## HYDROGEN APPLICATIONS

## STAINLESS STEEL AND HIGH NICKEL ALLOY TUBULAR SOLUTIONS













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

Tubacex is a global leader in the design, manufacturing, and installation of sophisticated industrial products and high-value-added services for the energy and mobility sectors. Tubacex provides value to its customers through its global presence, with production facilities and service centers in Spain, Austria, Italy, the United States, India, Thailand, Saudi Arabia, Dubai, Norway, Canada, Brazil, Singapore, Guyana, and Kazakhstan. Its sustainability and environmental policies are endorsed by leading ESG certification bodies, including commitments to reduce emissions through Science-Based Targets (SBT), accreditation in ratings like CDP (Rating A-), and adherence to S&P sustainability standards.



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



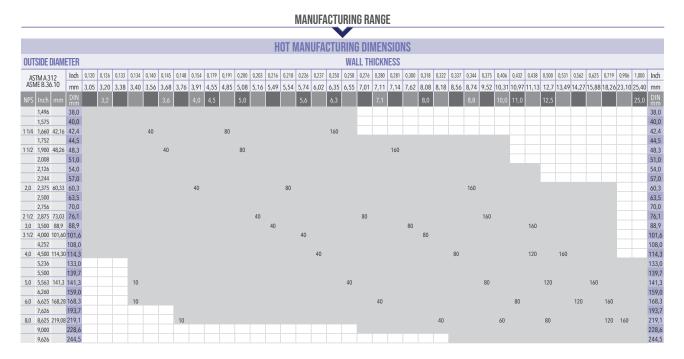
## THE WIDEST PORTFOLIO IN STAINLESS STEEL

A TRULY GLOBAL SOLUTIONS PROVIDER AT YOUR SERVICE

		SOLUTIONS	BUSINESS UNIT
	>	STAINLESS STEEL AND HIGH NICKEL ALLOYS BARS AND BILLETS	ACERALAVA TUBÂCEX GROUP
50 nexes			TTI TUBÂCEX
NIA TO THE			SCHOELLER BLECKMANN TUBÂCEX
	>	SEAMLESS PIPE AND TUBES TO 8" (EXTRUSION, PIERCING,	SALEM TUBE TUBÂCEX
		COLD FINISHING)	TUBACEX DURANT TUBÂCEX
			TTP TUBÂCEX
		SEAMLESS PIPE AND Tubes to 72"	IBF TUBÂCEX
		FITTINGS AND SPECIAL	TTA TUBÂCEX
	>	CONNECTIONS FROM ½" TO 72"	AWAJI STAINLESS TUBÂCEX
	<b>&gt;</b>	STAINLESS STEEL MACHINED PARTS	NTS  Group  SENAAT – TUBACEX JV
EN EN			TUBACEX UPSTREAM TECHNOLOGIES TUBACEX
Ö :0:	>	VALUE ADDED OPERATIONS AND SERVICES	TUBACEX SERVICES TUBÂCEX
			TUBACOAT TUBÂCEX
	>	STOCK, SERVICE AND Trading	TSS TUBÂCEX

## **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:



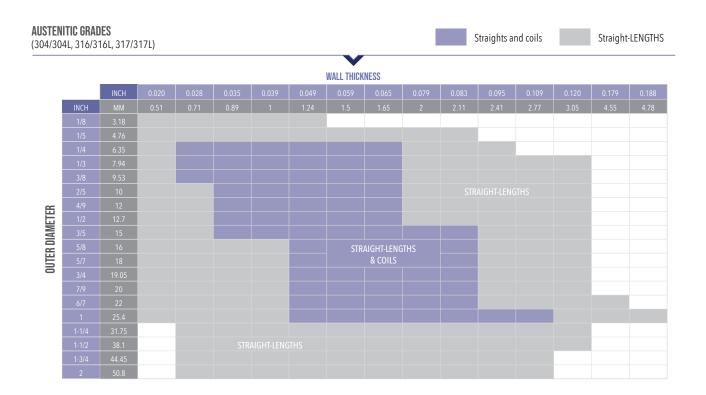
Range of Tubacex Tubos Inoxidables and Schoeller Bleckmann Edelstahlrohr for austenitic hot manufactured tubes and pipes. Production according to main manufacturing standards (ASTM/ASME, EN and other international manufacturing standards). Non standard articles available upon request.

#### MANUFACTURING RANGE **COLD MANUFACTURING DIMENSIONS OUTSIDE DIAMETER WALL THICKNESS** $\text{Inch} \quad | 0.020 \quad | 0.035 \quad | 0.049 \quad | 0.065 \quad | 0.083 \quad | 0.099 \quad | 0.055 \quad | 0.083 \quad | 0.099 \quad | 0.102 \quad | 0.109 \quad | 0.113 \quad | 0.120 \quad | 0.124 \quad | 0.133 \quad | 0.124 \quad | 0.140 \quad | 0.145 \quad | 0.148 \quad | 0.154 \quad | 0$ mm | 0,50 | 0,89 | 1,24 | 1,65 | 2,11 | 2,31 | 2,59 | 2,77 | 2,87 | 3,05 | 3,20 | 3,38 | 3,40 | 3,56 | 3,68 | 3,76 | 3,91 | 4,55 | 4,85 | 5,08 | 5,16 | 5,49 | 5,56 | 5,74 | 6,02 | 6,35 | 5,70 | 7,11 | 7,62 | 8,08 | 8,18 | 8,56 | 9,53 | 10,97 | 12,70 | 14,20 | mm 0,125 3,17 3,2 6,0 0,236 8,0 10,2 1/8 0,405 10,29 10,2 12,0 13,5 1/4 0,540 13,72 13,5 0,630 16,0 3/8 0,675 17,15 17,2 16,0 17,2 19,0 0.787 21,3 25,0 1/2 0,840 21,34 21,3 0.984 3/4 1,050 26,67 26,9 1,181 30.0 32,0 33,7 1,260 1,0 1,315 33,40 33,7 160 35,0 38.0 1.496 38.0 1,575 40,0 42,4 44,5 1 1/4 1,660 42,16 42,4 1,752 48,3 51,0 1 1/2 1,900 48,26 48,3 2,008 57,0 2,0 2,375 60,33 60,3 60,3 2,500 2,756 63,5 70,0 76,1 2 1/2 2,875 73,03 76,1 3,0 3,500 88,90 88,9 10 88.9 3 1/2 4,000 101,60 101,6 4,252 108.0 108,0 4,0 4,500 114,30 114,3 114,3 5,236 133,0 5,0 5,563 141,30 141,3 133,0 141,3 168,3 193,7 6,0 6,625 168,28 168,3 8,0 8,625 219,08 219,1

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)

	WALL THICKNESS															
															0.188	
	INCH	ММ	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
		4.76														
		6.35														
		7.94														
	3/8	9.53														
臣		12 12.7														
W																
OUTER DIAMETER																
臣																
10																
	6/7	22														
		38.1														
	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**

Seamless	_	1/2" ton 44"							
Welded		1/2" ton 72"							
Hot drawing, bending and cold drawing processes Any thickness Lengths from 0,5 to 20 meter									

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. 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 fiitings 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

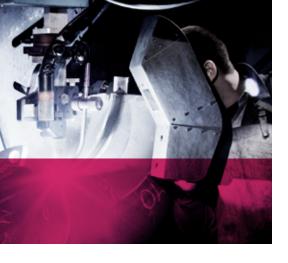
					V					
GRADE	C	MN	P	S	SI	CR	NI	MO	N	OTHER
TX 316/316L	≤0.03	≤2.00	≤0.040	≤0.015	≤0.75	16.50- 18.00	11.00- 13.00	>2.00	-	-
TX 316/316L HMo	≤0.03	≤2.00	≤0.040	≤0.015	≤0.75	16.50- 18.00	11.00- 13.00	>2.50	-	-
XM-19	≤0.06	4.0-6.0	≤0.045	≤0.030	≤1.00	20.5- 23.5	11.5- 13.5	1.50- 3.00	0.20- 0.40	Nb 0.10-0.30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

#### HIGH TEMPERATURE ALLOYS

GRADE	C	MN	P	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%.



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.

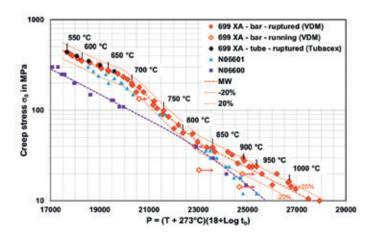
#### **Designations and standards:**

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



#### **CREEP RESISTANCE**

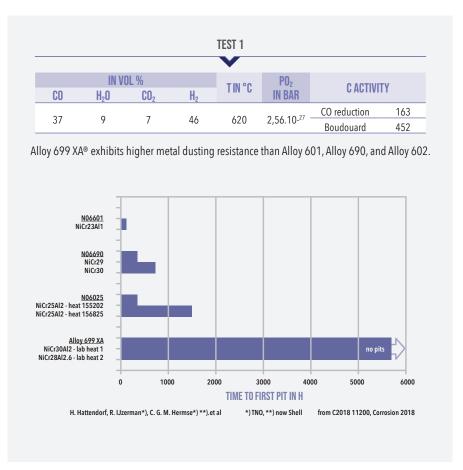
High-temperature strength of Alloy 699 XA® is at least at the level of Alloy 601, a nickel-based alloy with very high creep properties used in very demanding high-temperature applications



#### **METAL DUSTING RESISTANCE**

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





## 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.

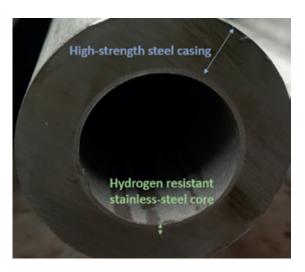
Alloy 800H and Alloy 800HT are nickel-iron-chromium alloys with controlled additions of carbon, aluminum, and titanium. Furthermore, both alloys are solution annealed to produce a final grain size of 5 ASTM or coarser. Because of the limited chemical composition and the achieved microstructure, Alloy 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:**

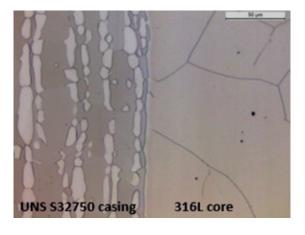
Applicable designations and standards will depend on the materials selected for casing and core.

#### 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 perfomance.







**COST EFFECTIVE SOLUTIONS** 



**REDUCTION OF RISKS** 



**IMPROVING LEAD TIMES** 



REDUCING ENVIRONMENTAL FOOTPRINT





MATERIAL DEVELOPMENT BEST CORROSION PERFORMANCE IMPROVED MECHANICAL PROPERTIES



#### 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.

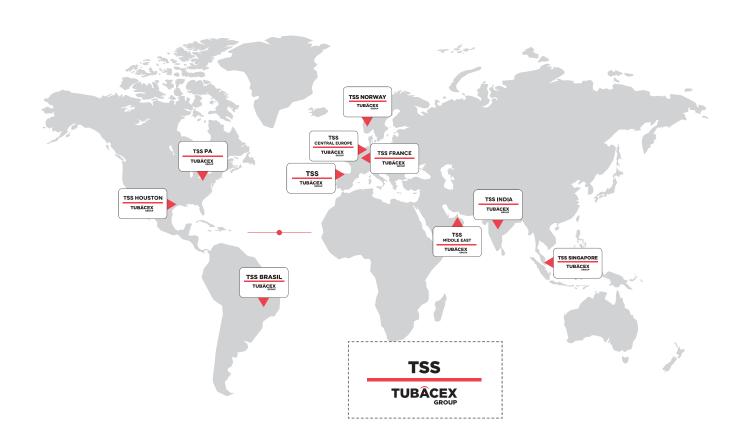


# TSS, THE LARGEST GLOBAL MASTER DISTRIBUTOR OF STAINLESS STEEL TUBULAR PRODUCTS

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.



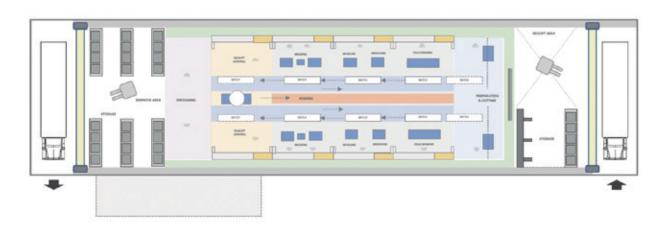


## **INDUSTRIAL SOLUTIONS**

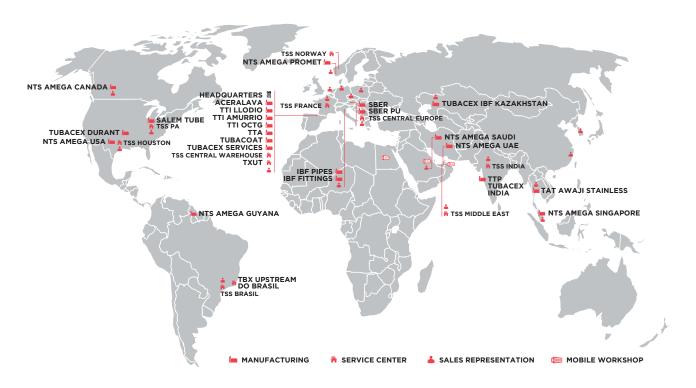
- Spooling plants for serial production.
- The development of the hydrogen economy needs industrial production of equipment at scale.

  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 Llodio. SPAIN

COLD FINISHING PLANT OCTG FINISHING PLANT

Amurrio. SPAIN

#### Schoeller Bleckmann Edelstahlrohr, GmbH

COLD FINISHING PLANT HOT EXTRUSION PLANT SPECIAL TUBE 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 Tubes & Pipes Pvt. Ltd.**

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**

NORWAY

SAUDI ARABIA

MACHINED PARTS
MANUFACTURING & REPAIR
UAE
USA
CANADA
SINGAPORE

#### **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

#### **TSS Brasil**

STAINLESS STEEL LONG PRODUCTS DISTRIBUTION Sao Paolo. BRAZIL

#### TSS India

STAINLESS STEELLONG 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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