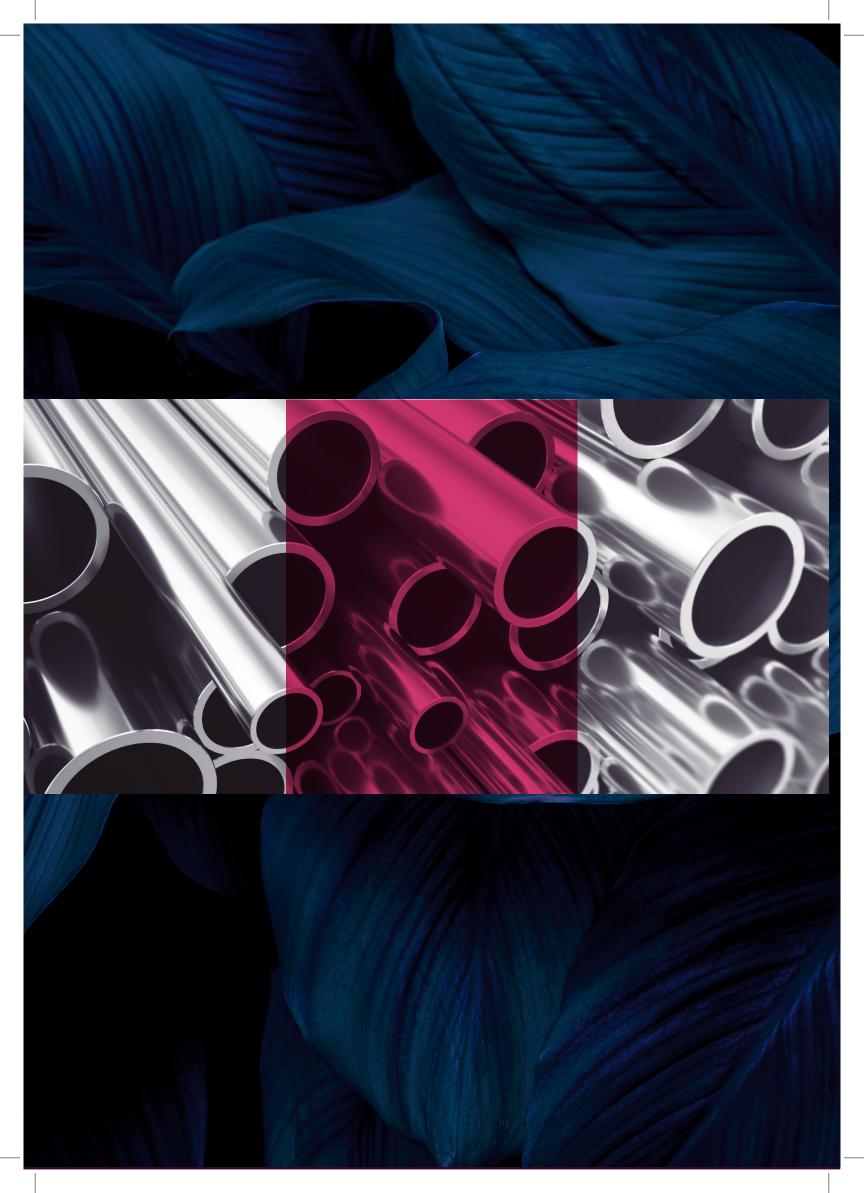
# HYDROGEN Applications

STAINLESS STEEL AND HIGH NICKEL ALLOYS TUBULAR SOLUTIONS







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....

# A GLOBAL LEADER IN SEAMLESS STAINLESS AND HIGH NICKEL ALLOYS PIPES AND TUBES



#### Worldwide presence

Through our commercial offices

#### **Competitiveness** Thanks to our lean manufacturing process

Service

Cooperation with our customers

#### Flexibility

In materials chemical composition & deliveries

#### Reliability

Of a fully integrated company

# OUR CUSTOMERS ARE THE MAIN DRIVER OF THE TUBACEX GROUP'S ACTIVITY AND EFFORTS.



# THE WIDEST PORTFOLIO IN STAINLESS STEEL

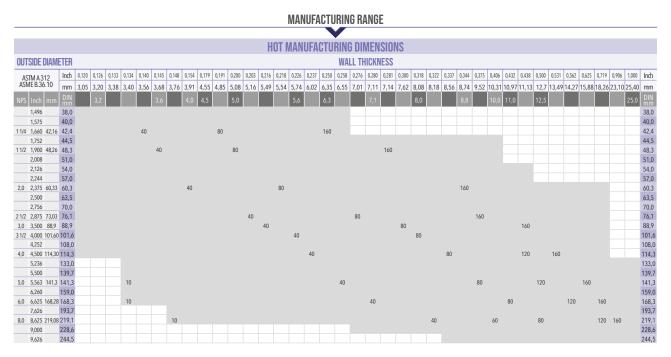
A TRULY GLOBAL SOLUTIONS PROVIDER AT YOUR SERVICE

		SOLUTIONS	BUSINESS UNIT		
		STAINLESS STEEL AND HIGH NICKEL ALLOYS BARS AND BILLETS			
Software N			TTI TUBÂCEX GROUP		
		SEAMLESS PIPE AND TUBES To 8" (Extrusion, Piercing,	SALEM TUBE		
		COLD FINISHING)			
			TTP TUBÂCEX GROUP		
		SEAMLESS PIPE AND Tubes to 72"			
		FITTINGS AND SPECIAL			
		CONNECTIONS FROM ½" TO 72"			
		STAINLESS STEEL Machined Parts	RTS Group SENAT-TUBACEK.JV		
		VALUE ADDED OPERATIONS And services			
		STOCK, SERVICE AND			
		TRADING			

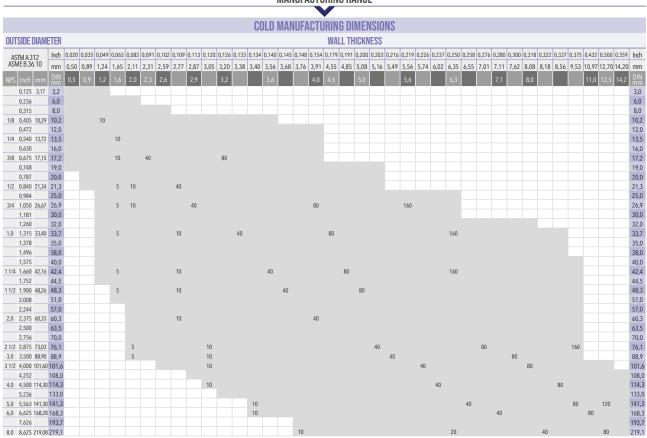
6 | TUBACEX GROUP

# **SEAMLESS PIPES AND TUBES**

The Tubacex Group has an extensive manufacturing program for Stainless Steel and Nickel Alloys Seamless pipes and tubes covering most dimensions and grades required by the industry. Seamless Stainless Steel Tubing can be hot or cold finished, covering the following range:



Range of Tubacex Tubos Inoxidables and Schoeller Bleckmann Edelstahlrohr for austenitic hot manufactured tubes and pipes. Production according to main manufacturing standards (ASTM/ASME, EN and other international manufacturing standards). Non standard articles available upon request.

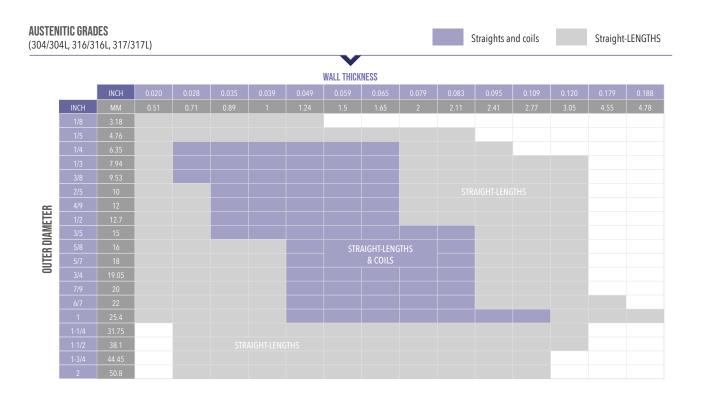


#### MANUFACTURING RANGE

Range of Tubacex Tubos Inoxidables, Schoeller Bleckmann Edelstahlrohr, Salem Tube and Tubacex India for Austenitic cold manufactured tubes and pipes. Production according to main manufacturing standards (ASTM/ASME, EN and other international manufacturing standards). Non standard articles available on request.

# **PRECISION TUBES**

TUBACEX offers the industry's largest portfolio of high-performance tubing, corrosion-resistant alloys, as well as a commitment to delivering on short lead times and emergency projects.



#### SUPER AUSTENITIC, DUPLEX, NICKEL-ALLOY, & PH GRADES

(904L, 6MO, 2205, 2507, 400, 600, 617, 625, 690, 825; N200; N201, C22, C276, 15-5, 17-4, 17-7)

	$\mathbf{v}$															
								WALL THICK	NESS							
		INCH	0.020	0.028	0.035	0.039	0.049	0.059	0.065		0.083	0.095		0.120	0.179	0.188
	INCH	MM	0.51	0.71	0.89	1	1.24	1.5	1.65	2	2.11	2.41	2.77	3.05	4.55	4.78
	1/8															
	1/5															
	1/4															
	1/3															
	3/8															
	2/5															
ŝ	4/9															
ΕT	1/2															
DIAN	3/5															
OUTER DIAMETER	5/8															
ET I	5/7															
_	3/4															
	7/9															
	6/7															
	1															
	1-1/4															
	1-1/2															
	1-3/4	44.45														
	2	50.8														

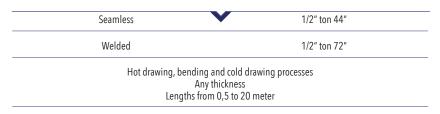


# FITTINGS AND SPECIAL COMPONENTS

The Tubacex range includes the design and manufacturing of butt welding fittings, tube bends, elbows, tees, reducers and caps (both seamless and welded), complementing the wide offer of tubular solutions, by IBF and TTA companies. In addition, IBF offers a wide range of special parts (manifolds, laterals, special reducers...)

The Tubacex Group's fitting and special components extensive production program is suitable for all kinds of projects. The range offered is one of the widest in the industry:

#### **MANUFACTURING RANGE - FITTINGS AND SPECIAL PARTS**

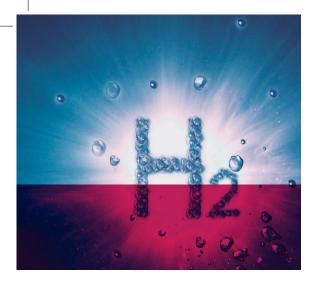


Materials covered include a wide range of grades, from carbon steel to titanium, with focus in Stainless Steel and High Nickel Alloys – same as described regarding trepanned pipes. The Tubacex Group maintains a very high stock level in finished and semifinished products, as well as base materials, to provide full flexibility and a extremely competitive lead time.

• In addition to fittings, special components such as laterals, manifolds, tees, stress joints, weldolets are manufactured at IBF fittings and special parts division, with a clear trend to a more particularized design.

FITTINGS	SPECIAL PARTS				
Butt Welding fittings & elbows	Special components				
Tees	Manifolds				
Reducers	Laterals				
3D / 5D Bends / Stress Joints	Special Reducers				

- Flexible production processes allow The Tubacex Group's products to be manufactured by a variety of production methods, to reach a wide range in a specialized market, where particularized designs are growingly demanded designs defined and calculated by our engineering departments.
- IBF has a technical department equipped with CAD systems for design and calculation. This department designs fittings and special ítems in compliance with all applicable standards and specifications and in conjunction with the client's specific requirements. In addition, the department offers support to the development of all necessary production equipment, machinery and technical processes.



# STAINLESS STEELS FOR HYDROGEN SERVICE

Hydrogen is a clean and sustainable energy source that is currently considered to be one of the best potential substitutes to fossil fuel. Hydrogen value chain including production, process, distribution and storage presents significant challenges for materials requiring resistance to hydrogen embrittlement, high mechanical properties to withstand high pressures and microstructure stability to resist cryogenic conditions or high temperature resistance. Stainless steels are perfect candidates to fulfil these requirements.

Tubacex is a transversal supplier to the whole hydrogen value chain. From gas production, in the case of grey or blue hydrogen, through all the generation technologies, liquefaction, transport, and most of the applications, our products are used.

As one stop shop supplier, we are producers of Steel, pipes, tubes and fittings, in a fully integrated way. In addition, we provide a broad spectrum of services associated with or without products, in order to better service our customers, and reduce the overall cost.

### **STEAM REFORMING:**

it is the most conventional and widely used to produce hydrogen. In order to reduce CO2 emissions, new concepts and designs are being developed like CCS or more efficient designs. TUBACEX produces different high temperature grades for these applications, and in collaboration with the company VDM, the new grade 699XA provides outstanding performance for the highly reductive atmospheres, present in recuperative designs.

#### **ELECTROLYZERS:**

Austenitic stainless steels are the most used materials in electrolyzers. In particular, TUBACEX supply piping, fittings and precision tubing for the balance of plant and instrumentation of the process.

#### **HYDROGEN STATIONS:**

Storage of hydrogen and high pressure conditions are the key characteristics of this application. TU-BACEX is one of the leading companies on high precision tubing. Furthermore, our offer includes high pressure tubing, with low diameter to thickness ratio, for the most demanding mechanical conditions.

#### **HYDROGEN INDUSTRIAL APPLICATIONS:**

The 316 series with different variants in generally used, but TUBACEX offers a complete portfolio of alloys that can be adjusted to meet particular specifications.





### AUSTENITICS: CROGENIC AND HIGH PRESSURE APPLICATIONS

					V					
GRADE	C	MN	Р	S	SI	CR	NI	MO	N	OTHER
TX 316/316L	≤0.03	≤2.00	≤0.040	≤0.015	≤0.75	16.50- 18.00	11.00- 13.00	>2.00	-	-
TX 316/316L HMo	≤0.03	≤2.00	≤0.040	≤0.015	≤0.75	16.50- 18.00	11.00- 13.00	>2.50	-	-
XM-19	≤0.06	4.0-6.0	≤0.045	≤0.030	≤1.00	20.5- 23.5	11.5- 13.5	1.50- 3.00	0.20- 0.40	Nb 0.10-0.30 V 0.10-0.30

#### HIGH TEMPERATURE ALLOYS

GRADE	C	MN	Р	S	SI	CR	NI	AL	TI	CU	N	OTHER
Alloy 800H/ 800HT	0.060- 0.100	≤1.50	≤0.030	≤0.015	≤1.00	19.00- 23.00	30.00- 34.00	0.25-0.60	0.25- 0.60	≤0.75	-	Co≤1.00 Fe>39.50 Al +Ti 0.85- 1.00 Ni+Co 30.00- 34.00
Alloy 699 XA	0.005- 0.10	≤0.50	≤0.02	≤0.01	≤0.50	26.0- 30.0	Reminder	1.9- 3.0	≤0.60	≤0.50	≤0.05	Nb≤0.50 Zr≤0,10 B≤0.008 Fe≤2.5

Other materials available uppon request.





# TX 316/316L

TX 316/316L, the low carbon version of 316, is a molybdenum alloyed austenitic stainless chromium nickel steel. It has very high immunity from sensitization. The austenitic structure gives these grades excellent toughness, even down to cryogenic temperatures. TX 316/316L is an excellent material to be used in hydrogen service due to its resistance to hydrogen embrittlement. For electrolyzers it is used as substrate for bipolar plates in due to the combination of corrosion resistance, electrical conductivity, and high strength.

The added molybdenum (>2.5%) of TX 316/316HMo improves pitting and crevice corrosion resistance compared to standard 316/316L chemistries with typical molybdenum contents around 2,1%. With higher strength at elevated temperatures, it is sometimes used for structural and pressure containing applications at temperatures above about 500°C.

# TX S20910 (XM19)

TX S20910 is a nitrogen-strengthened and manganese alloyed austenitic stainless steel with better corrosion resistance than stainless steel grades 316 and 317 and higher mechanical strength, about twice the yield strength at room temperature. In addition, TX S20910 has very good mechanical properties at both elevated and subzero temperatures. Unlike many austenitic stainless steels, TX S20910 does not become magnetic when cold worked or cooled to sub-zero temperatures. Moreover, TX S20910 has excellent hydrogen embrittlement resistance in comparison with 316L, even at high pressurized hydrogen gas at lower temperature.

# ALLOY 699 XA®

#### A nickel-based alloy with superior resistance to metal dusting.

Metal dusting is a high-temperature corrosion phenomenon occurring in carbonaceous environments at temperatures between 400 and 800 °C. These conditions inevitably occur in some industrial processes such as synthesis gas production, iron ore reduction, and ammonia or methanol plants. An example of application of Alloy 699XA® tubes is as catalyst tubing of a convective heat exchange reformer located adjacent to the primary reformer of some hydrocarbon processing plants. This parallel equipment uses the high heat level of the effluent of the primary reformer to reform additional feed. This special reformer reduces the emissions and can increase the total hydrogen capacity of the plant by 20-30%.



Material Data sheets available upon request

Under metal dusting conditions, vulnerable materials are disintegrated in high amounts of coke mixed with metal, metal carbides and metal oxides.



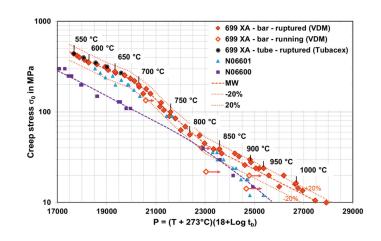
**Alloy 699 XA®** is a nickel-based alloy with chromium and aluminum additions. Hence, the formation of a highly protective oxide scale is the responsible of its high resistance to metal dusting. The alloy also exhibits very high creep strength.

Designations and standards: UNS N06699 - EN 2,4842 ASTM B167 - ASTM B163 Seamless pipes and tubes



### **CREEP RESISTANCE**

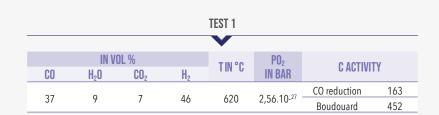
High-temperature strength of Alloy 699 XA® is at least at the level of Alloy 601, a nickel-based alloy with very high creep properties used in very demanding high-temperature applications



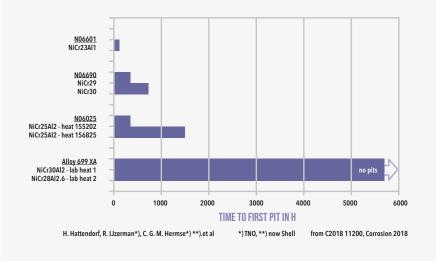
### **METAL DUSTING RESISTANCE**

Metal dusting laboratory tests in high carbon activity atmospheres showed outstanding metal dusting resistance of Alloy 699  $XA^{\otimes}$ .





Alloy 699 XA® exhibits higher metal dusting resistance than Alloy 601, Alloy 690, and Alloy 602.



# ALLOY 800H / ALLOY 800HT

A Ni-Fe-Cr alloy with excellent high-temperature strength and corrosion resistance Alloy 800H and Alloy 800HT are nickel-iron-chromium alloys that possess very good hightemperature strength and resistance to high-temperature corrosion phenomena such as oxidation and carburization, among others. These characteristics make these alloys extremely useful for many applications affected by long-term exposure to elevated temperatures and corrosive environments. Examples of applications in which hydrogen is involved are catalyst tubing, outlet manifolds, pigtails, convection tubing, and quenching-system piping in steam/hydrocarbon reforming; tubing in hydrogenation heaters for oxy-alcohol production; convection and cracking tubes, and pigtails for ethylene production; heater tubing for hydrodealkylation units; and cracking tubes, return bends and inlet and outlet flanges in the production of vinyl chloride monomer.

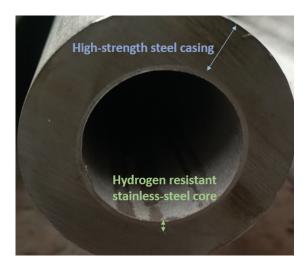
Alloy 800H and Alloy 800HT are nickel-iron-chromium alloys with controlled additions of carbon, aluminum, and titanium. Furthermore, both alloys are solution annealed to produce a final grain size of 5 ASTM or coarser. Because of the limited chemical composition and the achieved microstructure, Alloy 800H and Alloy 800HT display excellent creep and rupture strength and high-temperature corrosion resistance.



# **BIMETALLIC TUBES**

#### An innovative solution for high-pressure hydrogen transport

Bimetallic tubes are constituted of a high strength steel casing and a hydrogen resistant stainless-steel core. The combination of these two properties makes the bimetallic tube an optimum solution for high-pressure hydrogen transport.



Bimetallic tubes are produced by co-extrusion, so that a perfect metallurgical bonding between casing and core is achieved.

### **DESIGNATIONS AND STANDARDS:**

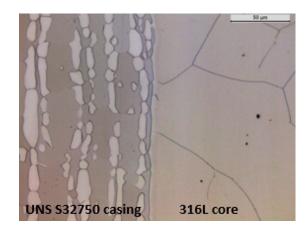
Applicable designations and standards will depend on the materials selected for casing and core.

#### **CHEMICAL COMPOSITION**

The chemical composition will depend on the materials selected for casing and core.

### **MICROSTRUCTURE**

The microstructure will depend on the materials selected for casing and core. In all cases, a perfect metallurgical bonding between the 2 steel grades is guaranteed.



Example of the perfect metallurgical bonding achieved in a bimetallic tube → UNS S32750 superduplex grade casing + 316L austenitic grade core.



# **TBX LABS**

Tubacex Innovation provides technical services for industry around the world.

Its vast multi-sector experience in material selection along with the deep knowledge of production processes, make Tubacex Innovation the best partner to optimize your projects. It is focused on material development, best corrosion performance and improved mechanical properties to offer efficient solutions in terms of cost, lead times, risk reduction and environmental performance.





### TECHNICAL ADVICE ON MATERIALS AND PROCESSES

Technical advice on the selection of materials and processes to ensure design integrity.



### INTENSIVE LAB Testing

Fully laboratory devoted to R&D with a group of researchers specialized in metalurgy.



# DESIGN AND ADVANCE SIMULATION

Design & verification through simulation and validation tools.



### YOUR PARTNER In R&D Projects

Our specialists ensure that the design, analysis, equipment selection and implementation are all aligned and buttressed by operational expertise.

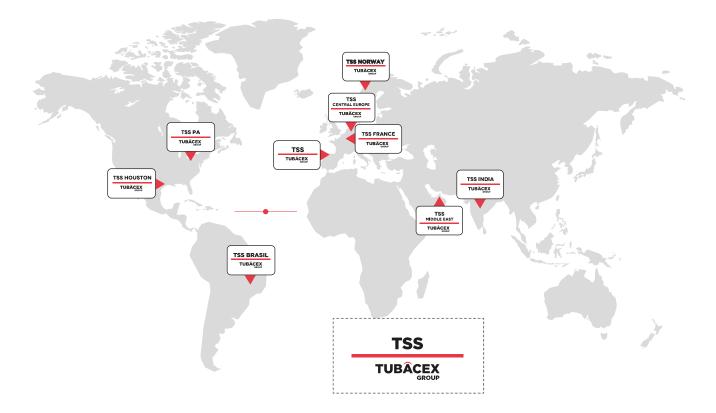


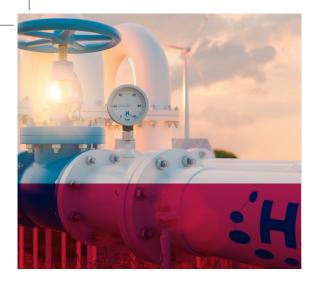
# TSS, THE LARGEST GLOBAL MASTER DISTRIBUTOR OF STAINLESS STEEL TUBULAR PRODUCTS

TUBACEX Group has reinforced its global leadership on the distribution market increasing its value proposal through TUBACEX Service Solutions (TSS), a master distributor capable of offering its distributor clients a wide range of products in stock with full availability anywhere in the world, as well as an array of high value-added services.

Thus, TSS joins a business group with experience in the manufacturing of seamless stainless steel and high alloy tubular products, making the most of the synergies already in place at the Group production plants worldwide to improve customer service. Thanks to this, TSS can guarantee immediate availability, quality and service as well as an array of competitive advantages oriented to reducing its clients' operative costs.

As master distributor, TSS brings TUBACEX's constantly growing product and service portfolio closer to clients, while significantly promoting services offered to them.

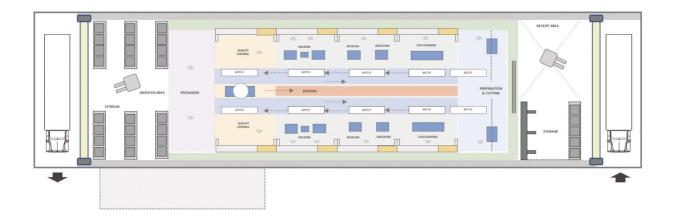




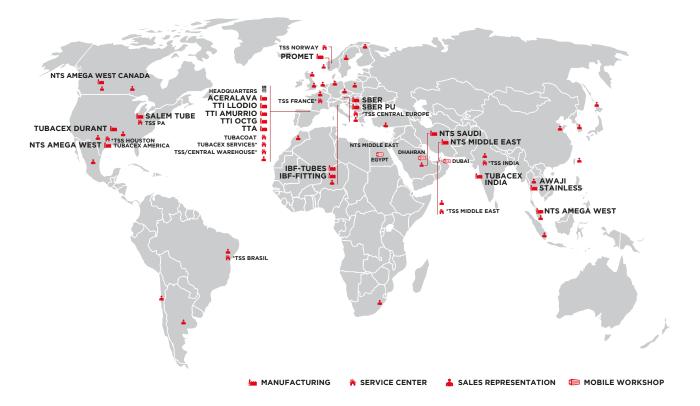
# **INDUSTRIAL SOLUTIONS**

- Spooling plants for serial production.
- The development of the hydrogen economy needs industrial production of equipment at scale. Only a high level of optimization in design and production will allow a substantial reduction of costs.
- Tubacex can be part of the scaling-up process by investing into highly automated lines to fabricate the tubular components needed for electrolyzers or other equipment.





# **TUBACEX AROUND THE WORLD**



Currently the Tubacex Group is exporting into more than 100 countries worldwide from its manufacturing sites and warehouses. The company has 15 commercial offices and a wide network of agents in several countries that lead to a global presence.

### **MANUFACTURING COMPANIES**

Acería de Álava, S.A.

STEEL MELTING SHOP Amurrio. SPAIN

Tubacex Tubos Inoxidables, S.A.

HOT EXTRUSION PLANT LIODIO. SPAIN COLD FINISHING PLANT OCTG FINISHING PLANT Amurrio. SPAIN

#### Schoeller Bleckmann

Edelstahlrohr, GmbH COLD FINISHING PLANT HOT EXTRUSION PLANT SPECIALTUBE PLANT Ternitz. AUSTRIA

Salem Tube, Inc. COLD FINISHING PLANT Greenville. PA. USA

Tubacex Durant COLD FINISHING PLANT Durant.OK.USA

#### IBF, S.p.a.

TUBES DIVISION Vituone - Milano. ITALY FITINGS DIVISION San Nicolò - Piacenza. ITALY Tubacex Prakash COLD FINISHING PLANT Umbergaon - Gujarat. INDIA

**Tubacex Awaji** STAINLESS FITTINGS Amphur Muang-Samutprakarn. THAILAND

Tubacex Taylor Accesorios, S.A. BUTT WELDING FITTINGS Artzeniega. SPAIN

**Tubacex Services, S.L.** TUBE FINISHING SERVICES Santander. SPAIN

Tubacoat CERAMIC TUBE COATING Santander. SPAIN

NTS Group MACHINED PARTS MANUFACTURING & REPAIR UAE USA CANADA SINGAPORE NORWAY SAUDI ARABIA

### **SERVICE & DISTRIBUTION COMPANIES**

Tubacex Service Solutions, S.A.

STAINLESS STEEL LONG PRODUCTS DISTRIBUTION Amurrio. SPAIN

Tubacex America, Inc. / TSS Houston STAINLESS STEEL LONG PRODUCTS DISTRIBUTION Houston. UNITED STATES

#### Metaux Inox Services, S.A.S. /

TSS France STAINLESS STEEL LONG PRODUCTS DISTRIBUTION Satolas & Bonce. FRANCE

TSS Central Europe STAINLESS STEEL LONG PRODUCTS DISTRIBUTION

Ternitz. AUSTRIA

STAINLESS STEEL LONG PRODUCTS DISTRIBUTION Sao Paolo. BRAZIL

TSS Brasil

TSS India

STAINLESS STEEL LONG PRODUCTS DISTRIBUTION Gandhidham. INDIA

TSS Middle East STAINLESS STEEL LONG PRODUCTS DISTRIBUTION Dubai. UAE

### Tubacex Upstream Technologies

OCTG Premium solutions Leioa. SPAIN



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