GLOBAL
POSCO WAY

posco TITANIUM

posco

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Titan of the world
Gift for human welfare

Discovered in 1790 and put in industrial usage in 1950, titanium has very short history compared to other materials. However, it is becoming one of the most important materials in 21st century. Especially, its superior specific strength and corrosion resistance have been expanding its usage from aircraft to shipbuilding, power plants, medical equipment, and other industrial fields. POSCO, as a total material provider, has entered titanium industry with world-leading technologies and experience accumulated in its steelmaking operations, and delivers better products to our customers with high stability.

1790년에 발견되어 1950년 상업생산이 시작된 티타늄은 다른 금속에 비해 그 역사는 짧지만 21세기에 주목 받는 신소재로서 비약적인 발전을 하고 있습니다. 특히, 높은 비강도와 뛰어난 내식성으로 인해 과거 우주항공산업에 국한되어 있던 응용분야를 최근 조선, 발전, 의료기기, 생활용품 등 일반 산업분야로 확대하고 있습니다. 포스코는 종합소재메이커로서 철강사업에서 축적한 세계 최고의 기술과 경험을 바탕으로 티타늄판재 사업을 시작하였으며, 스펀지 티타늄 제조사인 카자흐스탄의 UKTMP사와 합작사 설립으로 원료부터 제품까지 일관생산체제를 구축함으로써 고객에게 보다 경쟁력 있는 제품을 안정적으로 공급하고 있습니다.

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Besides its superior quality in weight, strength and corrosion resistance, titanium is a non-toxic, environment-friendly metal.

As a global leading steel company, POSCO is creating another success story in titanium industry.

티타늄은 무게, 강도, 내식성에 있어 우수할 뿐만 아니라 무독성의 환경친화적 금속입니다.
포스코는 선도적인 철강회사로서 티타늄 산업에서 또 다른 성공 신화를 창조하고 있습니다.

Characteristics

Light Weight
Specific gravity about 60% of steel
일반강 대비 60% 수준의 비중

High Specific Strength
Strength similar to steel
일반강 수준의 강도

Corrosion Resistance
Excellent corrosion resistance against seawater
해수에 대한 뛰어난 내식성

Low Thermal Expansion
Thermal expansion similar to glass or concrete
유리, 콘크리트와 유사한 열팽창계수

Non Magnetic
Never becomes magnetized
비자성

High Formability
Formability similar to 304 stainless steel
304스테인리스 스틸과 비슷한 수준의 성형성

Non Toxic
Low leaching out of metallic ions and low incidence of ionic allergy
낮은 수준의 금속이온의 침출 가능성 및 알레르기 발생률

Cost Effectiveness

In many applications, titanium offers opportunities for reducing operating costs.

- Better fuel economy through weight savings in engines and other mobile equipment
- Improved energy conservation by efficient heat transfer
- Resistance to aggressive materials such as crude oil with high level of hydrogen sulfide
- Reduction in environmental cost caused by corrosion leakage

티타늄 소재는 다양한 적용 분야에서 운전비용의 절감을 제공하고 있습니다.

- 제품의 경량화를 통해 엔진 등의 연료소비 절감
- 열전달 효율 향상을 통한 에너지 효율 향상
- 고 황화수소 원유 등과 같은 aggressive 소재에 대한 저항력
- 부식에 인한 오염물질 배출의 방지 등 환경비용 절감

Also, titanium provides cost reduction in maintenance and downtime by its superior corrosion resistance especially for plants and equipment designed for a long service life.

Welded titanium tube supplied for power plant surface condenser use, has been sold with a 40 year performance guarantee and many of the earlier installations of welded tube have now outlived their original guarantee period.

또한, 긴 수명이 요구되는 플랜트 및 장비에 티타늄을 사용하면 탁월한 내식성으로 유지 보수 비용을 절감할 수 있습니다. 발전소 콘덴서에 공급되는 티타늄 용접 튜브는 일반적으로 40년 이상의 품질보증을 하고 있으며 과거 설치된 튜브는 대부분 당초 보증기간 이상으로 사용되고 있습니다.

Power / Chemical / Desalination Plant

Thermal power plant

Dehydrogen Tower

Seawater Desalination Plant

Ocean Plant / Shipbuilding

Ocean Plant

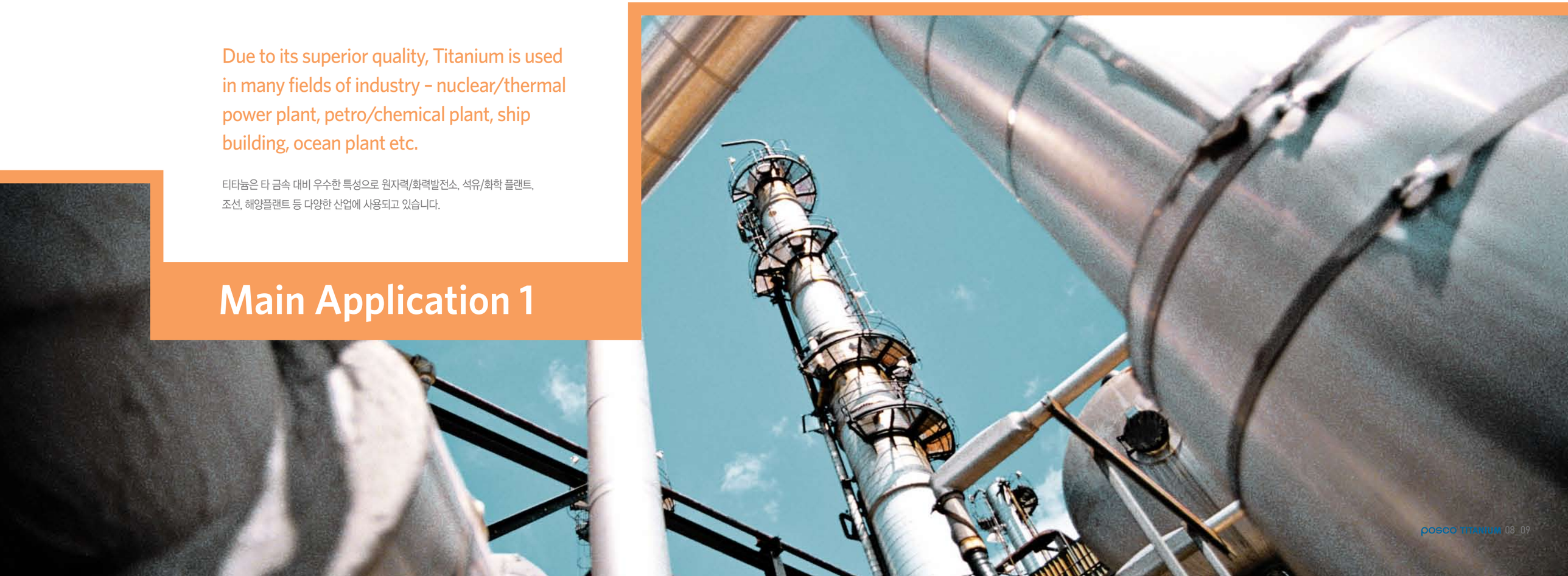
Plate Heat Exchanger

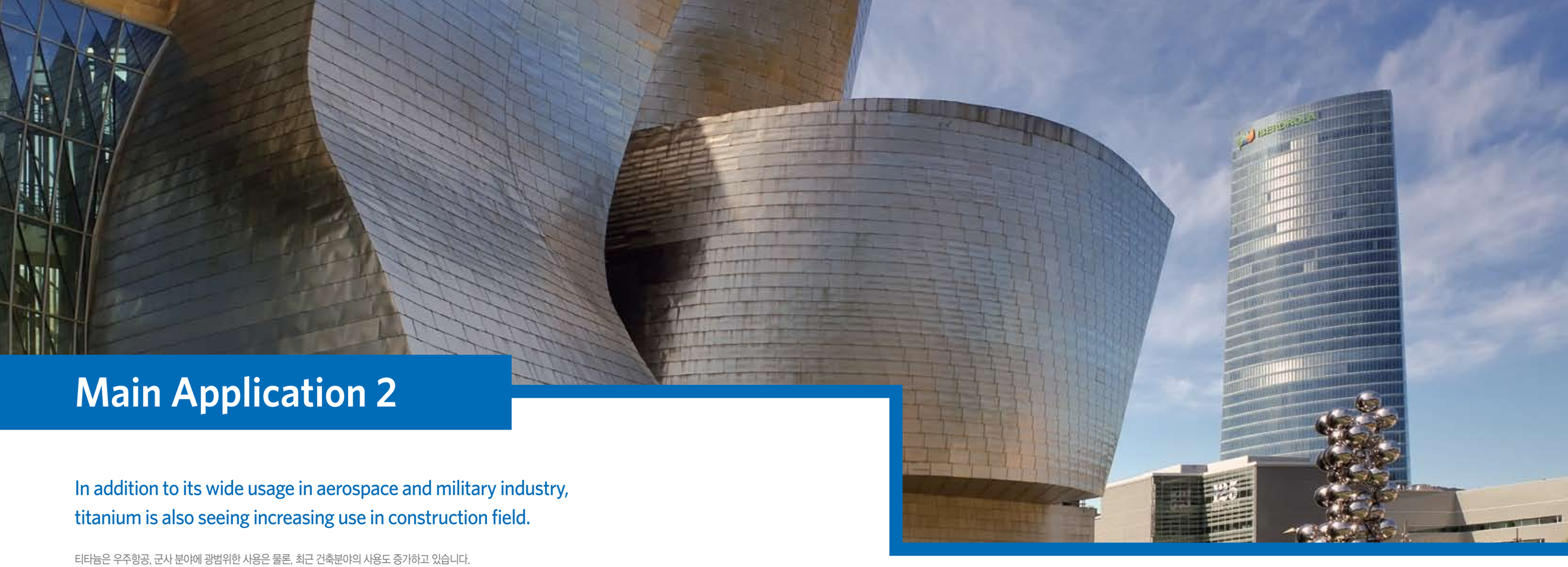
Plate Heat Exchanger

Due to its superior quality, Titanium is used in many fields of industry – nuclear/thermal power plant, petro/chemical plant, ship building, ocean plant etc.

티타늄은 타 금속 대비 우수한 특성으로 원자력/화력발전소, 석유/화학 플랜트, 조선, 해양플랜트 등 다양한 산업에 사용되고 있습니다.

Main Application 1





Main Application 2

In addition to its wide usage in aerospace and military industry, titanium is also seeing increasing use in construction field.

티타늄은 우주항공, 군사 분야에 광범위한 사용은 물론, 최근 건축분야의 사용도 증가하고 있습니다.

Aerospace / Military

F-15k

K-11

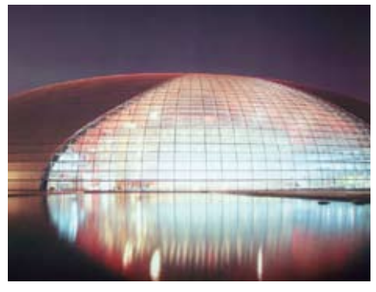
Space Shuttle

Construction

Guggenheim Bilbao, Spain

Benz Museum, Germany

SPFC Building, Korea



National Grand Theatre, China

Main Application 3

Moreover, titanium is appropriate for the products for sports, leisure, medical equipment, accessories, and the range of applications in industry is being expanded.

또한, 티타늄은 스포츠, 레저, 의료용 제품들과 액세서리에 적합한 소재로서,
그 응용분야가 확대되고 있습니다.

Sports / Leisure

Bicycle Frames

Golf Driver

Titanium Cookware

Automobile Muffler

Racket

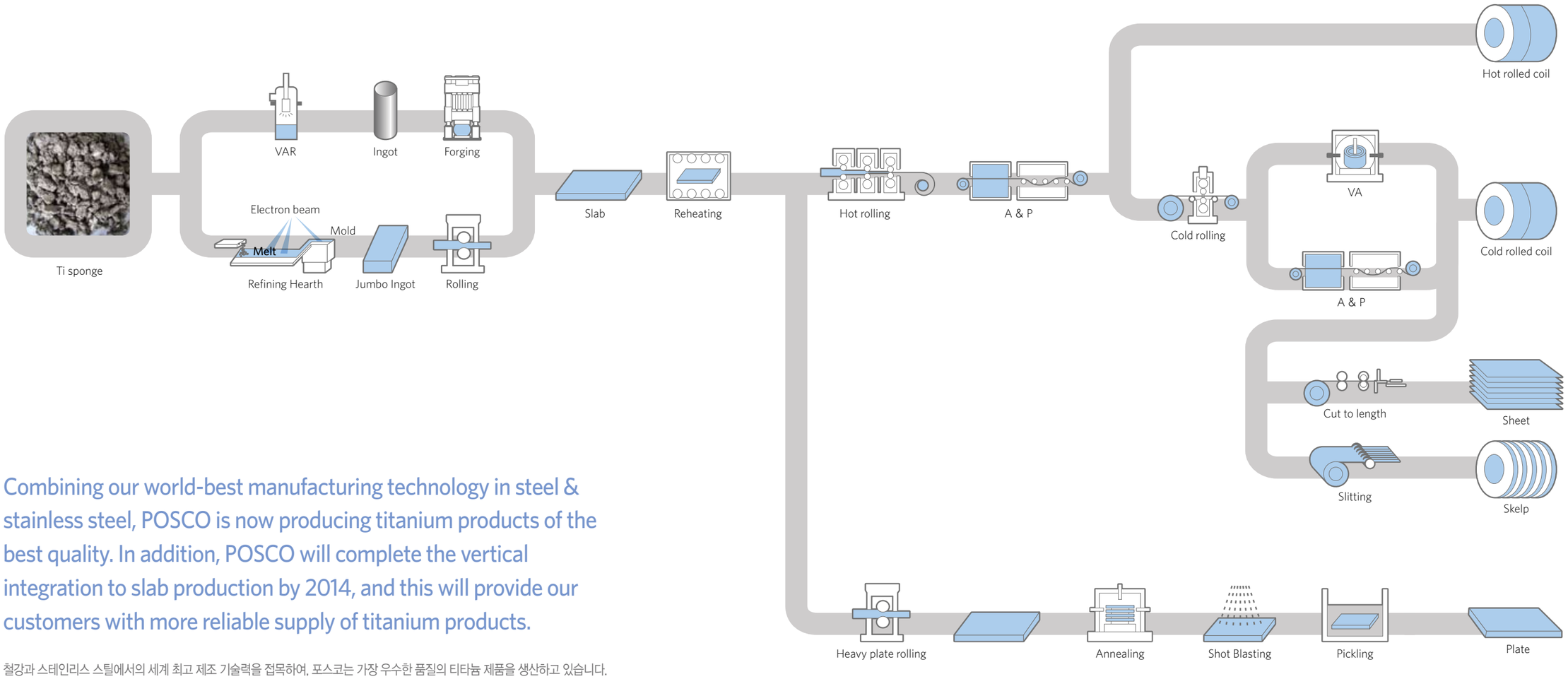
Medical Equipment / accessories

Dental Plate & Spring

Glasses

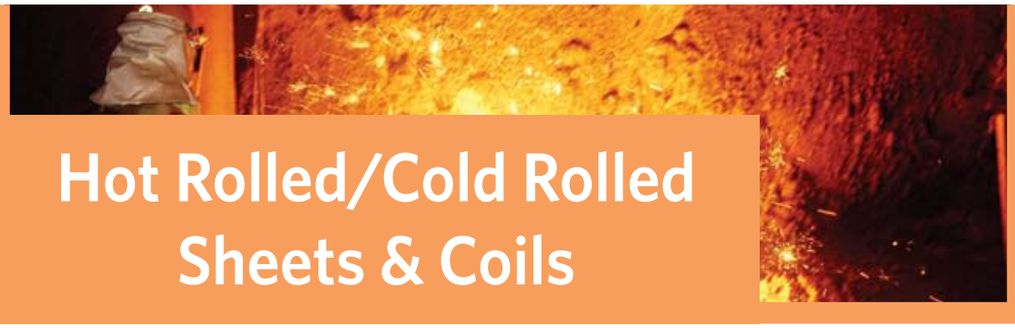
Accessories

Manufacturing Process



Combining our world-best manufacturing technology in steel & stainless steel, POSCO is now producing titanium products of the best quality. In addition, POSCO will complete the vertical integration to slab production by 2014, and this will provide our customers with more reliable supply of titanium products.

철강과 스테인리스 스틸에서의 세계 최고 제조 기술력을 접목하여, 포스코는 가장 우수한 품질의 티타늄 제품을 생산하고 있습니다.
또한, 2014년까지 완성될 슬라브 생산까지의 수직계열화를 통해 고객에게 보다 안정적으로 티타늄 제품을 공급할 것입니다.



Hot Rolled/Cold Rolled Sheets & Coils

HR/CR sheets are produced in high quality and accurate dimensions, mainly used for heat exchanger tube for nuclear, thermal power plants and plate heat exchanger(PHE).

HR/CR 코일은 우수한 품질과 규격으로 생산되며
주로 원자력, 화력발전 등의 열교환기용 튜브 및 선박용 판형열교환기용 소재로 쓰입니다.

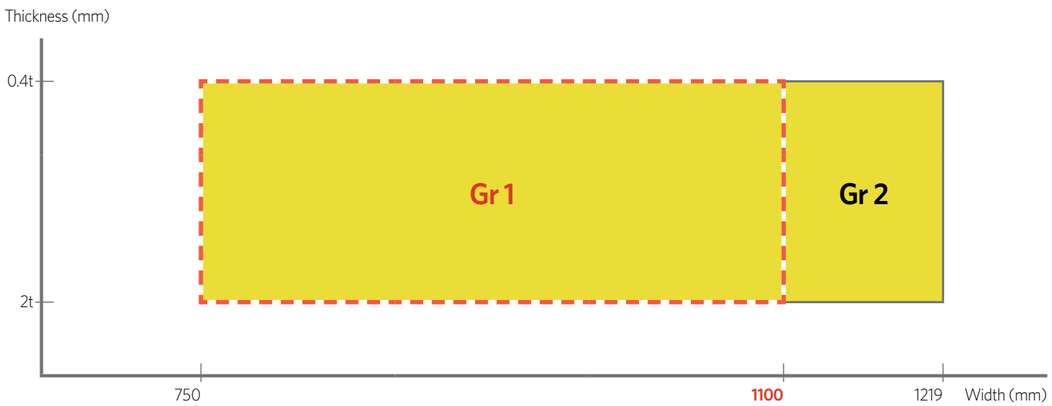
Application

Acceptable Standards

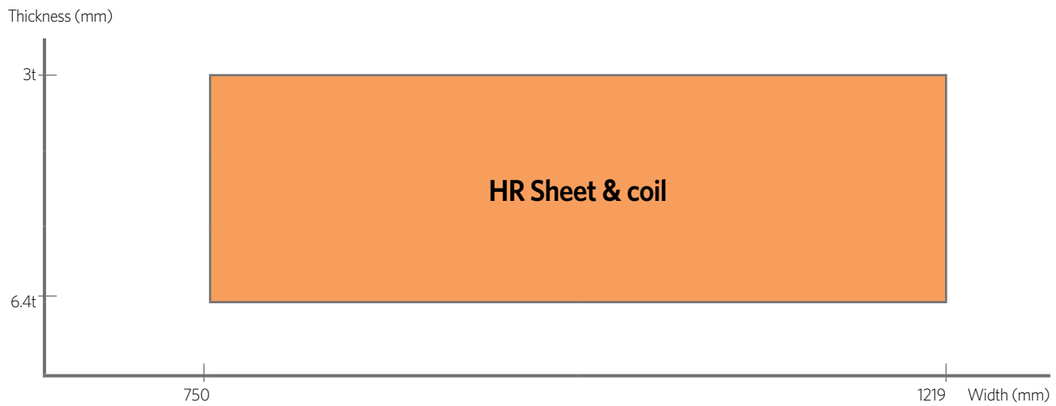
Standard	Grades
ASTM B265	Gr.1, Gr.2
ASME SB265	Gr.1, Gr.2
JIS H 4600	Class1, Class2

Available Sizes

COLD ROLLED SIZE (냉연)



HOT ROLLED SIZE (열연)



Plates

Plates are mainly used for tube sheet and pressure vessel.

후판은 주로 열교환기의 튜브 경판과 입력용기 등의 소재로 쓰입니다.

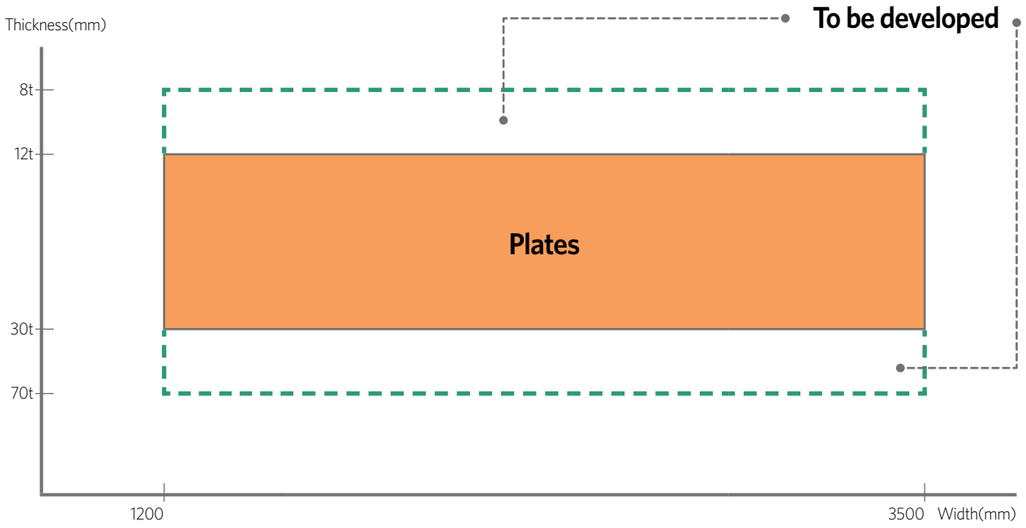
Application

Acceptable Standards

Standard	Grades
ASTM B265	Gr.1, Gr.2
ASME SB265	Gr.1, Gr.2
JIS H 4600	Class1, Class2

Available Sizes

PLATES SIZE (후판)



Titanium Sheet for HEAT EXCHANGER

판형열교환기용(PHE) 고가공성 티타늄 판재

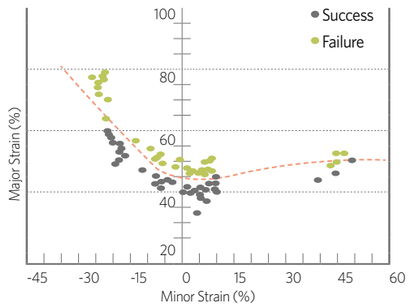
Mechanical properties 기계적 특성

Ultra-thin titanium plate for Excellent press formability (CP-Grade 1 VA)
High ductility (El > 45%), high formability (Erichsen value > 11mm)

프레스 성형성이 우수한 극박 티타늄 판재 (CP-Grade 1 VA)
고연성(El > 45%), 고가공성(Erichsen value > 11mm)

High Formabiity 판재 고성형성

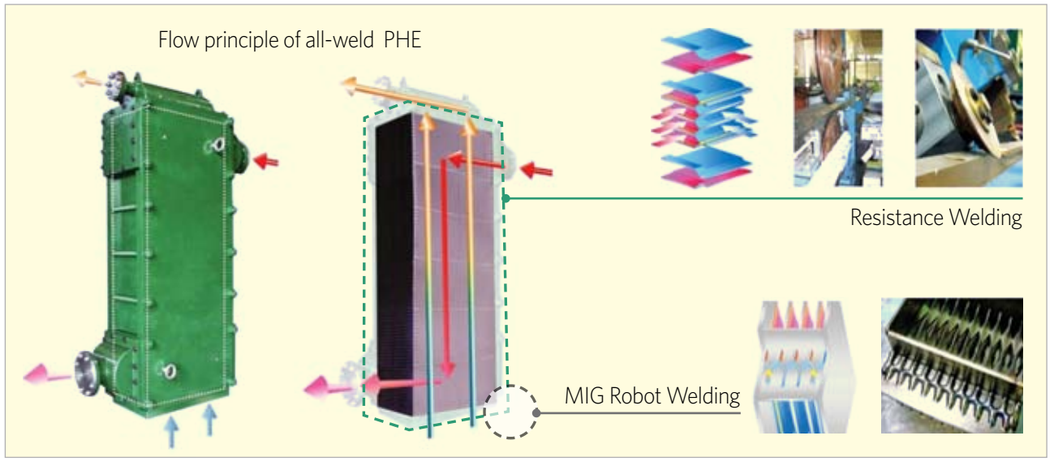
High Formabiity (Forming Limit Diagram)



High Erichsem-value

3-D Scanning (PHE)

[Xenesys 社]



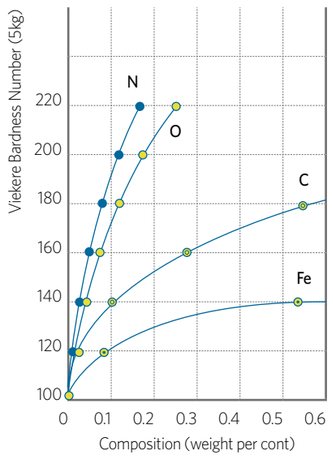
Technical Data

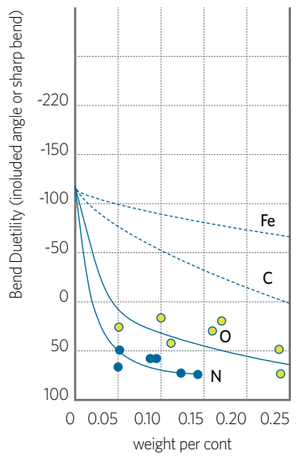
Titanium Standard

Chemical Composition & Mechanical Properties according to ASTM Standards							
DESIGNATION	GRADE 1	GRADE 2	GRADE 3	GRADE 4	GRADE 5	GRADE 7	GRADE 11
COMPOSITION(%MAX) 화학성분							
Oxygen (O)	0.18	0.25	0.35	0.40	0.20	0.25	0.18
Nitrogen (N)	0.03	0.03	0.05	0.05	0.05	0.03	0.03
Hydrogen (H)	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Carbon (C)	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Iron (Fe)	0.20	0.30	0.30	0.50	0.40	0.30	0.20
Aluminium (Al)	-	-	-	-	5.5~6.75	-	-
Vanadium (V)	-	-	-	-	3.5~4.5	-	-
Palladium (pd)	-	-	-	-	-	0.12~0.25	0.12~0.25
Residual each (total)	0.10(0.4)	0.10(0.4)	0.10(0.4)	0.10(0.4)	0.10(0.4)	0.10(0.4)	0.10(0.4)
MECHANICAL PROPERTIES 기계적 성질							
Tensile Strength MPa min.	240	345	450	550	895	345	240
인장강도 (ksi)	(35)	(50)	(65)	(80)	(130)	(50)	(35)
Yield Strength MPa	170~310	275~450	380~550	483~655	830	275~450	170~310
항복강도 (ksi)	(25~45)	(40~65)	(55~80)	(70~95)	(120)	(40~65)	(25~45)
Elongation % min.(연신율)	24	20	18	15	10	20	24
Hardness HV typical (경도)	100~150	160~200	180~220	200~280	310~350	160~200	100~150

- N is a very exceptional strength improvement but drop the elongation
- Improvment strength or elongation is controlled by O
- Improve strength & Drop elongation - N>O>C>Fe

- N은 매우 탁월한 강도 향상 원소이나, 연신율 하락 등도 영향
- 강도 향상, 연신율 하락 등은 적절한 O의 함량으로 재질 조절
- 강도 향상 및 연신율 하락 - N>O>C>Fe





Technical Data

Physical Properties

Comparison of Physical Properties with those of other Metals											
Item	Atomic no.	Atomic wt.	Density (g/cc)	Melting point (°C)	Linear thermal expansion coefficient (/°C)	Specific heat (J/g-°C)	Thermal conduc-tivity cofficient (W/m·K)	Specific electrical (μΩ-cm)	Electrical conductivity to Cu(%)	Young's modulus (GPa)	Poisson's ratio
Titanium	**22**	**47.90**	**4.5**	**1,668**	**8.4×10^{-6}**	**0.53**	**17.0**	**55**	**3.1**	**116**	**0.34**
Iron	26	55.85	7.9	1,530	12×10^{-6}	0.44	76.2	9.7	18	200	0.31
18-8 Stainless steel (SUS 304)	-	-	7.9	1,400 ~ 1,420	17×10^{-6}	0.50	16.2	72	2.4	195	0.3
Aluminum	13	26.97	2.7	660	23×10^{-6}	0.90	210	2.7	64	68	0.33
Aluminum alloy (7075)	-	-	2.8	476 ~ 638	23×10^{-6}	0.96	120	5.8	30	71.7	0.33
Magnesium	12	24.32	1.7	650	25×10^{-6}	1.03	159	4.3	40	44	0.35
Magnesium alloy (AZ-31B)	-	-	1.8	605 ~ 630	26×10^{-6}	1.0	96	9.3	19	45	0.35
Nickel	28	58.69	8.9	1,453	15×10^{-6}	0.46	60.7	9.5	18	207	0.31
Nickel alloy (monel)	-	8.8	8.8	1,300 ~ 1,350	14×10^{-6}	0.43	21.8	48	3.6	170	0.29
Hastelloy C	-	-	8.9	1,305	11.3×10^{-6}	0.43	11.1	130	1.3	205	-
Copper	29	63.57	8.9	1,083	17×10^{-6}	0.39	385	1.7	100	110	0.34

Notes : 18-8 stainless steel : Cr(18%)-Ni(8%)-Fe(R)
Monel : Ni (70%)-Cu (30%) Hastelloy C : 54Ni-17Mo-15Cr-5Fe-4W
AZ-31B : Al (3%)-Zn (1%)-Mn (0.2%) - Mg(R)
7075 : Tempered and quenched ultra-super duraluminum [Cu (1.6%)-Mg (2.5%)-Cr (0.3%)-Zn (5.6%)-Al (R)]
Crystal structure α Titanium (≦885°C) : close-packed hexagonal lattice a=2.9504 Å c/a=1.587
β Titanium (≦885°C) : body-centered cubic lattice a=3.3065 Å
Latent heat of fusion : 14.5 cal/g Permeability : 1.0001

Technical Data

Corrosion Resistance

Comparison of corrosion resistance between titanium and other metallic materials

Classification	Corrosion medium	Concentration (%)	Temperature (°C)	Titanium	SUS304	SUS316	Hastelloy C
Inorganic acids	Hydrochloric acid	1	25	A	B	A	A
			Boiling	D	D	D	C
		10	25	B	D	D	D
			Boiling	D	D	D	D
	Sulfuric acid	1	25	A	A	A	A
			Boiling	D	D	C	B
		10	25	B	B	B	A
			Boiling	D	D	D	B
	Nitric acid	10	25	A	A	A	A
			Boiling	A	A	A	B
		65	25	A	A	A	B
			Boiling	A	B	B	D
Organic acids	Acetic acid	10	Boiling	A	A	A	A
		60	Boiling	A	B	B	A
	Ossalic acid	10	25	A	C	B	A
		30	Boiling	D	D	D	A
	Formic acid	10	25	B	B	B	B
		25	60	D	C	B	B
	Lactic acid	10	Boiling	A	B	B	B
		85	Boiling	A	D	D	B
Alkali	Sodium hydroxide	10	100	A	A	A	A
		40	Boiling	D	B	B	B
	Potassium carbonate	5	Boiling	A	A	A	A
		20	Boiling	A	A	A	A
Inorganic chlorides	Sodium chloride	25	25	A*	B*	B*	B
			Boiling	A	B*	B*	B*
	Ammlnium chloride	40	25	A*	B*	B*	A
			Boiling	A*	C*	B*	A*
	Zinc chloride	20	Boiling	A*	D	D	D
		50	Boiling	A	D	D	D
	Magnesium chloride	42	25	A*	A*	A*	A
			Boiling	A	A*	A*	A*
	Iron chloride	30	25	A*	D	D	C
			Boiling	A	D	D	D
Inorganic salts	Sodium sulphate	20	25	A	A	A	A
			Boiling	A	A	A	A
	Sodium sulfide	10	25	A	A	A	A
			Boiling	A	B	B	A
	Sodium chlorite	5	25	A	C	C	C
		15	25	A	C	C	C
	Sodium carbonate	30	25	A	A	A	A
			Boiling	A	A	A	A
Organic compounds	Methyl alcohol Carbon tetrachloride	95	25	A	A	A	A
		100	Boiling	A	B	B	B
	Phenol Formaldehyde	Saturate	25	A	A	A	B
		37	Boiling	A	A	A	B
Gas	Chlorine	Dry	25	D	A	A	A
		Humid	25	A*	D	D	D
	Hydrogen sulfide	Dry	25	A	C	B	A
		Humid	25	A	B	A	B
	Ammonium	100	40	A	A	A	A
			100	A	A	A	A
Others	Seawater	-	25	A	A	A	A
			100	A*	B*	B*	A*
	Naptha	-	80	A	A*	A*	A
			180	A	A*	A*	A

A : 〈0.125mm / year B : 0.125~0.5mm / year C : 0.5~1.25mm / year D : 〉1.25mm / year *Local corrosion such as pitting and crevice corrosion resistance

Titanium Welding Features

CP Titanium welding

- Weldability of CP titanium is good in general
- Impurities (O,N) during titanium welding cause changes in the mechanical properties
  ⇨ Blocking atmosphere or shielding gas required (Ar Gas)

- 순티탄의 용접성은 일반적으로 좋습니다.
- 티타늄 용접 중의 불순물(O,N) 은 기계적 물성변화에 원인이 됩니다. ⇨ 대기차단 또는 보호가스 필요 (Ar 사용)

Properties of titanium materials and welds

Impurity content (wt%) by bulk chemical analysis	CP-Ti filler rod	CP-Ti plate
Oxygen	0.189	0.189
Nitrogen	0.011	0.007
Carbon	0.029	0.021
Bend strength, MPa (ksi)	N/A	109 (16)

Source: Struers e-Journal of Materialography, 3/2004

CP Titanium Welding process

- Gas Tungsten Arc Welding(GTAW) : Generally used 가장 많이 활용됨
- Gas Metal Arc Welding(GMAW) : Occur the spatter a lot 스패터 발생 많음
- Plasma Arc Welding(PAW) : Available till 10 mm by 1 pass welding : 10mm까지 1pass 용접가능
- Electron Beam Welding(EBW) : Welding aircraft parts and submarine apply 항공부품 및 잠수정 용접시 적용
- Laser Beam Welding(LBW)
- Friction Stir Welding(FSW)
- Resistance Welding(RW)

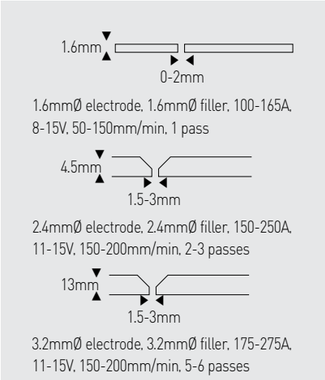
Titanium Welding Features

GTAW(TIG)

- Currently most common process for titanium welding
- Easy welding: Easy control due to low density and high surface tension
- Shielding gas: Ar is mainly used
- Improvement for TIG productivity
  - Hot Wire TIG: Increase speed for weld filler to improve multi-layer welding productivity
  - Activated-TIG (A-TIG): applying specific flux for achieve deeper penetration Before Welding on the surface

- 현재 티타늄 용접에 가장 보편적으로 적용하는 공정.
- 용접용이성 : 낮은 비중과 높은 표면장력은 컨트롤이 용이함
- 보호가스 : 주로 Ar 사용
- TIG의 생산성 개선
  - Hot Wire TIG: 용접부 채움속도를 높혀 다층용접에 대한 생산성 향상
  - Activated-TIG(A-TIG) : 용접 전 표면에 특수한 플럭스를 도포하여 더 깊은 용입 달성

Example welding parameters (1mm=0.04inch)



Suggested welding paraneters for automatic TIG and MIG welding titanium (1/16" = 1.6mm)

	TIG (GEA) without filler			TIG (GTA) with filler			MIG (GMA)			
Gauge, in	0.030	0.060	0.090	0.060	0.090	0.125	0.125	0.250	0.500	0.625
Electrode diameter, in	1/16	1/16	1/16-3/32	1/16	1/16-3/32	3/32-1/8	1/16	1/16	1/16	1/16
Filler wire diameter, in	-	-	-	1/16	1/16	1/16	-	-	-	-
Wire feed rate, ipm	-	-	-	22	22	20	200-225	300-320	375-400	400-425
Voltage, V	10	10	12	10	12	12	20	30	40	45
Amps, A	25-30	90-100	190-200	120-130	200-210	220-230	250-260	300-320	340-360	350-370
Nozzle ID, in	3/4	3/4	3/4	3/4	3/4	3/4	3/4-1	3/4-1	3/4-1	3/4-1
Torch shield, cfh	15Ar	15Ar	20Ar	15Ar	20Ar	20Ar	50Ar+ 15He	50Ar+ 15He	50Ar+ 15He	50Ar+ 15He
Trailing shield, cfh	20Ar	30Ar	50Ar	40Ar	50Ar	50Ar	50Ar	50Ar	60Ar	60Ar
Backing gas, cfh	4Ar	4Ar	5Ar	5Ar	6Ar	6Ar	30Ar	50Ar	60Ar	60Ar
Travel speed, ipm	10	10	10	12	12	10	15	15	15	15
Power supply	DCEN	DCEN	DCEN	DCEN	DCEN	DCEN	DCEP	DCEP	DCEP	DCEP

Source: welding titanium, TWI 1999

Titanium Welding Features

CP Titanium GTAW

- Material : CP Ti Gr.1, 6.35mmt
- Filler wire: CP Ti Gr.1, 4.8phi
- Welding Process : GTAW-DCSP method
- Shielding Gas : Ar
- Weld improvement: V-type, 60 º bevel angle, four-pass fill

Microstructure for welding part

- Coloring Structure : After Etching, various colors appear depending on Ti Oxidation of grain
- Bending strength of welded part reduced from 109MPa to 73.3MPa after welding

- 에칭후 Ti 그레인 산화정도에 따라 여러가지 색이 나타남
- 용접부 굽힘강도는 용접전 109MPa에서 용접후 73.3MPa로 감소

Typical tensile properties of TIG weldments

Alloy	Tensile Strength (MPa)		Proof Stress (MPa)		Elongation (%)	
	Parent	Weld	Parent	Weld	Parent	Weld
Grade 2	460	510	325	380	26	18
Ti-6A1-4V	1000	1020	900	880	14	8
Ti-3A1-2.5V	705	745	670	625	15	12

Fig. weld center before Etching
(after bending test and the microhardness test)

Fig. welding part after Etching
(Ar used)

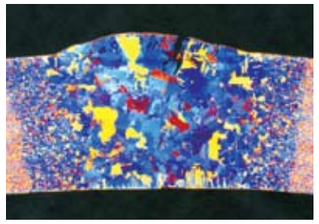


Fig. weld Center microstructure
(Arrow is beta phase)

Global Network

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02. Zhangjiagang Pohang Staninless Steel Co., Ltd.(ZPSS) Zhangjiagang, China
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86-532-8683-7020 86-532-8683-7011

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86-411-8751-5003 86-411-8751-4710

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07. POSCO-Foshan Steel Processing Center Co.,Ltd. Foshan, China
86-133-2283-8326 86-757-8387-1384

08. BX STEEL POSCO Cold Rolled Sheet Co., Ltd. Benxi, China
84-414-782-3705 86-414-782-2002

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19. POSVINA Co., Ltd. Vietnam
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21. Myanmar POSCO Steel Co., Ltd. Myanmar
95-1-638-304 95-1-365-418

22. POSCO(Thailand) Co., Ltd. Thailand
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23. The Siam United Steel Co., Ltd Rayong, Thailand
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91-20-5602-7012 91-2114-308-146

25. POSS Delhi Steel Processing Centre Pvt. Ltd. Delhi, India
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26. POS-Hyundai Steel Manufacturing India Private Limited. Chennai, India.
91-44-2715-6457 91-4111-256-458

27. POSCO-India Pvt. Ltd. Buba, India
91-674-230-3690 91-674-230-0058

28. POSCO Japan Co., Ltd. Tokyo, Japan
81-3-3546-0924 81-3-3546-6519

29. POSMMIT Steel Centre Sdn., Bhd. Malaysia
60-3-6092-5200 60-3-6092-0382

30. PT. POSMI Steel Indonesia Indonesia
62-21-8998-1157 62-2-898-0775

31. POSCO Australia Pty. Ltd.
62-21-8998-1157 62-21-898-0775

32. Nickel Mining Company New Caledonia
687-28-0488 687-28-1567

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