

Direct Reduction Industry

Advanced Centrifugal Castings

High Performance Alloys for Direct Reduction Industry



Schmidt + Clemens History

- 1879** Foundation of steel trading company in Frankfurt am Main on 1st May 1879 by Ludwig Schmidt and Wilhelm Clemens
- 1900** Foundation of the Kaiserau location
Acquisition of the first water-powered hammer mills
- 1923** Initiation of heat treatment
- 1932** Initiation of static casting production
- 1950** Initiation of horizontal centrifugal casting
- 1955** Initiation of investment casting production
- 1963** Initiation of vertical centrifugal casting
- 1964** First delivery of centrifugal casting tube to the petrochemical industry
- 1974** Foundation of CENTRACERO S.A., Spain
- 1979** The 100th anniversary of S+C
- 1982** Foundation of Schmidt + Clemens, Inc., Houston / Texas, USA
- 1997** Foundation of ALFANAMETAL, Czech Republic
Takeover of Bowers & Jones Ltd., UK
- 2000** Foundation of Schmidt + Clemens Brasil Ltda., Brazil
- 2001** First implementation of micro alloys on Midrex[®] DR plants
- 2001** Foundation of Schmidt + Clemens Asia Sdn. Bhd., Malaysia
- 2004** 125th anniversary of Schmidt + Clemens
- 2004** First implementation of Centralloy[®] 60 HT D partial Midrex Reformer
- 2009** Foundation of Schmidt + Clemens Saudi Arabia Fabrication Shop, KSA
- 2010** First implementation of Centralloy[®] HT E in a HyL[®] plant
- 2012** First implementation of Centralloy[®] 60 HT D in a full Midrex[®] Reformer



Midrex[®] is a registered trade mark of Kobe Steel, LTD.
HyL[®] is a registered trade mark of HYLSA S.A. de C.V. a HYLAMEX company.

Advanced Centrifugal Casting Alloys for DR Industry

Schmidt + Clemens is the market leader in centrifugally cast tubes for Direct Reduction Industry, thanks to the trust of many customers around the world, which has allowed us to provide more than 40000 tube assemblies since 1986. Our leading position is the result of:

- High metallurgical product quality, ensured by our stringent quality systems, which constitutes the basis for achieving the required product performance and lifetime.
- Highly efficient manufacturing methods including unique melting, machining and welding techniques, as the result of a mayor ongoing investment programme in manufacturing development.
- Product improvement boosted by specialists in our RDS department, who are responsible for developing new materials with the specific objective of meeting the most demanding operational requirements.
- Since 2001, specially developed materials for Midrex® and HyL® processes have been the core target of S+C, resulting in the successful implementation of microalloyed materials, and lately in 2004, the HT family of alloys for service up to 1200 °C, improving performance and productivity of the DR plants.
- Customer service offered through our worldwide network of facilities.

Our high quality products, innovative developments and our complete range of services are the basis for our company objectives: complete customer satisfaction and confidence.





Products for Midrex® Reformers

- Fully assembled reformer tubes
- Convection coils and recuperator bundles
- Accessories
- Specialised services such as monitoring or metallurgical support

New metallurgies were developed in Schmidt + Clemens. The main outcome was observed in plant reliability improvement and lifetime extension of the tubes.

The proprietary Centralloy® G 4852 Micro and Centralloy® G 4879 Micro materials were specially designed by Schmidt + Clemens for DR Reformer applications to meet the most stringent mechanical requirements and were already supplied since 2001. Centralloy® 60 HT D has been designed for the operation of the reformer tubes up to a maximum firebox temperature of 1185 °C thus, resulting in a significant increase in plant productivity. This is based in a completely new metallurgy with superior oxidation and mechanical properties.

Range of Alloys

Description				Chemical Composition								Most common application for Midrex® reformer tubes
No	Trade Mark Centralloy®	ASTM Type	Designation according to DIN EN 10027 Part 1	Approximate values in wt%								
				C	Si	Mn	Cr	Ni	Nb	W	Others	
1	G 4852	HP+Nb	GX40NiCrSiNb35-25	0.4	1.5	1.5	25	35	1.5	–	–	Bottom section
2	G 4852 Micro	HP+Nb (MA)	GX45NiCrSiNbTi35-25	0.45	1.5	1	25	35	1.5	–	+ Add.	Bottom section
3	G 4852 Micro R	HP+Nb (MA)	GX45NiCrSiNbTi35-25	0.45	0.8	1.5	25	35	1	–	+ Add.	Bottom section
4	G 4879	NA 22H/HV	G-NiCr28W	0.45	1.5	1.5	28	48	–	5	–	Top section
5	G 4879 Micro	NA 22H/HV (MA)	G-NiCrTi28W	0.5	1	0.75	28	48	–	5	+ Add.	Top section
6	60 HT D	–	–	0.45	–	–	27	Bal.	0.7	–	Fe, Al, + Add.	Top section

Features

Chemical composition of alloys designed for Midrex® DR Reformers include:

- 0.4–0.5 wt% carbon and nickel higher than 35 wt% for mechanical resistance and structural stability at high temperatures.
- Chromium contents higher than 25 wt% for necessary oxidation resistance.
- Aluminium, which is used in Centralloy® 60 HT D as a source for oxide layers build-up against high temperature corrosion phenomena. Our Centralloy® 60 HT D constitutes the latest alloy development, unique in the world of centricast products.

Balanced compositions lead to material structures with optimised physical and mechanical properties.

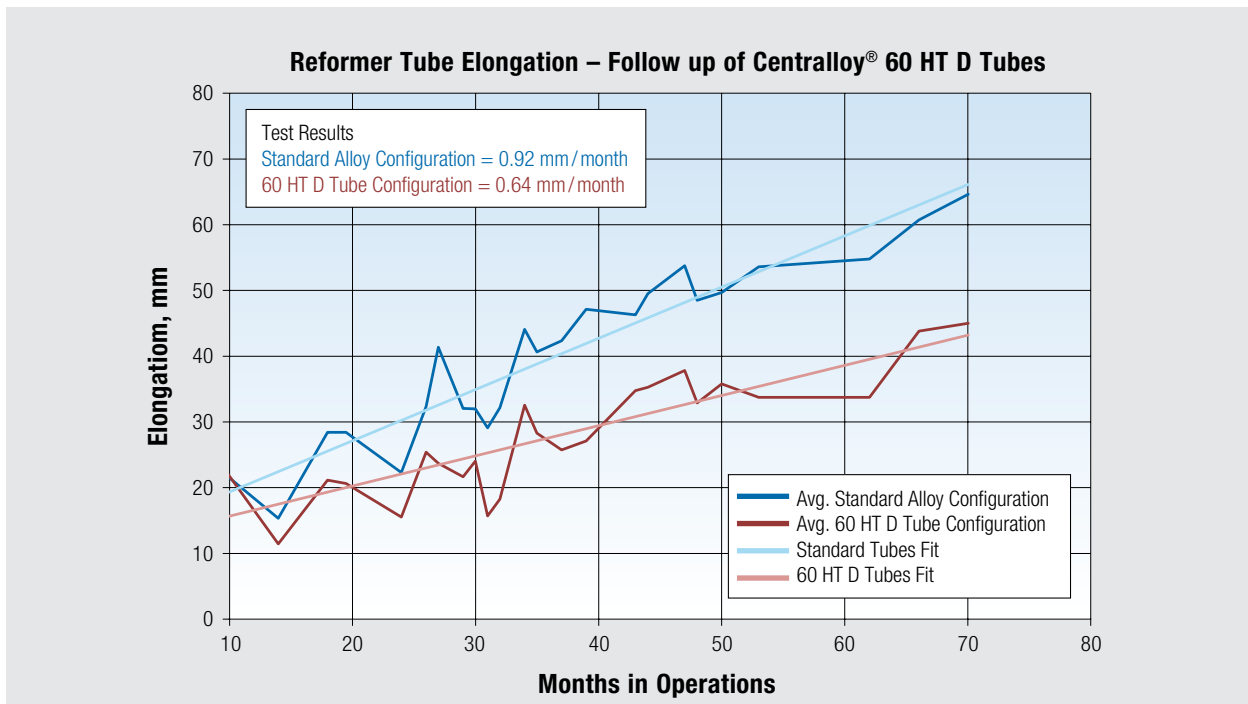
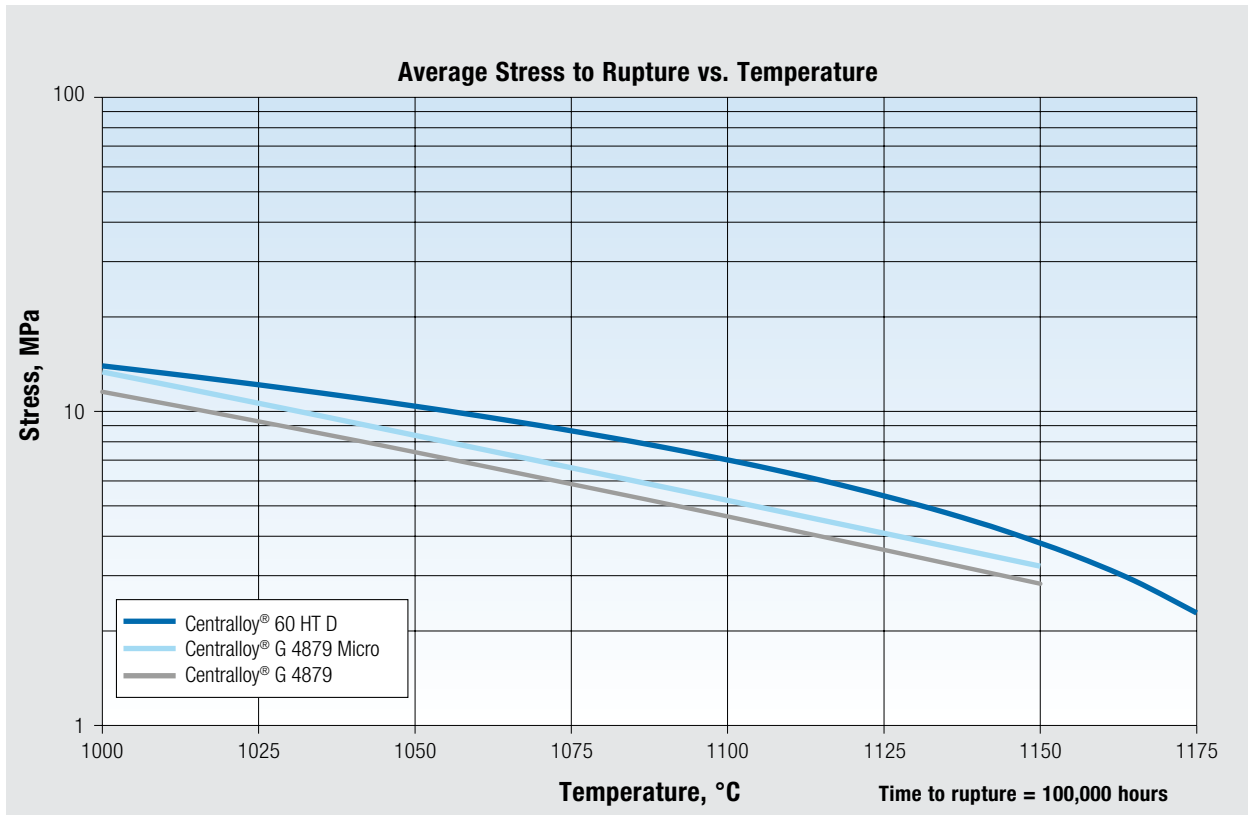
Carbon content leads to the formation of:

- Primary M_7C_3 -type carbides during casting, which are transformed into $M_{23}C_6$ upon ageing.
- Secondary carbides of the $M_{23}C_6$ - and M_6C -type during ageing.
- Primary and secondary niobium carbides.

Fine carbides precipitation results in improved high temperature mechanical properties including creep strength.

Further improvement is possible by the addition of strong carbide forming elements like titanium. Creep strength is increased by 15–20%. Because of the small amounts of carbide forming elements used, such alloys are called micro alloys.

Comparative Performance



Highest requirement of reformer tubes is found in the top section material. In addition to a high creep strength able to withstand throughout the lifetime of the tubes, reduced elongation of the overall assembly is necessary to maintain dimensional stability of the tubes during operation to avoid hot bands.

Products for HyL[®] Plants

- Reformer tubes
- Process gas heaters coils
- Convection modules
- Accessories
- Specialised services



Catalyst Tubes for HyL[®] Steam Reformer:

Centralloy[®] G 4852 Micro R is specially designed for steam reformer with the highest creep rupture strength, combined with excellent oxidation resistance.

Coils for HyL[®] Process Gas Heaters:

Centralloy[®] ET 45 Micro provides the best protection against metal dusting in PGH coils. Centralloy[®] HTE offers delayed coke deposition and the best carburisation resistance.

S+C provides the material selection for the optimum PGH coil configuration.

Range of Alloys

Description				Chemical Composition								Most common application in HyL [®] plants
No	Trade Mark Centralloy [®]	ASTM Type	Designation according to DIN EN 10027 Part 1	Approximate values in wt%								
				C	Si	Mn	Cr	Ni	Nb	W	Others	
1	G 4852	HP+Nb	GX40NiCrSiNb35-25	0.4	1.5	1.5	25	35	1.5	–	–	Steam reformer tubes
2	G 4852 Micro	HP+Nb (MA)	GX45NiCrSiNbTi35-25	0.45	1.5	1	25	35	1.5	–	+ Add.	Steam reformer tubes
3	G 4852 Micro R	HP+Nb (MA)	GX45NiCrSiNbTi35-25	0.45	0.8	1.5	25	35	1	–	+ Add.	Steam reformer tubes
4	ET 45 Micro	–	GX45NiCrSiNb45-35	0.45	1.6	1	35	45	1	–	+ Add.	Preheater coils – Metal Dusting
5	ET 45 LC	–	GX13NiCrNb45-35	0.13	0.8	1.5	35	45	0.8	–	+ Add.	Preheater coils – Metal Dusting
6	HT E	–	–	0.45	–	–	30	45	0.5	–	Fe, Al, + Add.	Preheater coils – Coking, Carburisation

Features

Chemical composition of alloys designed for HyL[®] products include:

- 0.4–0.5 wt% carbon and nickel higher than 35 wt% for mechanical resistance and structural stability at high temperatures.
- Chromium contents higher than 25 wt% for necessary oxidation resistance.
- Aluminium, which is included in Centralloy[®] HT E as a source for oxide layers build-up against coking and carburisation, for the best performance at high temperature.

Balanced compositions lead to material structures with optimised physical and mechanical properties.

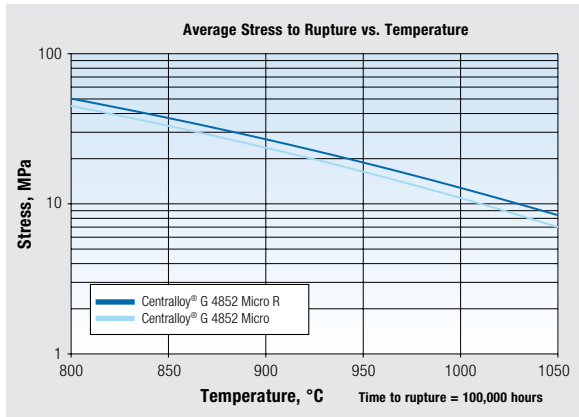
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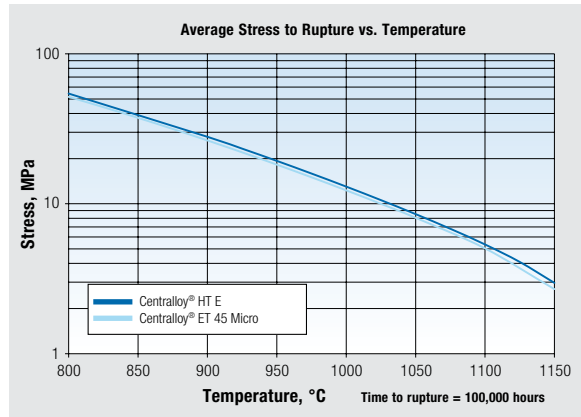
Fine carbides precipitation results in improved high temperature mechanical properties including creep strength.

Further improvement is possible by the addition of strong carbide forming elements like titanium. Creep strength is increased by 15–20%. Because of the small amounts of carbide forming elements used, such alloys are called micro alloys.

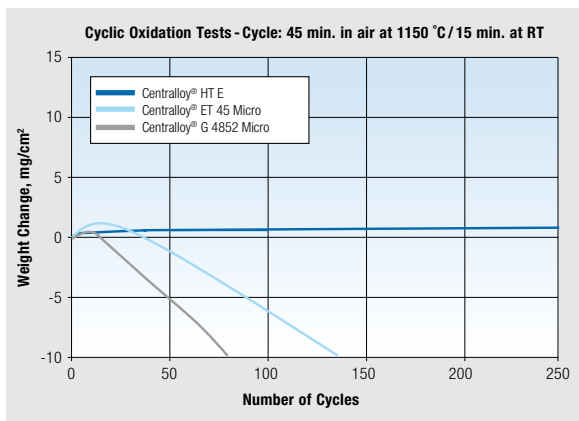
Comparative Performance



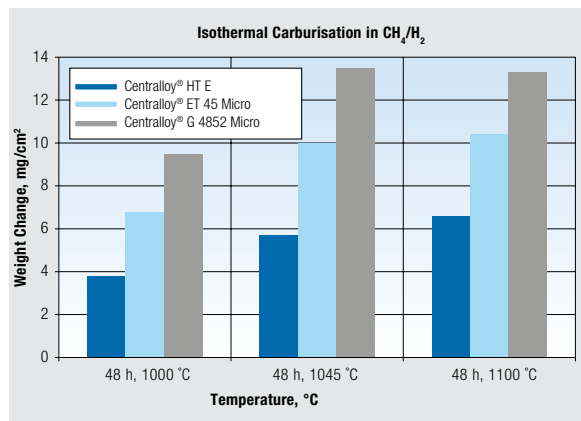
With the highest creep strength in the market, Centralloy® G 4852 Micro R can substantially increase lifetime or allow wall thickness reduction of reformer tubes. Creep properties improvement is achieved by the formation of nano precipitates.



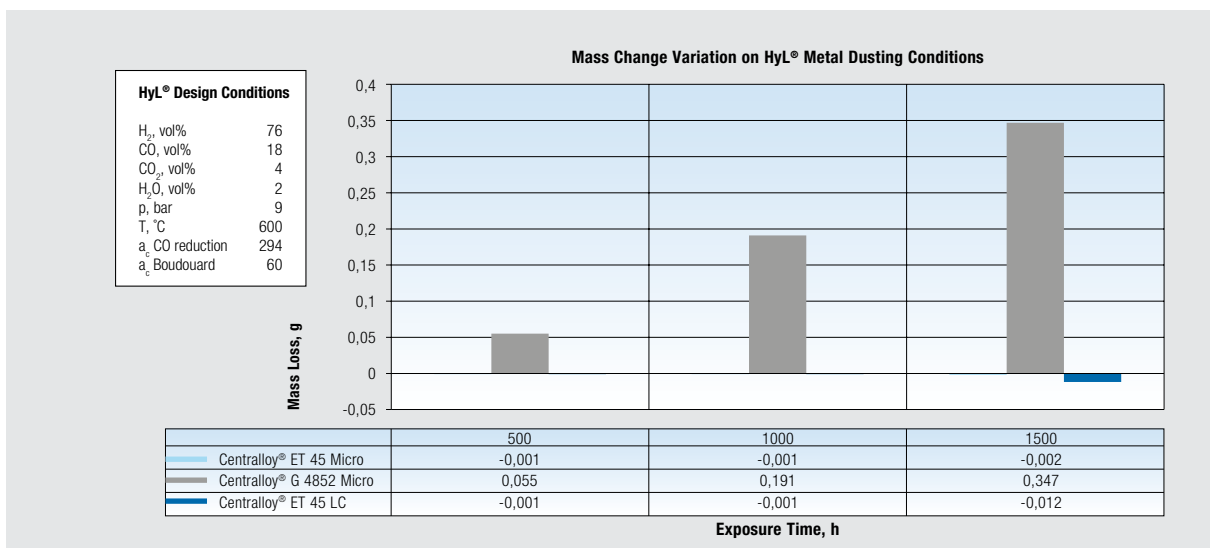
Centralloy® HT E combines an excellent oxidation, coking and corrosion resistance, together with significant creep strength for the operation in HyL® PGH coils.



The formation of extremely protective alumina layers of Centralloy® HT E, is substantially improving the performance of this alloy under oxidising and carburising atmospheres.



Higher resistance to carburisation and coking of Centralloy® HT E, allows material to withstand severity of PGH coil atmospheres for longer time.



Under metal dusting conditions, Centralloy® ET 45 Micro and Centralloy® ET 45 LC have proven excellent stability for HyL® PGH coils.

Customer Service

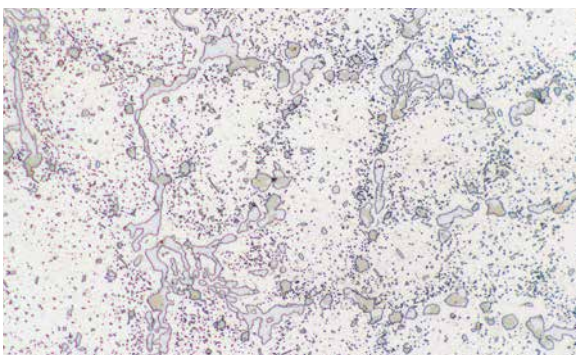
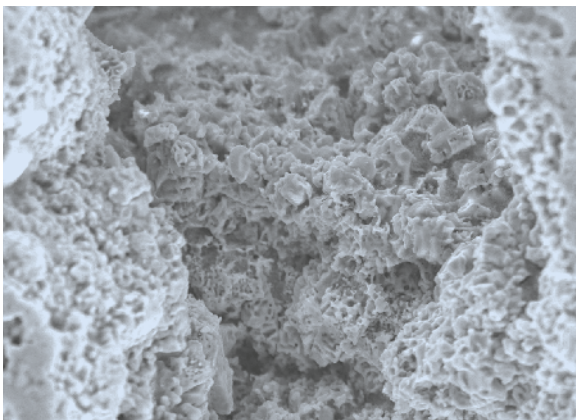
Many years of experience in centrifugal casting led Schmidt+Clemens to develop a specific Customer Service Policy, exceeding continuously our customer's expectations and needs.

Schmidt + Clemens is keen to offer technical assistance. Shared experience with our customers determines the strategy for the development and improvement of our materials and services.

Schmidt + Clemens provides:

- Reformer tubes inspection.
- Plant data collection evaluation.
- Reformer tubes performance monitoring.
- Technical assistance during major shutdowns.
- Material selection consultancy.
- Metallurgical and remaining life consultancy.
- Site installation.
- Assistance in emergencies.

All of the above follows the purpose of acting as your problem-solving partner.



Complete package supplier

S+C supplies complete reformer tube assemblies and coils. Accessories provided as part of the assemblies may include:

- Tee pieces
- Ceramic fibres and refractories
- Cones and flanges
- Top and bottom canister assemblies
- Compensators
- Backing rings
- Static casting fittings
- Welding consumables

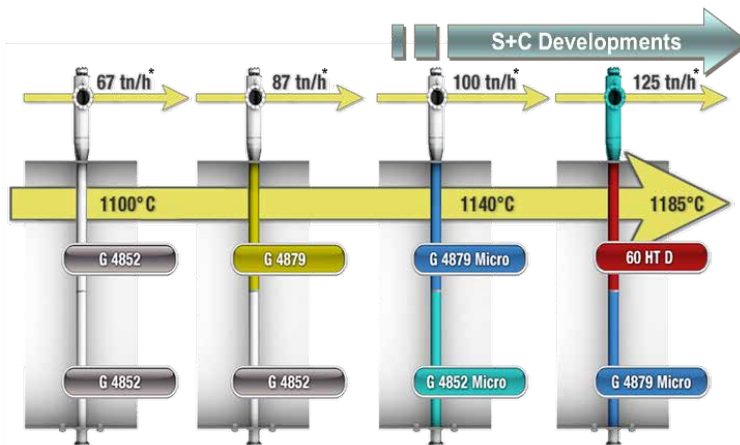


Research and Development

S+C holds the leading position in the DR market, being the unquestionable reference company regarding quality and reliability of their products. This strong market position is due to the great effort of the S+C group during the last years to understand their customer needs and develop products to meet the most demanding requirements.

S+C has been through many years the pioneer to introduce into the DR market new developments such as specifically developed microalloyed materials for the DR Midrex® and HyL® markets, capable of achieving the longest time in operation with the highest dimensional stability.

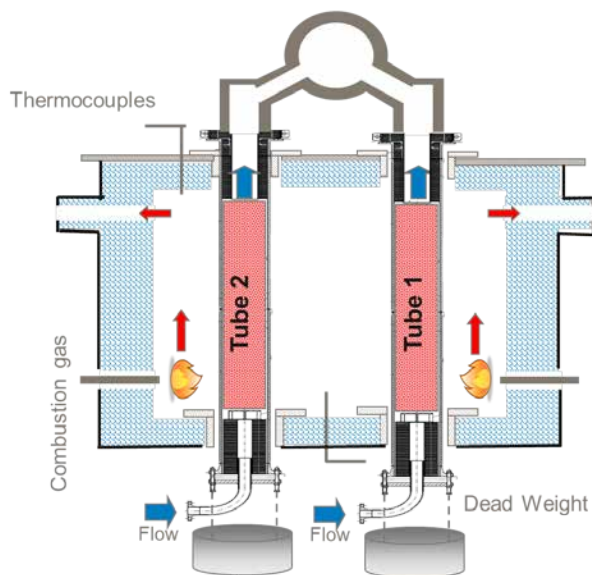
One of the most demanding enterprises that the S+C group was engaged, was the research and development of a new material suitable to allow higher operation of the Midrex® reformers and HyL® PGH, limited until then by the metallurgical constrain of the available materials. Using the group synergy, the knowledge achieved during the development of alloys for extreme high temperature applications and a multidisciplinary approach led S+C to introduce into the market the latest alloy generation, Centralloy® 60 HT D and Centralloy® HT E. Simplicity in the result of using aluminium as alloying element does not reflect the technical complexity in achieving the desired highest resistance to oxidation and creep. The superior properties of both alloys have set a new limit for the operation of DR plants.



* Theoretical Reformer Capacity for 288 (8" ID) – 220 (10" ID) tubes

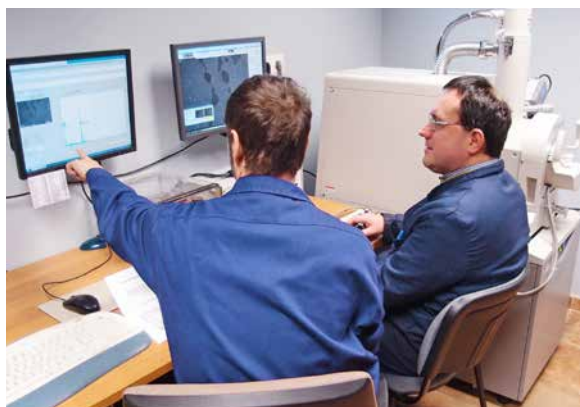
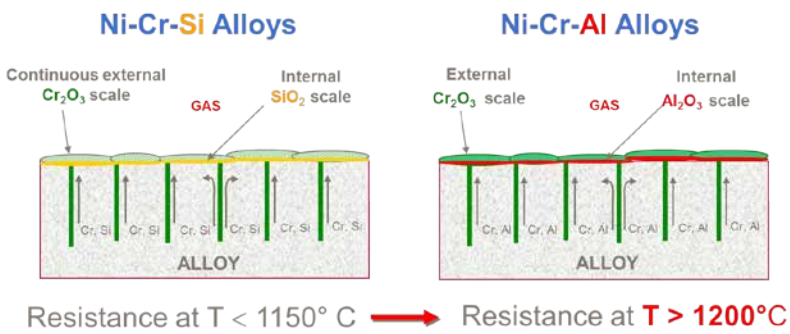
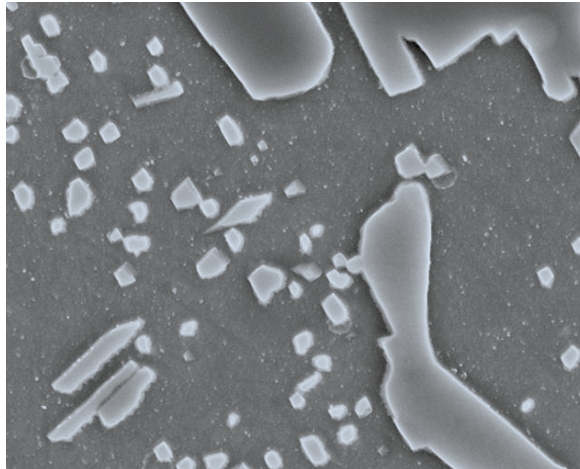


Pilot Plant Furnace Design



This has not only been tested on laboratory scale, up scaling from lab tests to pilot plant testing was first ever done in order to ensure a proper selection of this material for higher never used temperatures, leading to the tests in specially designed pilot plants at even higher temperatures than the targeted during full scale plant operation, in order to ensure reliability for the customer furnace. Continuous operation at 1200 °C was first reproduced.

The long term compromise of S+C with the R&D for DR includes dedicated technical and human resources ensuring customer satisfaction and products able to meet their highest expectancies.



Industries

- Petrochemicals
- Iron-ore direct reduction

Services

- Business consulting
- Analysis of operational data
- Training of customer personnel
- Welding supervision

Germany

Schmidt + Clemens GmbH + Co. KG Edelstahlwerk Kaiserau

Kaiserau 2, 51789 Lindlar

Phone: +49 2266 920

Fax: +49 2266 92370

E-Mail: info@schmidt-clemens.com

Spain

Schmidt - Clemens Spain S.A.U.

Ctra. Estella-Vitoria, Km. 12

31280 Murieta, Navarra

Phone: +34 948 53 46 00

Fax: +34 948 53 46 01

E-Mail: centracero@schmidt-clemens.com

Brazil

Schmidt + Clemens Brasil Ltda.

Avenida Beta, 351

13213-070, Jundiá, Sao Paulo

Phone: +55 11 3378 3901

Fax: +55 11 4582 9888

E-Mail: scbrasil@schmidt-clemens.com.br

Malaysia

Schmidt + Clemens (Asia) Sdn. Bhd.

No. 15, Jalan Pemaju U1/15, Section U1

Hicom Glenmarie Industrial Park

40150 Shah Alam, Selangor Darul Ehsan

Phone: +60 3 5569 1945

Fax: +60 3 5569 1425

E-Mail: sc-asia@schmidt-clemens.com

Czech Republic

S+C Alfanametel s.r.o koncern

783 57 Tršice c. 126

Phone: +420 58 59 57 428

Fax: +420 58 59 57 430

E-Mail: alfa@alfanametel.cz

USA

Schmidt & Clemens Inc.

24 Greenway Plaza Suite 1301

Houston, Texas 77046

Phone: +1 713 629 7770

Fax: +1 713 629 7373

E-Mail: sales-us@schmidt-clemens.com

Saudi Arabia

Schmidt + Clemens Saudi Arabia Ltd.

Lot no. 97, Abu Talha Al. Ansari Street

Teabah, Al Jubail Dakhl Ah Mahdood

P.O. Box 1126, Jubail, 31951

Phone: +966 3 344 5842

Fax: +966 3 344 5843

E-Mail: bharat@schmidt-clemens.com

India

Schmidt + Clemens GmbH + Co. KG

India Liaison Office

A 214 Mahindra Gardens, S.V. Road

Goregaon (W), Mumbai 400 062

Phone: +91 22 8748 445

Fax: +91 22 8791 226

E-Mail: scindia@vsnl.net

www.schmidt-clemens.com

