Welding Solutions for Oil & Gas Downstream

voestalpine Böhler Welding

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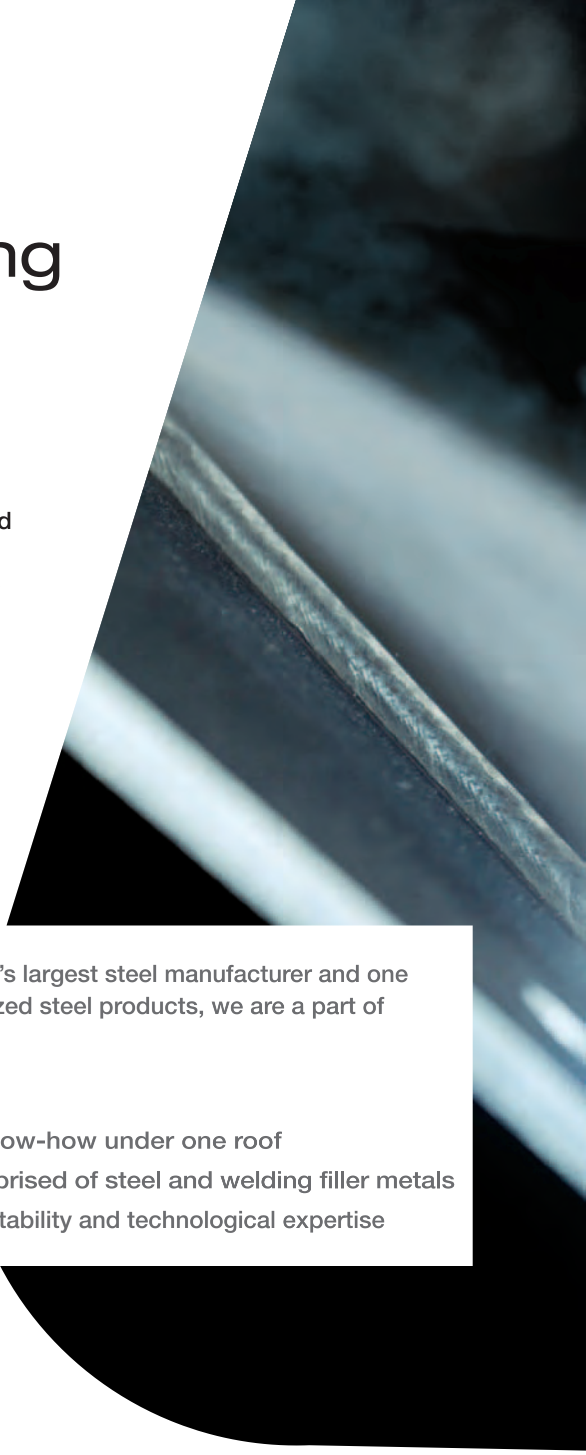
Metallurgical Expertise for Best Welding Results



voestalpine Böhler Welding (formerly Böhler Welding Group) is a leading manufacturer and worldwide supplier of filler metals for industrial welding and brazing applications. With more than 100 years of experience, the enterprise has decisively influenced the development of welding technology, setting the benchmark with its innovative solutions. The solidity is also reflected in the confidence of our employees who, as owners of the enterprise, hold a good portion of the shares.

As a part of the voestalpine Group, Austria's largest steel manufacturer and one of the world's leading suppliers of specialized steel products, we are a part of a global network of metallurgy experts.

Our customers benefit from:

- Comprehensive welding and steel know-how under one roof
- Coordinated complete solutions comprised of steel and welding filler metals
- A partner offering maximum economic stability and technological expertise

Customer first

Absolute customer focus is our guiding principle. We see ourselves as a provider of solutions to challenging welding projects. We ensure that our customers get the right filler metals, use them correctly, and that all welding process parameters are adjusted for the best possible performance. We consider it as our responsibility to guarantee that we deliver to our customers, now and in the future, the best possible solutions. We also strive to develop new products, optimize existing products, and streamline processes so as to achieve very short turnaround times.

Experienced and committed employees

We rely on committed employees who have been trained to the highest standards. It is their knowledge, skills, and personal commitment that ensure the long-term success of our company and its customers. In combination with our premium quality products, the individual technical support provided by our globally acting application technicians and specialist welding engineers empowers our customers to master even the most difficult and challenging welding tasks.

Three competencies – three brands

In our efforts to afford our customers the best possible support and promote development in line with specific targets, we have built our core competences within Joint Welding, Repair & Maintenance Welding and Soldering & Brazing. This way we offer our customers the largest and most comprehensive product portfolio of filler materials within our three brands:

- Böhler Welding
- UTP Maintenance
- Fontargen Brazing

Welding Solutions for demanding industries

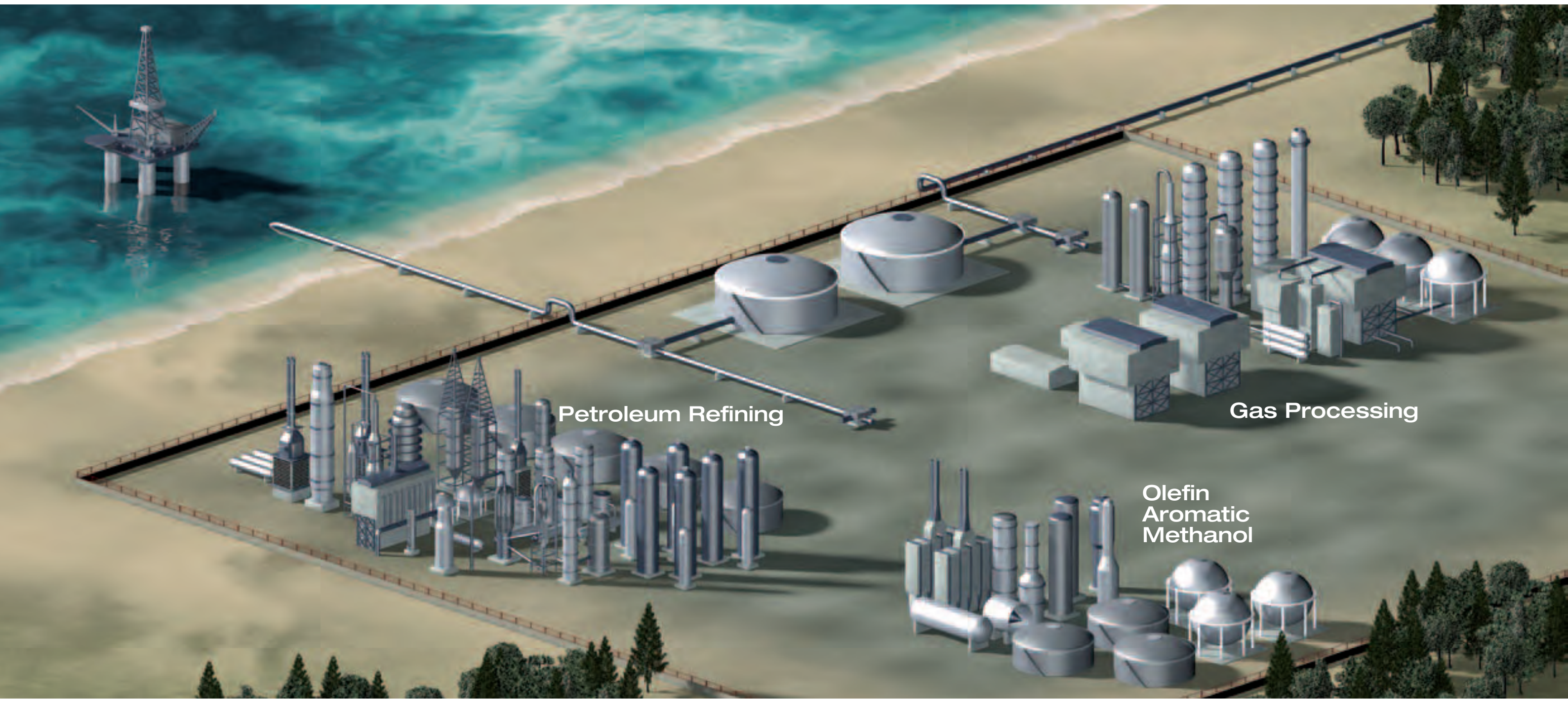
We focus on industries with high technological standards and deliver products tailored to industry-specific requirements. In the development and optimization of filler materials, we collaborate closely with customers, manufacturers, and research institutes.

Whether destined for use in challenging scenarios or in standard applications – our high quality filler materials are ideally suited for all applications in the following industry sectors:

- Oil and Gas
- Pipeline
- Chemical
- Power Generation
- Transportation & Automotive
- Maintenance & Repair
- Brazing Industries

Our Industry Competence Comes From Experienced People

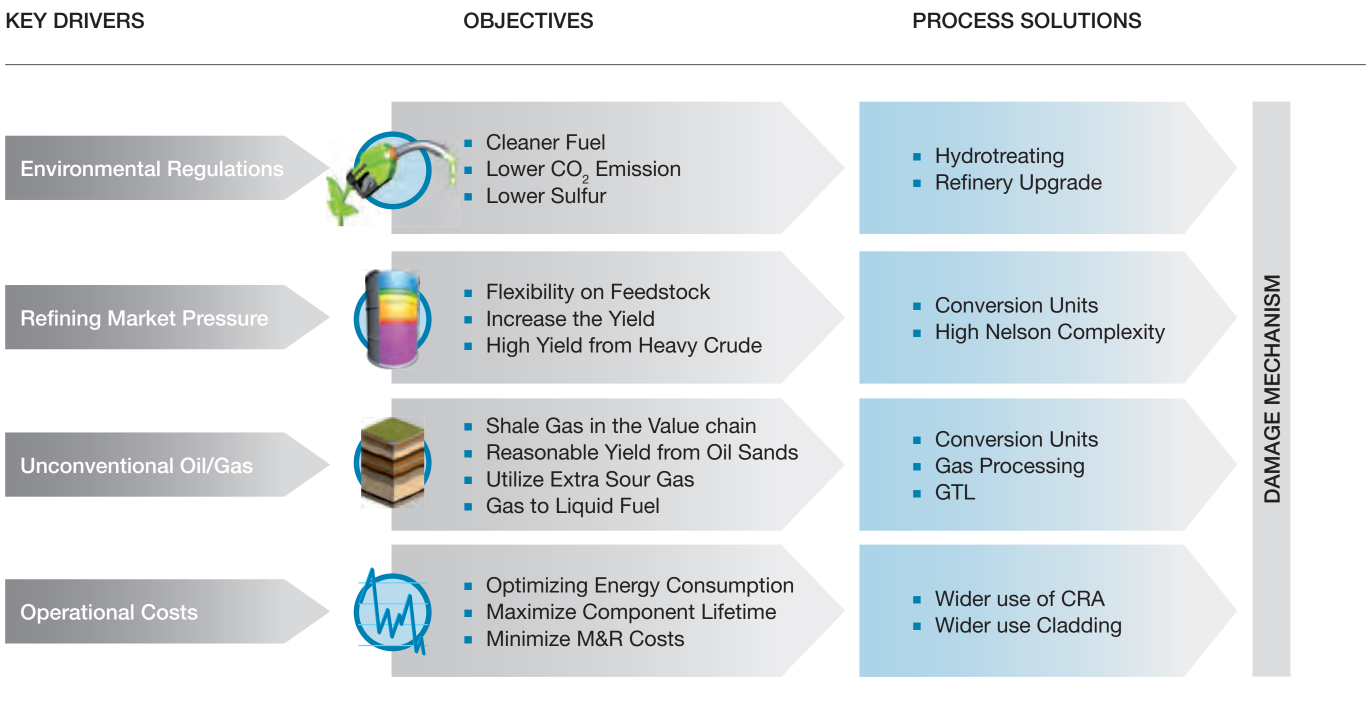
Oil and gas play an important role in the future global energy supply model. However, the emergence of new and unconventional sources of oil and gas will change the landscape with regard to extraction and processing in many significant ways. Upstream Oil & Gas refers to the search for crude oil and natural gas, followed by their recovery and production. This segment is also referred to as the Exploration and Production (E&P) sector; it includes the search for potential underground or sub-sea oil and gas fields, the drilling of exploratory wells, and the subsequent drilling and operation of the wells that recover and bring the crude oil and/or raw natural gas to the surface. Downstream Oil & Gas refers to the refining and processing of the extracted oil and gas from both conventional and unconventional resources. This segment is also referred to as hydrocarbon processing and includes refineries, natural gas processing plants, Olefins and Aromatics as well as Methanol plants.



voestalpine Böhler Welding provides solutions driven by its high-quality welding consumables for safe, efficient, and cost-effective operation of upstream, midstream, and downstream facilities and equipment to these segments worldwide. These products are supplied by regional manufacturing, development, sales, and support units under a range of products that are recognized worldwide.

Oil & Gas Downstream – Walking on the Edge of Steel Limits

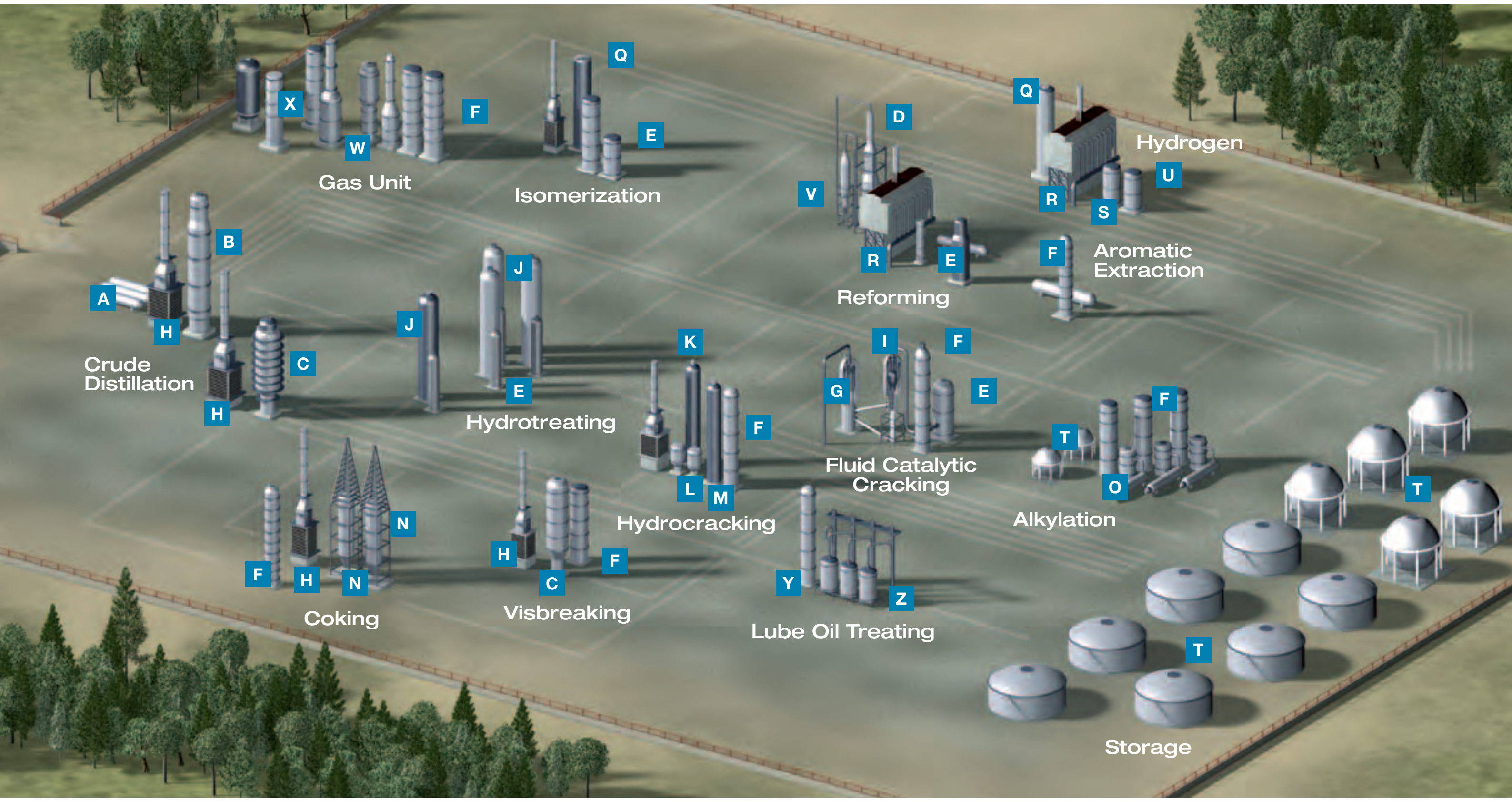
Global demand for fuel products is increasing. The quality of petroleum compounds, such as crude oil or natural gas that is extracted in different geographical locations varies, and extra-heavy oil is playing a more significant role than in the past. More sources of unconventional oil and gas from oil sands and shale have been recently explored, and they have been receiving a great deal of attention. Today, environmental regulations with regard to fuels and petrochemical products have become more stringent.



All these variables put together a complicated function in front of the oil and gas “super-majors” to make top-quality products especially from extra-heavy feedstock, and still achieve a healthy margin. As shown in this road map derived from the key drivers, the main challenge in setting defined objectives and developing solutions is to maintain the integrity of the process component while dealing with a wide range of damage mechanisms. These additional damage mechanisms are either related to the unconventional feedstock or enhanced service conditions. In recent years, steel manufacturers have been developing better steel grades to withstand such service conditions. One must take into consideration that steel products need to be welded or cladded by weldoverlay; it is at this point that customers face the main welding challenges. A good example is development of vanadium-enhanced Cr-Mo steels, which require special weld fabrication expertise. Welding consumables may seem to be a very small part of this industry, but almost all oil and gas downstream experts confirm that welding and welding technologies are the main drivers in the development of optimized process reactors and furnaces. The requirements for welding consumables in the downstream segment are generally considered to be more stringent than the conventional standard requirements for the same grades in other fields. In the following, we will summarize the most important damage mechanisms in each of the three main plants. We will also be providing information about two of the major challenges: fabrication of hydroprocessing reactors (Page 8) and reforming / cracking furnaces (Page 13).

Oil Refineries

Hydrocarbon molecules come in many different sizes and shapes that generally depend on the quality of the crude oil. In an oil refinery, five different process categories are utilized to achieve both a higher yield and cleaner fuel.



- **Fractionating** hydrocarbon molecules by size, e.g., in a crude distillation unit
- **Cracking** larger molecules into smaller ones, e.g., in a fluid catalytic cracking unit or a hydrocracking unit
- **Combining** smaller hydrocarbon molecules into larger molecules, e.g., in an alkylation unit
- **Changing** the molecule shapes, e.g., in a catalytic reforming unit
- **Hydrotreating** units are also needed to reduce sulfur, aromatics, nitrogen, oxygen, and metals while enhancing the combustion quality, density, and smoke point of fuels

Depending on the process, its feedstock and operating conditions, various damage mechanisms can pose a threat to the life cycle of a refinery, to equipment integrity, and to plant safety. Many of these damage mechanisms can directly or indirectly relate the quality of welding consumables and welding condition. Some of the major damage mechanisms are listed in this text.
The choices regarding the base material used for critical process equipment in a refinery as well as for weld-overlay cladding are limited. Some of these choices are listed in Table A, which refers directly to the relevant product for the target grade.

Unit	Damage Mechanisms
Crude Distillation Unit	Sulfidation
	Wet H2S Damage (Blistering/HIC/SOHIC/SCC)
	Creep / Stress Rupture
	Polythionic Acid Stress Corrosion
	Naphetanic Acid Corrosion
	Ammonium Chloride Corrosion
	HCl Corrosion
	Caustic Corrosion / Cracking
	Erosion / Erosion-Corrosion
	Aqueous Organic Acid Corrosion
	Fuel Ash Corrosion
Gas Unit	Sulfidation
	Wet H2S Damage (Blistering/HIC/SOHIC/SCC)
	Ammonium Bisulfid Corrosion
	Chloride SCC
	Flue Gas Dew Point Corrosion
	Amine Corrosion / Cracking
	Titanium Hybriding
	Sulfuric Acid Corrosion
Isomeriza-tion Unit	High Temperature Hydrogen Attack (HTHA)
	HCl Corrosion
	Caustic Corrosion / Cracking

Table B: Damage mechanisms

		Joining Alloy Choices																			Weld-Overlay Deposit Choices											
	Components	C-Mn	C- ½ Mo	1 ¼ Cr ½ Mo	2 ¼ Cr 1 Mo	2 ¼ Cr 1 Mo ¼ V	5 Cr ½ Mo	9 Cr 1 Mo	S.S 304H	S.S 310	Alloy 800 / 800H	Alloy HP / HP Nb	S.S 347	Alloy 600	Alloy 625	Alloy 825	Alloy 617	1% Ni	2.5% Ni	3% Ni	S.S 410S	S.S 308L	S.S 308H	S.S 316L	S.S 317L	S.S 347	Alloy 254 SMo	Alloy 276	Alloy 825	Alloy 625	Alloy 400	Alloy 200
A	Desalter	•																				•					•		•	•		
B	Atmospheric Distillation Tower	•																			•			•	•							
C	Vacuum Distillation Tower	•																														
D	Naphtha Reformer Reactor			•																												
E	Feed/Effluent Heat Exchanger		•	•	•	•																•		•		•					•	•
F	Fractionator	•		•																	•	•		•							•	•
G	FCC Regenerator	•	•																				•									
H	Fired Heater								•	•																						
I	FCC Reactor				•	•															•											
J	HDS Reactor	•			•	•																				•						
K	Hydrocracking Reactor				•	•																				•						
L	Hot Separator				•																					•						
M	Cold Separator	•																						•								
N	Coke Drum			•																	•									•		
O	Alkylation Reactor	•																											•	•	•	•
P	Post Heater/Furnace Piping						•	•	•	•			•																			
Q	Hydrogenation Reactor			•	•												•									•						
R	Steam Reformer Furnace										•	•																				
S	Low Temp. Shift Convertor	•																														
T	Storage Tanks	•																•	•	•												
U	High Temp. Shift Convertor			•																												
V	CCR Regenerator		•								•	•																				
W	Sulfur Recovery Piping													•	•	•																
X	Sour Water Stripper	•																										•				
Y	Extraction Tower	•																			•			•	•							
Z	Evaporator	•							•	•																						

Table A: Alloy choices for major refinery components

Unit	Damage Mechanisms
Delayed Coking	Sulfidation
	Wet H2S Damage (Blistering/HIC/SOHIC/SCC)
	Creep / Stress Rupture
	Naphetanic Acid Corrosion
	Ammonium Chloride Corrosion
	Ammonium Bisulfide Corrosion
	Thermal Fatigue
	Carburizaion
	Dealloying
	Carbonate SCC
Hydro-treating & Hydro-cracking Unit	Sulfidation
	Wet H2S Damage (Blistering/HIC/SOHIC/SCC)
	High Temperature Hydrogen Attack
	High Temperature H2/H2S Corrosion
	Polythionic Acid Stress Corrosion
	Naphetanic Acid Corrosion
	Creep / Stress Rupture
	Temper Embrittlement
	Ammonium Chloride Corrosion
	Ammonium Bisulfide Corrosion
	Amine Corrosion / Cracking
	Hydrogen Embrittlement
	Chloride Stress Corrosion Cracking
	Brittle Fracture
	Reheat Cracking

Unit	Damage Mechanisms
Vis-breaking	Sulfidation
	Wet H2S Damage (Blistering/HIC/SOHIC/SCC)
	Polythionic Acid Corrosion
	Naphetanic Acid Corrosion
	Ammonium
	Ammonium Chloride Corrosion
	Ammonium Bisulfide Corrosion
	Carburization
	Chloride SCC
	Creep / Stress Rupture
	Sour Water Corrosion
FCCU	Sulfidation
	Wet H2S Damage (Blistering/HIC/SOHIC/SCC)
	Creep / Stress Rupture
	Polythionic Acid Stress Corrosion
	Naphetanic Acid Corrosion
	Ammonium Chloride Corrosion
	Thermal Fatigue
	Graphitization
	Temper Embrittment
	Decarburization
	Carburization
	Reheat Cracking

Unit	Damage Mechanisms
Catalytic Reforming	High Temperature Hydrogen Attack
	HCl Corrosion
	Creep / Stress Rupture
	Temper Embrittlment
	Carburization
	Hydrogen Embrittlement
	Ammonia SCC
	Mechanical Fatigue
	Metal Dusting
Lube Oil	Phenol (Cabolic Acid) Corrosion
Alkylation	Caustic Corrosion / Cracking
	HF Acid Corrosion
	Erosion / Erosion-Corrosion
	Hydrogen Stress Corrosion HF
	Galvanic Corrosion
	Dissimilar Weld Metal (DMW) Cracking
Hydrogen Unit	High Temperature Hydrogen Attack (HTHA)
	Thermal Fatigue
	Temper Embrittement
	Carbonate SCC
	Amine Corrosion / Cracking
	Chloride SCC
	Thermal shock
	Reheat Cracking
	CO_2 Corrosion
	Metal Dusting

Hydroprocessing reactors

Production of cleaner fuels in accordance with current standards requires a refinery to use hydrotreating units to reduce sulfur, aromatics, nitrogen, oxygen, and metals while improving the combustion quality and smoke point of naphtha, diesel, and kerosene.

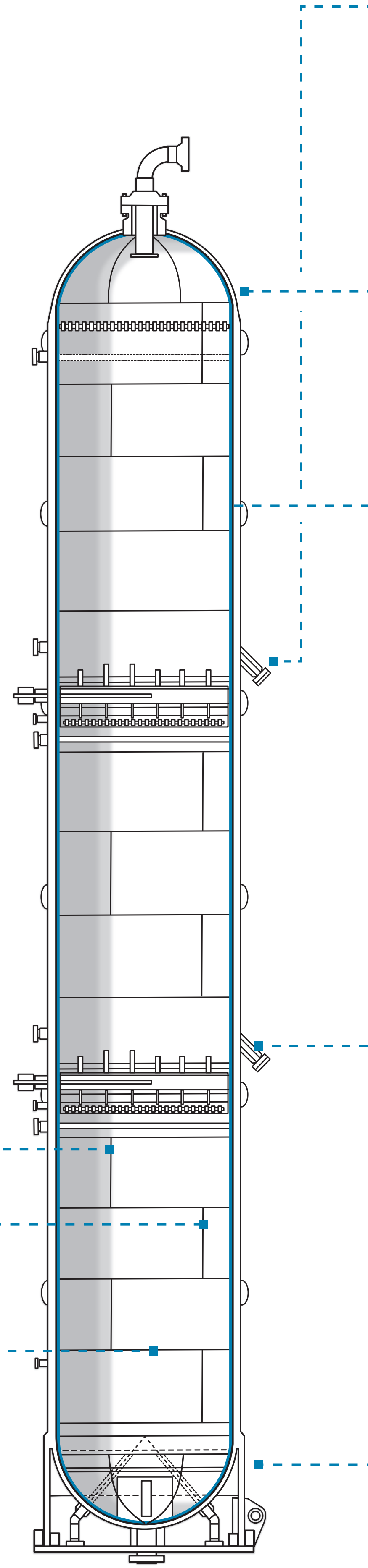
Hydrotreating / hydrodesulphurization (HDS) reactors are critical equipment in a hydrotreating unit.

In order to increase the refinery's yield rate, however, conversion units are needed to crack the vacuum gas oil (VGO) and the atmospheric gas oil (AGO) as well as the gas oil from the coker and the visbreaker units. This method enables the refinery to process the residual oil ("the bottom-of-the-barrel"). For example, hydrocracking is a catalytic cracking process that is assisted by the presence of hydrogen. In this case, hydrocracking reactors are the critical equipment.

The common element among hydroprocessing reactors of this type is the use of advanced 2.25Cr-1Mo-0.25V material, which has numerous merits over conventional grade material, including greater tensile strength at elevated temperatures, enabling the industry to use reactors with lower wall thickness and weight (about 25% less weight). Additionally, it makes reactors less susceptible to damage mechanisms, such as temper embrittlement and high temperature hydrogen attack (HTHA) and last but not least, it provides stronger resistance to weld overlay disbonding induced by hot hydrogen.

Despite all these advantages, weld fabrication of reactors made of this grade of material ultimately becomes challenging due to various material sensitivities. e.g., weld cracking and re-heat cracking. Furthermore, intermediate and post-weld heat treatment as well as non-destructive examination (NDE) requires a different – and very precise – process compared to conventional 2.25Cr-1Mo grades. An example is the Time Of Flight Diffraction (TOFD) ultrasonic test.

Let's take a brief look at the welding of a hydroprocessing reactor:



A Fabrication of the reactor shell

Depending on the design requirements and the wall thickness, shell material can be fabricated from plate or forged rings. If plates are used, they must be re-rolled and longitudinally welded to form a ring. A combination of both plate rings and forged rings is also possible, for example, forged rings for the quench zone and support skirt and plate rings for the rest of the shell arrangement. Narrow gap submerged arc welding (SAW), either with tandem or single wire, is the process of choice. With our wire/flux combination and the corresponding parameter setting, it is feasible to have the smallest possible opening, which significantly reduces the consumption of filler metals and welding time. A smaller amount of GTAW rod and SMAW electrode is also deposited.

Longitudinal Joints: ASME SA542 Gr. D CL 4a. ASME SA832 Gr. 22V

Circumferential Joints:
Forged rings: ASME SA336 Gr. F22V
Plate-fabricated rings: ASME SA832 Gr. 22V or ASME SA542 Gr. D, CL 4a

B Nozzle welds

Piping nozzles, instrumentation nozzles, as well as the hand holes are critical areas as they are the only openings of the reactor and must thereby withstand conditions within the reactor. The conventional method represents the use of the SMAW process for the nozzle welds, but experienced fabricators currently use single-wire SAW. Due to the especially restrained condition of the joint, ISR (intermediate stress relieving) is of paramount importance.

C Shell to dished end / dished end to support welds

Heads are either single-piece or multi-piece welded. Precise joint alignment is also needed as the dished end has a lower wall thickness compared to the shell. If forged profiles are used, skirt to bottom is sometimes a single forged piece.

D Weld overlay

The usual overlay deposit for such reactors is S.S 347. Depending on the accessibility and the cladding area, different processes are chosen:

Inside reactor: Strip cladding SAW, ESW 2 layer, ESW single layer, ESW high speed
Inside nozzles, fittings and restoration: FCAW, SMAW, GTAW
Weld-overlay build-up of the internal "supports": SMAW, GTAW. CrMo-22V FCAW 347

An important point to Cr-Mo 22V build up overlay is the necessity of ISR (intermediate stress relieving) due to restrained condition.

E Heat treatment

DHT: Dehydrogenation heat treatment of 350° C for 4 hours is essential to minimize the susceptibility to cold cracking due to residual hydrogen in the weld.
ISR: Intermediate stress relieving is necessary, especially for highly restrained joints such as nozzle welds. The recommended temperature for ISR is 650 – 670° C for 4 hours to ensure a partial elimination of the residual stresses in the weld.
PWHT: Post weld heat treatment for CrMo-22V has a very narrow tolerance in comparison to conventional steel grades. The recommended PWHT is 705° C for 8 hours.
Max PWHT: Several heat treatments are applied during fabrication, including DHT, ISR, and final PWHT. Sometimes, repairs are undertaken during fabrication.
An additional cycle should be planned for any necessary repairs after installation.
A maximum PWHT condition, which has an equal effect of all previously cited PWHT cycles, must be simulated. To that end, and to define one PWHT condition that covers all cycles, the Hollomon parameter (HP) of all the PWHTs should be calculated and then for any given time a PWHT temperature can be calculated vice versa.

$$\mathbf{HP} = (273°C + \mathbf{T}) \times (20 + \log_{10}(\mathbf{t}/60))\ 10^{-3}$$
$$\mathbf{T} = 10^{3}\ \mathbf{HP}/(20 + \log_{10}(\mathbf{t}/60)) - 273°C$$
$$\mathbf{t} = 60 \times 10^{(1000\ \mathbf{HP}/(273°C + \mathbf{T}) - 20)}$$

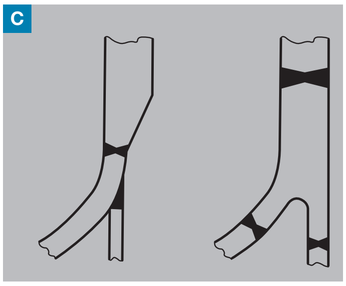
Step cooling: is done to simulate an accelerated embrittlement for evaluation of potential temper embrittlement.

F Reheat cracking and tramp elements

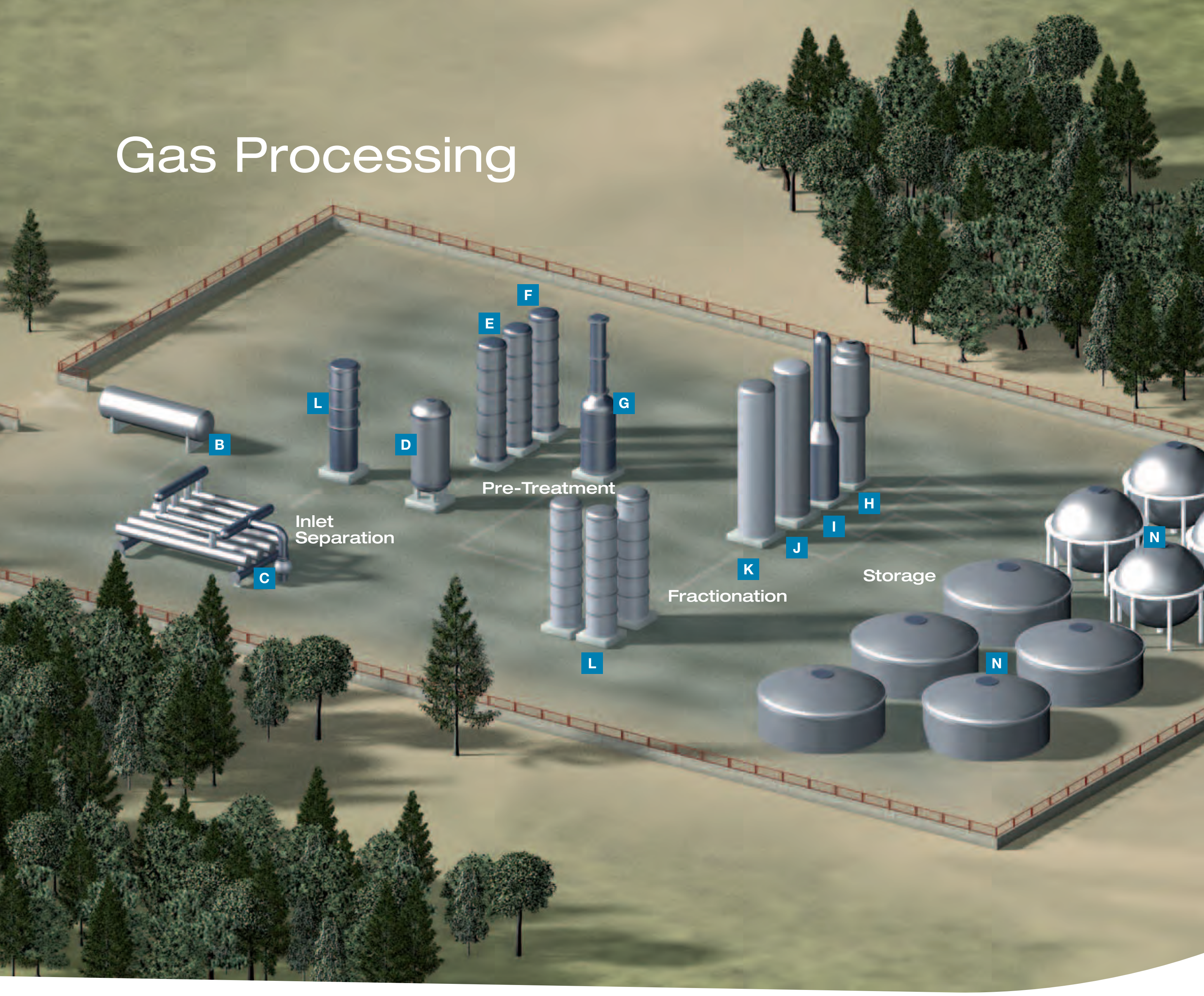
Since introduction of this material, the industry has encountered many difficulties due to reheat cracking after PWHT. With precisely controlled amount of the tramp elements (Typical X factor: 8 and typical K factor: 0.7), the reheat cracking problem is under control.

G Standard codes; recommended practices

ASME BPVC Section VIII Division 2, API RP 934A, API RP582, ASTM G146-01



Gas Processing



In the form it is extracted, natural gas cannot be used as fuel or feedstock. It needs to be treated in gas processing plants. Irrespective of whether a gas processing plant is constructed for a specific gas field or inside a refinery to process refinery gases, it generally contains:

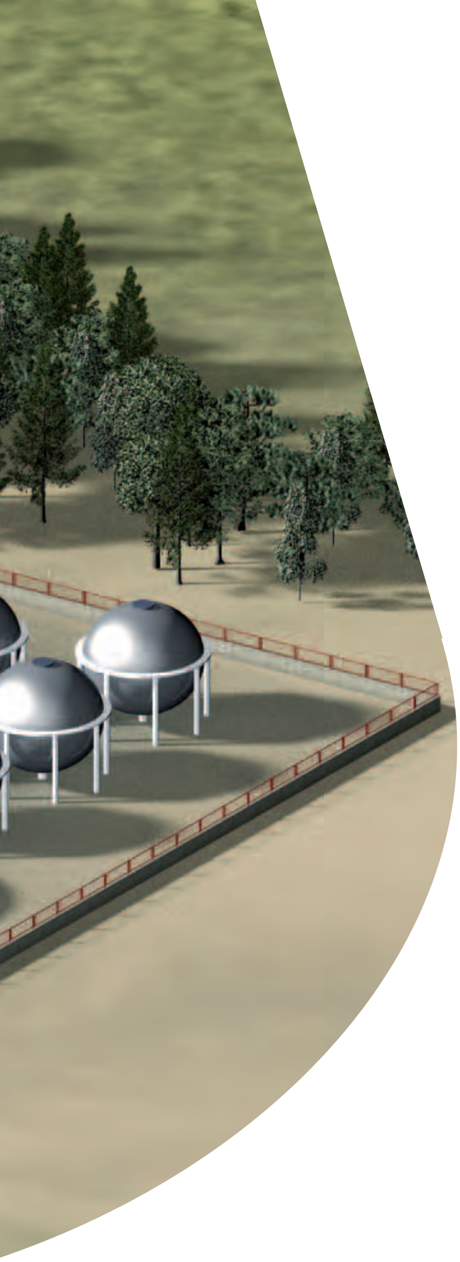
Inlet facilities: To separate natural gas from water and impurities. These facilities can also include slug catcher manifold/drum

Pre-treatment: To remove sulfur, H_2O, Hg, and CO_2 from natural gas

Fractionation: To fractionate different gaseous and NGL hydrocarbons

The global gas resource landscape has changed significantly within the past decade. Unconventional gas, so called either due to its quality (sour and ultra-sour gas) or its source (shale gas, coal gas), has begun to play an important role. As such, there is a need for different solid or weld overlaid corrosion resistance alloys in different separators and fractionators. Examples are the injection lines, inlet separators, and slug catcher manifold / drums in which – depending on the sourness of the gas – S.S 316L, Alloy 825, or Alloy 625 weld overlay is applied.

Selection of the base material can also vary depending on the operating pressure or job site temperature. Use of carbon steel as well as low alloy / chrome-molly alloys is possible depending on the operating conditions.



In Table D, we have listed some of the critical process equipment in a gas processing plant. A number of the major damage mechanisms in a typical gas processing plant are listed in Table C. Some of these damage mechanisms can be controlled by selecting high-quality base material and welding consumables.

Unit	Damage Mechanism
Inlet Facilities	Wet H2S Blistering
	Wet H2S HIC
	Wet H2S SOHIC
	Wet H2S SCC
	Slugging
	Amine Degradation Corrosion
Pre-Treatment	Sulfidation
	Wet H2S damage (Blistering/HIC/SOHIC/SCC)
	Ammonium Bisulfide
	Alkaline SCC
	Erosion / Erosion-Corrosion
	Amine Cracking
	Amine Corrosion
	CO_2 Corrosion
	Chloride Stress Corrosion Cracking
	Titanium Hybriding
	Sulfuric Acid
	Mercury Attack Corrosion
	Flue Gas Dew Point Corrosion

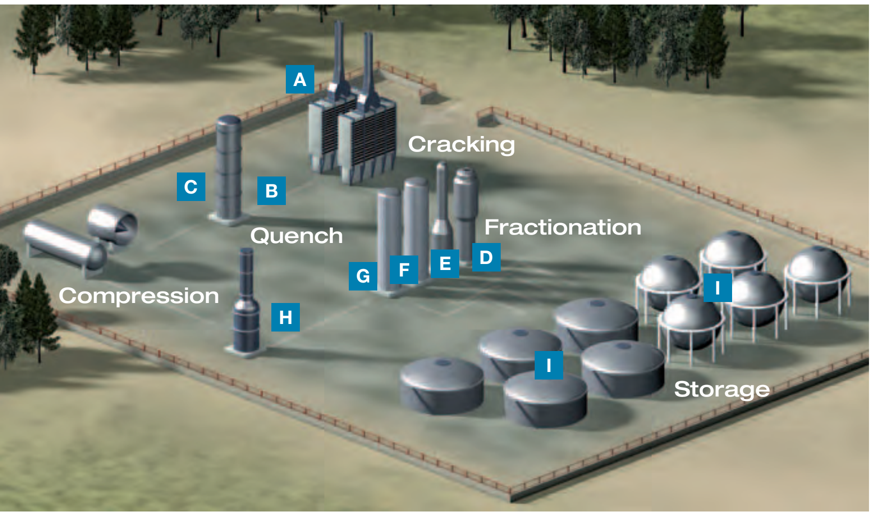
Table C: Damage mechanisms

		Joining Alloy Choices									Weld-Overlay Deposit Choices							
	Components	**C-Mn**	**1 ¼ Cr ½ Mo**	**2¼ Cr 1Mo**	**S.S 316L**	**Alloy 625**	**1% Ni**	**2.5% Ni**	**3% Ni**	**Alloy 22**	**S.S 308L**	**S.S 316L**	**S.S 317L**	**Alloy 254 SMo**	**Alloy 276**	**Alloy 825**	**Alloy 625**	**Alloy 22**
A	Sour Gas Injection Pipes			•														
B	Slug Catcher Drum	•										•		•			•	
C	Slug Catcher Manifold	•										•		•			•	
D	Inlet Separator	•										•		•		•	•	
E	Sour Water Stripper	•																
F	Dehydrator	•																
G	Amine Regenerator	•										•					•	
H	De-Methanizer	•			•							•					•	
I	De-Ethanizer	•			•							•						
J	De-Propanizer	•																
K	De-Butanizer	•																
L	Fractionator	•									•							
M	Sulfur Recovery Line	•			•	•										•	•	
N	Storage Tanks	•					•	•	•									
O	Flue Gas Desulphurization									•								•

Table D: Alloy choices for main gas processing components

Olefins and Aromatics

Olefins (such as Ethylene and Propylene) and Aromatics (Benzene, Toluene, and Xylene) are key products in the petrochemical industry. Naphtha from the oil refinery enters the cracking furnace and is cracked by being heated to 1,150°C. The cracked hydrocarbon enters the quench oil / water columns. The gases are then compressed and liquefied in different temperatures down to -150°C.



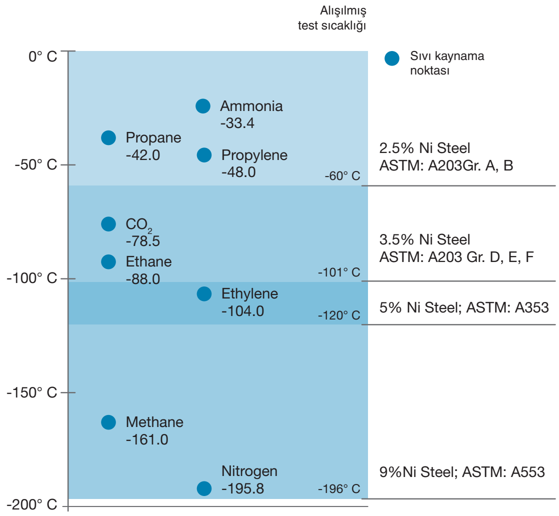


Table E: Steel choices for cryogenic application

A cracker furnace represents the heart of a plant (a description follows on the next page). voestalpine Böhler Welding draws upon many years of experience in the production of filler metals for welding the cracker furnace tubes. A plant has both high-temperature parts and low-temperature areas. Various hydocarbons have very low boiling temperatures and therefore, low-temperature steels grades are needed for transport and storage of these materials within the plant. Some cryogenic products are listed in the products table of this brochure. However, all the LPG- and LNG-related products are separately described in our LNG/LPG brochure.

In Table F, we have listed some of the critical process equipment in an Olefin / Aromatic plant. A number of the major damage mechanisms from typical olefins/aromatics are listed in Table G. Some of these damage mechanisms can be controlled by selecting high-quality base material and welding consumables.

		Joining Alloy Choices											Weld-Overlay Deposit Choices		
	Components	C-Mn	Alloy 35 / 45 Nb	5Cr ½Mo	9Cr 1Mo	S.S 316L	S.S 347	S.S 310	S.S304H	1% Ni	2.5% Ni	3% Ni	S.S 308L	S.S 316L	Alloy 625
A	Cracking Furnace		•												
B	Post Furnace Piping			•	•		•	•	•						
C	Quench Column	•											•	•	
D	De-Methanizer	•				•								•	•
E	De-Ethanizer	•				•								•	•
F	De-Propanizer	•													
G	De-Butanizer	•													
H	Ethylene Oxide Reactor	•													
I	Storage Tanks									•	•	•			

Table F: Alloy choices for main olefin/aromatic plant components

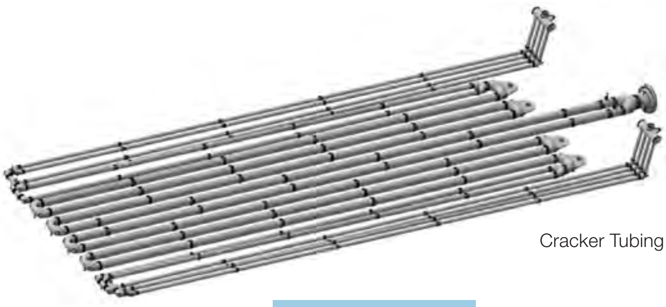
Unit	Damage Mechanism
Cracking	Creep / Stress Rupture
	Carburization
	Temper Embrittlement
	Thermal Shock
	Graphitization
	Thermal Fatigue
	Caustic Corrosion
	Caustic Crack
Quench	Caustic Corrosion
Fractionation	Caustic Crack
	Low Temperature Embrittlement

Table G: Damage mechanisms

Welding of Reformer and Cracker Tubes

In petroleum refining, there is the demand for a steam / catalytic reforming process that reforms the hydrocarbon molecule to a desired shape. This process is also used for hydrogen production in the hydrogen unit of large-scale refineries, where very large amounts of process hydrogen are needed. The operating temperature can exceed 900°C. In petrochemical plants, e.g., in Olefin and Aromatic plants, naphtha from the refinery first enters into a cracker, the heart of the plant. The temperature in the cracker furnace can exceed 1,150°C. The cracking process leaves coke on the tube walls, which results in higher temperatures that can reach the operational limits.

In both of the above-mentioned applications, centrifugally cast tubes represent the main element of the process. The tubes and the respective welded joints must be able to withstand numerous damage mechanisms, including but not limited to creep / stress rupture, carburization, and fatigue. Being able to balance increased strength, higher creep resistance, and greater toughness has been a challenge for the industry. Over decades, the industry has benefited from the introduction of new alloys with various Cr and Ni content and the addition of alloying elements, such as Si, Ti, Zr, Nb, Mo, Co, etc. to create the ability to withstand higher operating temperatures and, at the same time, to reach reasonable creep strength and carburization resistance. Over-alloyed welding consumables have always been available in our portfolio, but similar or matching consumables for every new tube grade have been what we offer in order to minimize the difference between the thermal expansion coefficient in the weld joint and the tube; this enables a longer life cycle of the welded tubing.
A list of the main products for the welding of furnace tubes is provided in the product section of this brochure.


Cracker Tubing


Reformer Tube

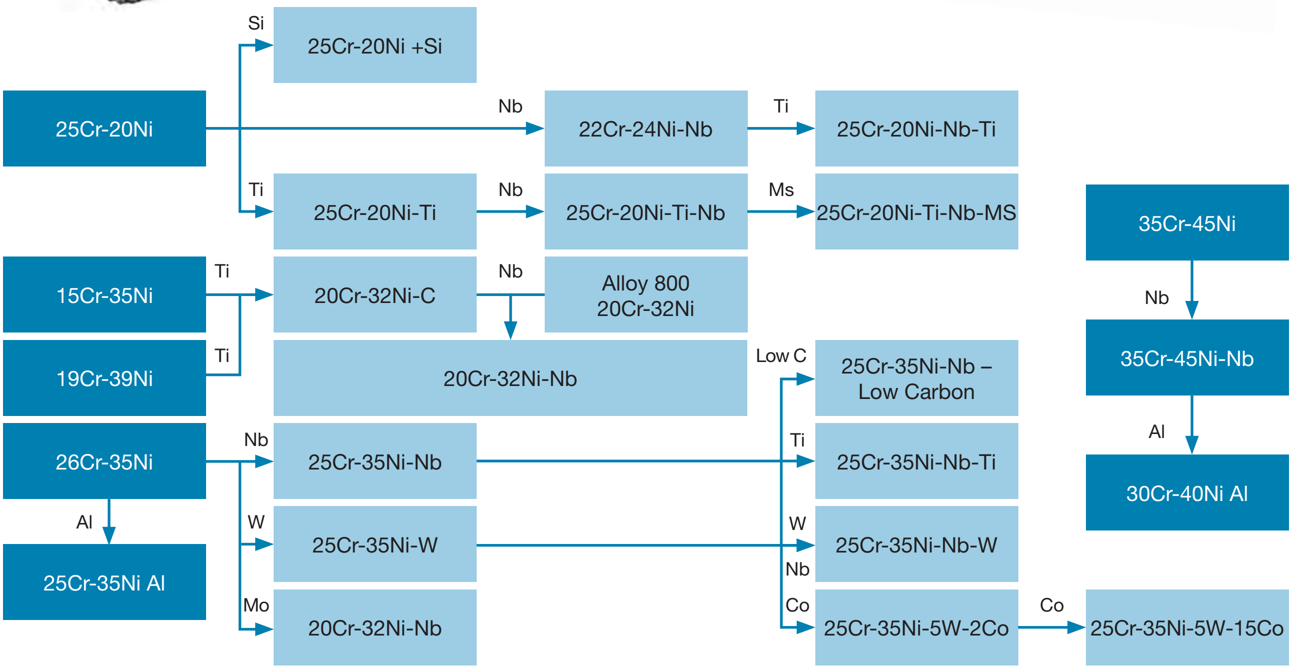


Table H: Cast tube alloy evolution

References

HELPE Refinery Greece

Fabricator name: Larsen and Toubro
Component: Hydrocracking Reactor (970 MT)
Base material: CrMo-22V (292mm)
Joining products: SMAW: Phoenix Chromo 2V
GTAW: Union I CrMo 2V
SAW wire: Union S1 CrMo 2V
SAW Flux: UV 430 TTR-W

Burgas Refinery Bulgaria

Fabricator name: Belleli Energy CPE S.r.L
Component: Hydroprocessing Reactors
Base material: CrMo-22V + S.S 347 (240 + 3mm)
Joining products: SMAW: Phoenix Chromo 2V
GTAW: Union I CrMo 2V
SAW wire: Union S1 CrMo 2V
SAW Flux: UV 430 TTR-W
Cladding Products: Strip: SOUDOTAPE 21.11 LNb,
Flux: RECORD EST 122

Mina Abduallah and Mina Al-Ahmadi Refinery Kuwait

Fabricator name: Larsen and Toubro
Component: 22 Hydroprocessing Reactors
Base material: CrMo 22, CrMo-22V
Joining products: SMAW: Phoenix SH Chromo 2 KS, Phoenix Chromo 2V
GTAW: Union I CrMo 910 Spezial, Union I CrMo 2V
SAW wire: Union S1 CrMo 2, Union S1 CrMo 2V
SAW Flux: UV 420 TTR-W, UV 430 TTR-W

This is a short list of some of our partners:

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Axens
Bechtel
Belleli Energy C.P.E S.r.l
Borsig GmbH
CB&I Lummus
Cessco Fabrication and Engineering
Chevron
Chiyoda
CNPC
Daelim
Doncaster Paralloy Ltd.
Doosan Engineering and Construction
Duralloy Technologies
ExxonMobil
FBM Hudson Italiana
Felguera Calereria Pesada
Fluor
Foster Wheeler
GE - Nuovo Pignone
General Welding Wroks Inc.
Godrej and Boyce
Haldor Topsoe
Hitachi Zosen
Hyundai Heavy Industries
ISGEC
Japan Steel Works
KBR
Koch Industries
Kubota Metal Corporation
Larsen and Toubro
Lurgi
MAN DWE GmbH
Manoir Industries
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OLMI
OMZ
PETROBRAS
Relliance Industries
Rolle S.p.A
Samsung Engineering
Schmidt + Clemens GmbH
Schwartz Houtmont
Shanghai Boiler Works
Shell Global Solutions
SINOPEC
Taylor Forge Engineering Products
Technip
Tecnicas Reunidas
TOTAL Raffinage
Thyssenkrupp Uhde
UOP
V.R.V
Winkels
Worley Parsons

If the product list is missing, please contact us.

Technical references: ASME BPVC, API RP571, API 934A

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