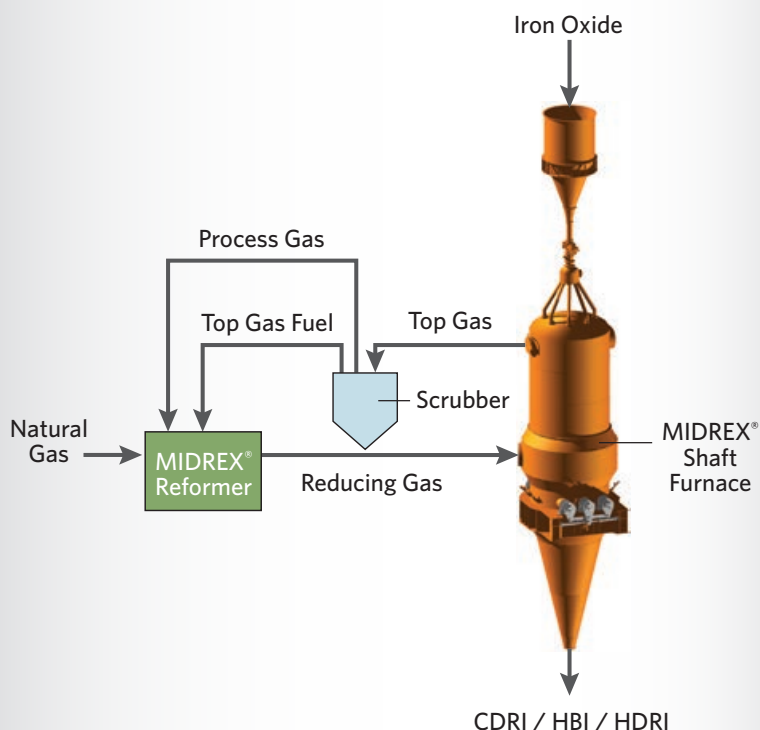
MIDREX® REFORMER & PROCESS DESCRIPTION

Within the MIDREX® Shaft Furnace direct reduced iron (DRI) is produced by reacting iron oxide with a hot reducing gas made up of H_2 and CO . The H_2 and CO reduces Fe_2O_3 into metallic iron (Fe) and the by-products of this reaction are CO_2 and H_2O .

In the MIDREX® Reformer natural gas is heated and catalytically reformed along with the recycled CO_2 and H_2O from the reduction process to generate a rich reducing gas to make DRI.

As part of the MIDREX NG™ design, the reduction byproducts, CO_2 and H_2O , along with unreacted H_2 and CO are recycled to minimize energy consumption and to produce additional reducing gas. In addition to providing the reducing gas, the MIDREX® Reformer also provides the energy needed for the reduction reactions within the MIDREX® Shaft Furnace.

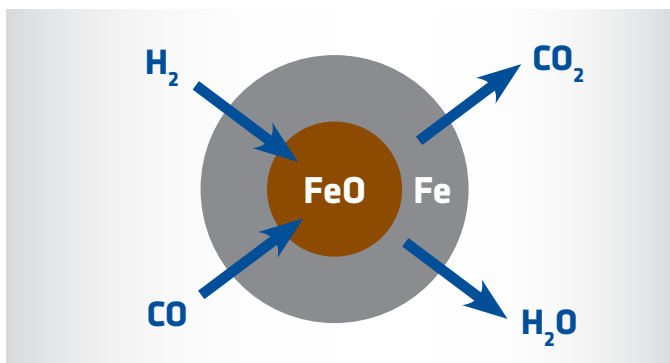
MIDREX® PROCESS FUELED BY NATURAL GAS MIDREX REFORMER®



MIDREX NG™ Plant



THE OVERALL REDUCTION REACTIONS ARE:



Carbon dioxide (CO₂) and water vapor (H₂O) are byproducts of the iron oxide reduction reactions.



UNIQUE FEATURES OF THE MIDREX[®] REFORMER

By design, the MIDREX[®] Reformer is able to manage CO₂ in the recycle gas as well as capitalize on the heating value of the recycle gas to generate more reducing gas. This offsets the amount of reducing gas used during reduction in the shaft furnace. Another way to view this is that less natural gas must be added to produce an equal amount of reducing gas.

The recycle of CO₂ byproduct from the reduction furnace creates an additional reforming reaction of CH₄ + CO₂ to produce 2H₂ and 2CO, which in turn generates extra reducing gas for making DRI.

The MIDREX[®] Reformer enables the use of recycled gas and hot reformed gas to be fed to the shaft furnace without quenching and reheating, providing for a very efficient process. This single component eliminates the need for a separate CO₂ removal system, the need for a process gas re-heater and the cost to both build and operate these units.

- **MIDREX[®] Reformer reforms both CO₂ and H₂O with natural gas, thus eliminating the need for an expensive CO₂ removal system**
- **Generates low H₂/CO ratio reducing gas—resulting in better energy efficiency**
- **Valuable heat is retained from the MIDREX[®] Reformer eliminating the requirement of an expensive gas heater**

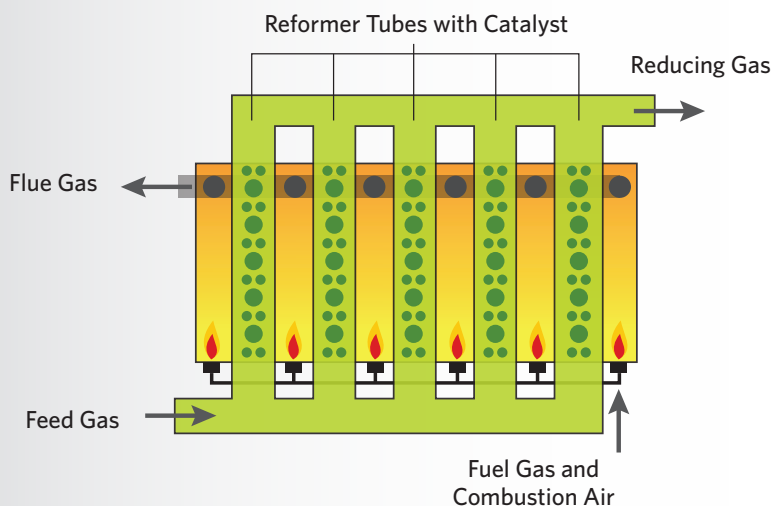
BENEFITS OF THE MIDREX[®] REFORMER

THE BASIC CONCEPT OF THE **MIDREX[®] REFORMER** REMAINS THE SAME AS IN WHEN IT WAS FIRST INTRODUCED; HOWEVER, THE PERFORMANCE, RELIABILITY AND FLEXIBILITY HAVE STEADILY IMPROVED ALLOWING EVEN OLDER **MIDREX[®] PLANTS** TO OUTPRODUCE AND OUTPERFORM COMPETING TECHNOLOGIES' NEW FACILITIES.



THE MIDREX[®] REFORMER AT A GLANCE

- No steam system required for reforming
- No CO₂ removal system required for operation
- Hot reducing gas can be directly used in the MIDREX[®] Shaft Furnace without quenching and reheating
- No O₂ required for reforming
- By using CO₂ for reforming, less natural gas is required
- Enables **MIDREX NG[™]** to be a simple closed loop system minimizing energy consumption and the number of moving parts within the plant



TYPICAL COMPOSITION

	INLET	OUTLET
H ₂	35	55
CO	19	35
CO ₂	15	2
H ₂ O	13	6
CH ₄	17	1
N ₂	1	1
Temp. (°C)	580	980



PROVEN PERFORMANCE

MIDREX NG™ PLANTS ARE THE STANDARD BY WHICH THE DIRECT REDUCTION INDUSTRY IS JUDGED.

Many factors can affect the profitability of a direct reduction plant...changes in energy, ore, labor and utility costs and the ups and downs of the steel industry. However, the factor that has the greatest impact over the life of the plant is the choice of process technology.

Designed for Today, Engineered for Tomorrow™ is more than a marketing slogan at Midrex. We work with owners and operators to ensure their plants are capable of dealing successfully with real world market changes.

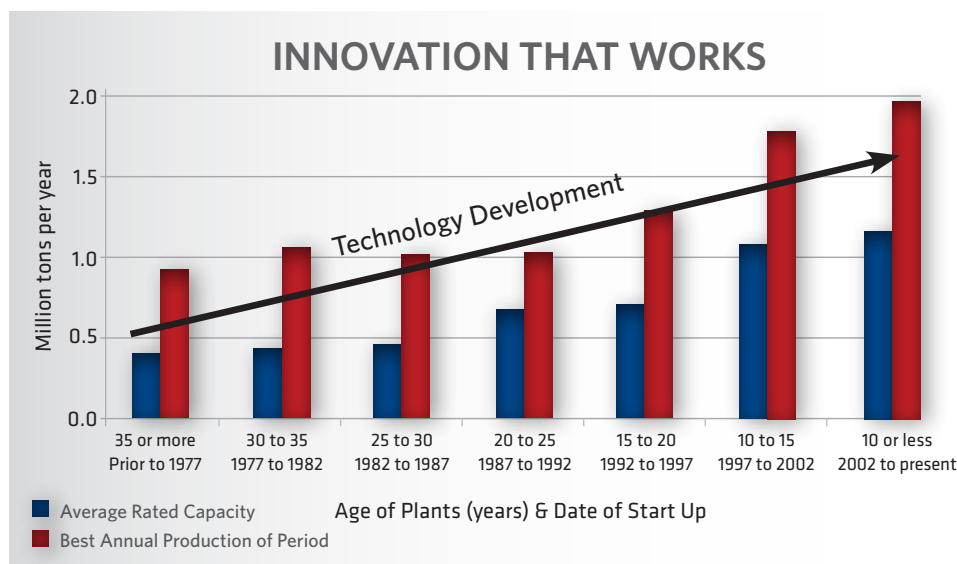
MIDREX NG™ Plants are known for their reliability and hours of continuous operation. A number of MIDREX® Plants have produced 500,000 metric tons more than their design capacities in a single calendar year. This is one reason why MIDREX® Plants year in and year out produce the most tons and have the highest availability in the industry.

Hours of Operation x Capacity = Production → Profits

Profits x Years = VALUE → Sustainability

In times of difficult market conditions, MIDREX® Plants can be turned down to produce fewer tons with no significant economic impact and can be returned to full operation quickly and efficiently. In several cases, MIDREX Plants have been moved to more advantageous market locations and even modified to produce a different product or to use an alternative fuel.

Few investments can stand the test of time...especially going back to the early 1970s. Today MIDREX® Plants built almost 45 years ago are in operation and exceeding their original design capacity and product quality.





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