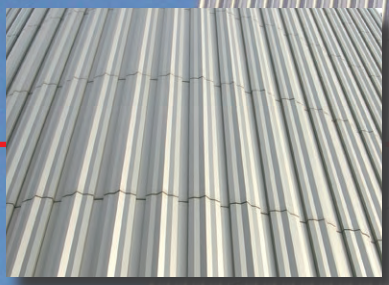
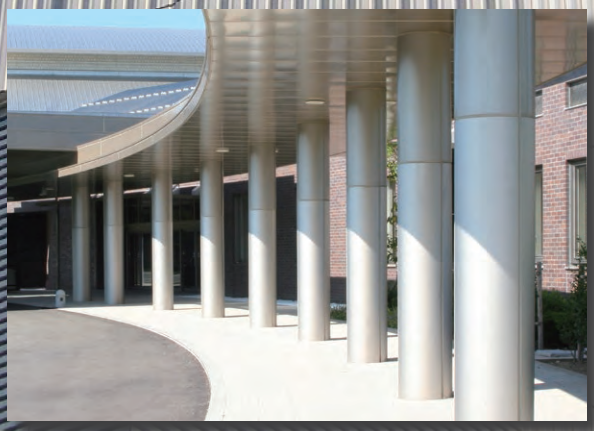
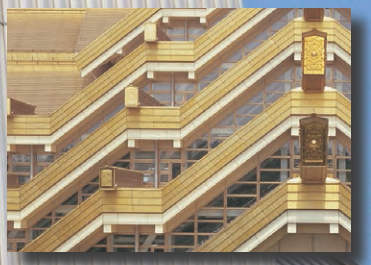
S·Tajima

ARCHITECTURAL METALS



Titanium Products for Architecture





SANWA TAJIMA CORPORATION

Titanium, the strongest metal, capable of withstanding severe natural environments protects the exterior of architecture, and enhances the long cycle characteristics of building materials.

Titanium with its superior corrosion resistance is hardly corroded under natural environments, and regarded as an environmentally-resistant and -friendly optimal building material for its lightness and low thermal expansion characteristics. Through the advantage of these characteristics, titanium is widely used in harsh environments such as coastal and industrial areas.
Based on the technical experiences cultivated in the long history, Sanwa Tajima has researched the characteristics of titanium as a building material and developed the optimal processing and engineering technologies to achieve outstanding performances in many architectural buildings.

Titanium was discovered as an element in 1790,
and given the name after Titans (giant) in Greek mythology.
The industrial production of titanium began around 1946.
Due to its excellent characteristics such as light weight, strength, and corrosion resistance, titanium began to be applied in the fields of aerospace, chemistry, electric power, etc. Now its demand has expanded even to architecture, civil engineering, medicine, and consumer products.
The application of titanium to construction materials started in the 1970s.
As a material of industrial design with unparalleled corrosion resistance performance, the application range of titanium expanded from the highly corrosive environments including seaside areas to permanent architectural structures (museums, shrines and temples, etc.).
Recently, it has also begun to be widely used for general architecture.
In the future, the demand for titanium building materials is expected to further expand.


Titanium sponge

Basic characteristics of titanium architectural materials

Corrosion resistance

Titanium is not corroded in the use of building materials due to its far superior corrosion resistance. However, among practical metal materials, titanium has a higher electric potential. Therefore, if titanium comes into contact with a base metal such as copper alloy and aluminum in an electrically conductive solution, corrosion on the surface of the base metal may be accelerated (Galvanic corrosion).
When titanium comes into contact with austenitic stainless steel at relatively low temperature, there is generally no problem of galvanic corrosion due to the smaller potential difference between titanium and the stainless steel.

High strength

Having almost the same level of strength as steel, titanium is a metal with high specific strength (strength-to-weight ratio). As building material, JIS Type 1 is mainly used, due to its high workability.

Specifications for pure titanium for industrial use (JIS Type 1)

Chemical composition						Mechanical properties (thickness:0.5-15 mm, excl.)			Bend Test (thickness:0.5-5 mm, excl.)	
H	O	N	Fe	C	Ti	Tensile strength (N/mm²)	Proof stress (N/mm²)	Elongation (%)	Bend angle	Inside radius
≦0.013	≦0.15	≦0.03	≦0.20	≦0.08	Remainder	270 - 410	≧165	≧27	180°	Thickness by 2

(Source:Nippon Steel Corporation)

Light weight

The specific gravity of titanium is 4.51, which is 60% of that of steel, 50% of copper, and 1.7 times higher than aluminum. Its light weight means a small load to a structure and makes construction work easier. Depending on the usage, corrosion margin is not necessary, which makes weight reduction possible.

Low thermal expansion

The coefficient of linear thermal expansion is half compared with stainless steel and copper, and one third compared with aluminum. The value is close to that of glass or concrete, so titanium can be used together with them. Titanium does not expand/contract much accompanying changes in temperature, which is advantageous for long-size applications.

Excellent aesthetic qualities

The base metal itself has a silver color that is tastefully austere and calm, presenting a sense of excellent quality. In addition, various colors can be produced using the anodic oxidation method.

Comparison of physical properties between titanium and other metals

Item \ Metallic materials	Titanium	Stainless steel SUS 304	Stainless steel SUS 316	Iron	Copper	Aluminum
Melting point ℃	1,668	1,398～1,453	1,398～1,453	1,530	1,083	660
Specific gravity	4.51	7.93	8.0	7.9	8.9	2.7
Thermal expansion coefficient ×10^{-6}／℃(20~100)	8.4	17.3	16.0	12.0	17.0	23.0
Thermal conductivity cal/cm²/sec/℃/cm	0.041	0.039	0.039	0.150	0.920	0.490
Electric resistance μΩ-cm	47	72	74	9.7	1.7	2.7
Young's modulus kg/mm²	10,850	19,300	19.300	21,000	11,000	7,050

(Source:Nippon Steel Corporation)

Officially approved as a non-conbustible materials

(Minister of Land, infrastructure and Transporter Certification No."NM-8596")

Workability

◆Forming

Due to its easy processability in bending and press-forming at room temperature, titanium is generally used as a material for formed products. The forming methods applied are press-forming techniques such as bending, deep drawing, stretch forming, and spinning, as those applied for stainless steel.

(1) Bending

■Spring-back of titanium tends to be larger than that of other metals. Among pure titanium materials, the soft materials exhibit the same level of spring-back as SUS304, but the spring-back becomes larger as the strength of the material is increased. One effective method for reducing spring-back is to bend the material at an angle allowing the estimated spring-back amount, or to use a die set corresponding to the sheet thickness to press the material until it contacts with the die set completely.

(2) Pressing

■Press-forming is often carried out at room temperature and titanium is mainly used as a forming material.

■The deformation conditions in press forming include stretch forming and deep drawing, among which deep drawing properties of pure titanium are superior to its stretch forming properties.

◆Joining

Joining methods of titanium material include welding, brazing, pressure-welding, diffusion bonding, and mechanical bonding such as bolt-nut bonding, the same as those used for other materials.

◆Welding

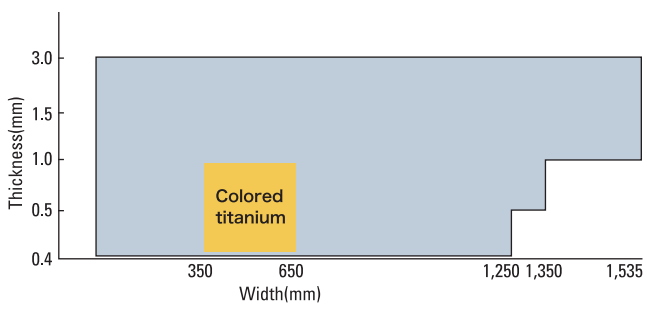
■Resistance weldings such as stud welding of the panel, seam and spot welding of the roof are also applied to titanium building materials. These weldings can be carried out under atmospheric conditions with a welder used for ordinary stainless steel.

■Titanium has excellent welding properties, causing a little change in the mechanical properties or corrosion resistance in the welded area. However, titanium has a high affinity for oxygen and nitrogen gases at high temperature, and a reaction of titanium with these gases may cause hardening or embrittlement which could lead to a decrease in ductility and a generation of blowholes in the welded area. Therefore, arc welding of titanium material should be performed in an inert gas or a vacuum atmosphere. In addition, the welding material and the electrode as well as the welding environment should be cleaned thoroughly.

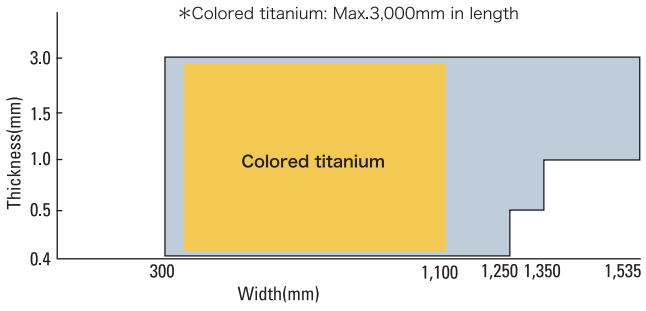
Range of availability of our products (Cold rolled sheets)

(1) Material size

Coils

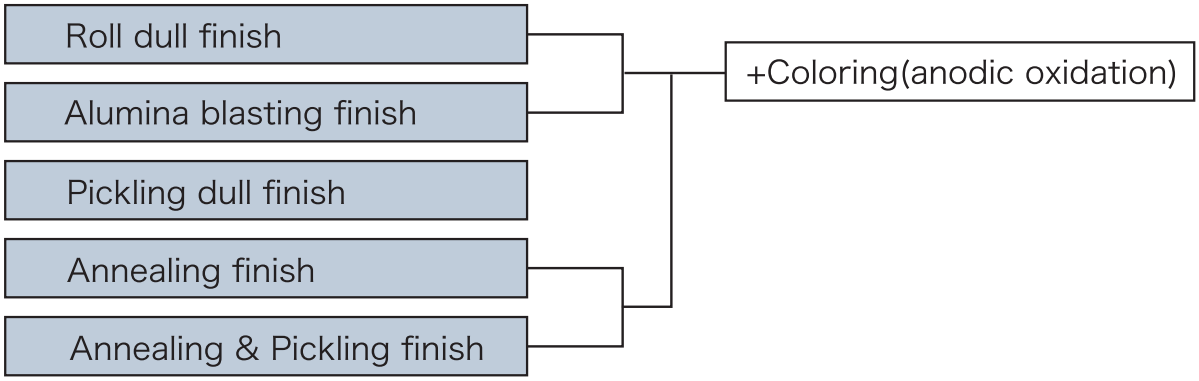


Sheets



Surface finish

Sanwa Tajima has collaborated with leading titanium manufacturers for producing an extensive range of metal finishing services and color pattern designs to create optimal design of products.

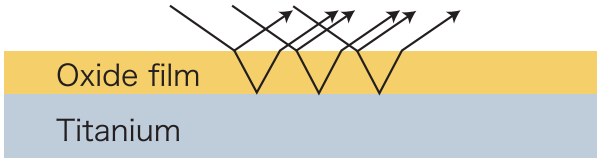


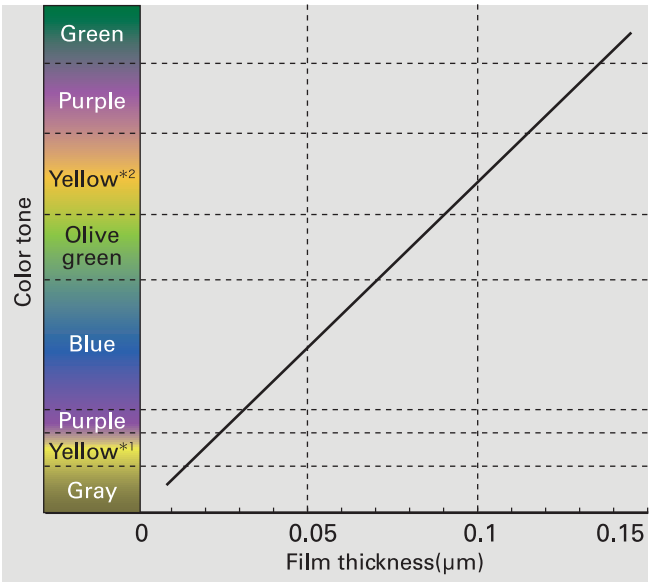
Principle of coloring of titanium

Coloring (Anodic oxidation)

Oxide film formation on the surface by anodic oxidation treatment produces beautiful, highly saturated colors according to film thickness through the interference effect of light.

Principle of interference color





(Source: Nippon Steel Corporation)

In using colored titanium, please understand the following points.

① **Due to coloring by light interference, colors may look different depending on the season, climate, period of time, angle of viewing, etc.**
Some colors may look like a totally different color when it is raining. This is a characteristic of an interference color.

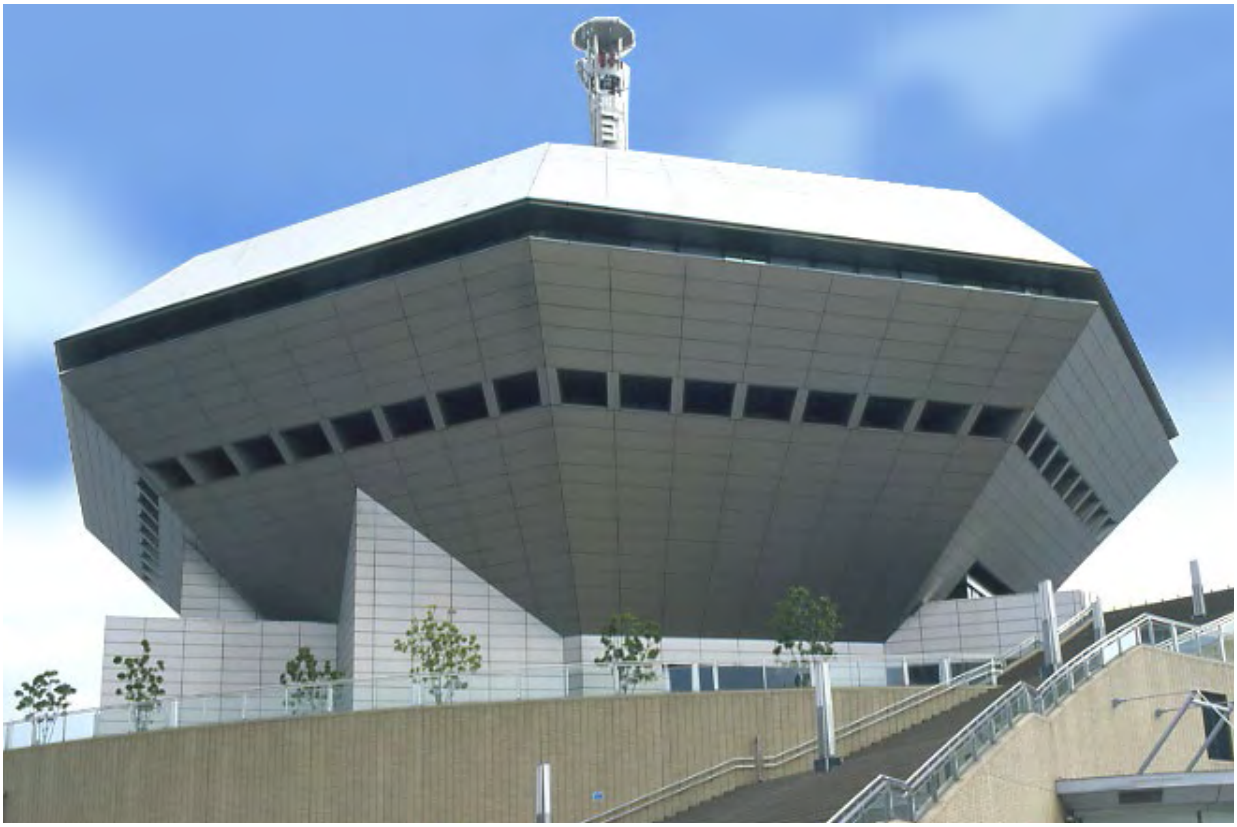
② **Because the oxide film of the titanium surface is very thin, the color is strongly influenced by the surface condition of the base metal.**
When the surface finishing is different, the colors may look different even if the thickness of the oxide films is the same. Also, even if the finishing is the same, each coil reflects the subtle color difference of the base.
As such, we have our customers check the color using a sample, and we also color part of the material that will be actually used and have them check it. Furthermore, when multiple coils are used, we manage the application to prevent color irregularity.

③ **Depending on the climate condition, the oxide film may grow and the color may change.**
Among our products, we have a case in which we delivered the colored titanium with a thin oxide film of yellow *1, and the film grew and the color changed into purple in about ten years.
This happened because the oxide film was extremely thin in order to produce this color, and the color range was narrow.
If you want yellow, we recommend yellow *2, whose oxide film is relatively thick and whose color range is relatively wide.
However, please understand that the color of the colored titanium may change.

* The hue changes according to the changes in film thickness, from gray to yellow, purple, blue, yellowish green, yellow, purple, and green.

④ **Like other metals, titanium gets stains and finger prints.**
The stain may make the color appear different, but the stain can be removed by using a cleaning agent. If the stain is left as is, however, it may not be easily removed later.
For cleaning, a neutral detergent (threefold dilution) is recommended. Use of a cleaning agent containing strong acid may dissolve the oxide film on the surface, making it impossible to recover the original color.

On the cutting edge of our times, titanium is an environmentally friendly metal.

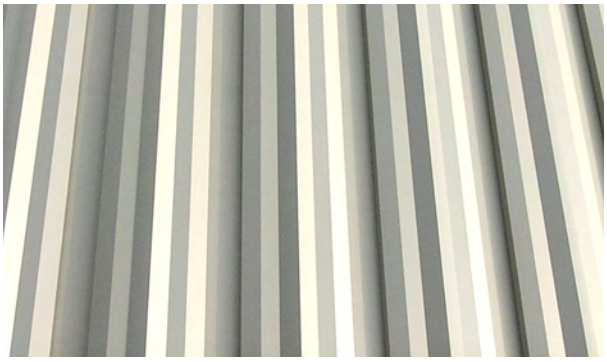


Minatomachi River Place

Panel Curtain Wall
Surface : Super Annealing and Pickling Roll emboss
Thickness : 0.6mm
Weight: 33 tons
Archtects: Yasui Architects & Engineers
Constractor : Kajima Corporation
Address : Osaka
Completion : 2002

Showa-kan Peace Museum

Panel Curtain Wall
Surface : Alumina blust finish
Thickness : 1.5mm
Weight : 56 tons
Archtects : K.Kikutake Architects
Constractor : Takenaka Corporation
Address : Tokyo
Completion : 1998



Sanuki Kodomonokuni Museum

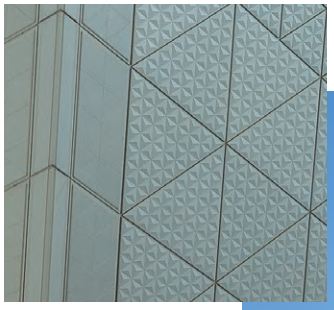
Dome Panel Curtain Wall
Surface : Super Annealing and Pickling finish
Thickness : 1.54mm
Weight : 8 tons

Archtects : Azusa Sekkei Co.,Ltd.
Constractor : Asunaro Aoki Construction Co.,Ltd.
Address : Kagawa
Completion : 1994

Tokyo Big Sight

Panel Curtain Wall, Ceiling
Surface : Annealing and Pickling press emboss
Thickness : 0.6, 1.5mm
Weight : 140 tons

Archtects : Axs Satow Inc.
Constractor : Hazama Corporation
Address : Tokyo
Completion : 1993



Nihon Life Insurance Naha Bldg.

Panel Curtain Wall
Surface : Annealing and Pickling finish
Thickness : 0.6mm
Weight : 7 tons
Archtects : Obayashi Corporation
Constractor : Obayashi Corporation
Address : Okinawa
Completion : 1987

Daido Life Insurance Naha Bldg.

Panel Curtain Wall
Surface : Annealing and Pickling finish
Thickness : 0.6mm
Weight : 5 tons
Archtects : Obayashi Corporation
Constractor : Obayashi Corporation
Address : Okinawa
Completion : 1993

Sekai Mahikari Bunmeikyodan Sushin Daishinden

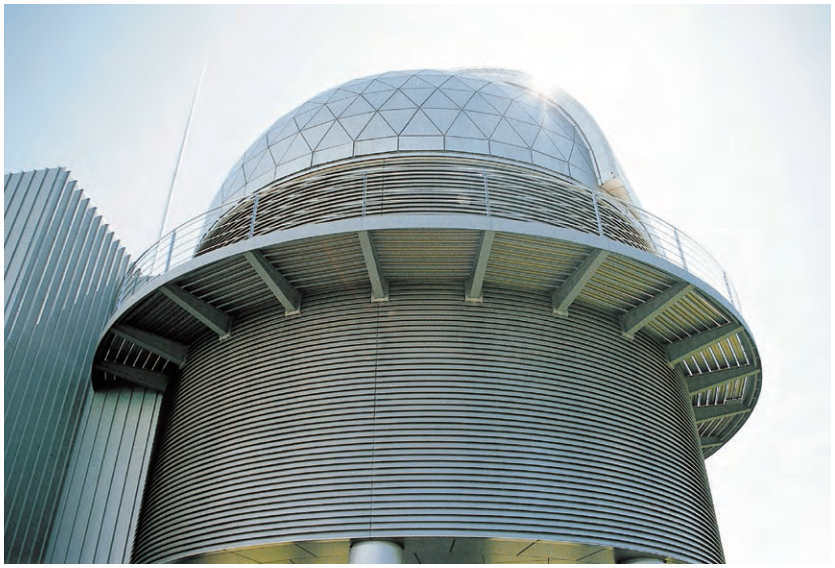
Roof Panel & Ornaments Panel
Surface: Mirror, Gold anodized finish
Thickness : 0.6, 1.0mm
Area : 18,000㎡
Archtects : Maniwa Sekkei
Constractor : Kajima Corporation
Address : Shizuoka
Completion : 1993

Yokoshi Tomonokai, Suza

Flat Roof
Surface : Picking and Roll Dull
Thickness: 0.6, 1.2mm
Area : 9,400㎡
Archtects : Maniwa Sekkei
Constractor : Tokyu Construction Co.,Ltd.
Address : Ibaragi
Completion : 1998
Photo : Nippon steel Corporation

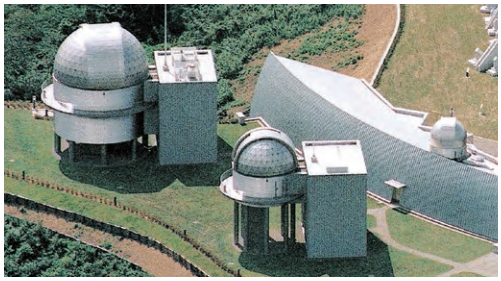
Kannon-ji Temple

Column Cover & Beam Cover Panel
Surface : Bead blust finish
Thickness : 0.6, 1.0mm
Archtects : Taisei Corporation
Constractor : Taisei Corporation
Address : Tokyo
Completion : 2007



Gunma Astronomical Observatory

Roof Panel
Surface : Picking and Roll Dull
Thickness : 0.4, 2.0mm
Area : 340㎡
Archtects : Arata Isozaki & Associates
Constractor : Ikehara Corporation,
Tsukui Corporation
Address : Gunma
Completion :1999
Photo : Nippon steel Corporation



Komatsu Kaga Memorial Hall

Columun Cover Panel
Surface : Annealing and Pickling finish
Thickness : 2.0mm
Archtects : Yamashita Sekkei Inc.
Constractor : Hazama Corporation
Address : Ishikawa
Completion : 2011

Sea-ice Observation Tower in Monbetsu Port

Panel, Sash, Bridge Roofing
Surface : Roll Dull, Hairline finish
Thickness : 1.0mm
Area : 2,500㎡
Archtects : Ishimoto Architectural & Engineering Firm. Inc.
Constractor : Penta-ocean Construction Co.,Ltd.
Address : Hokkaido
Completion : 1996
Photo : Nippon steel Corporation

Okinawa Prefectural Bldg.

Entrance Canopy Panel
Surface : Annealing and Pickling finish
Archtects : Kisho Kurokawa architect & associates
Constractor : Taisei Corporation
Address : Okinawa
Completion : 1990

Ito-Yokado Yachiyodai Store

Monument (Lighting tower)
Surface : Hairline finish , Anodized finish
Address : Chiba
Completion : 1994

Shin-Nikko Bldg.

Entrance Panel
Surface : Gold anodized finish
Archtects : Nihon Sekkei
Constractor : Kajima Corporation
Address : Tokyo
Completion : 1988

Cleaning method

①Removing adhesive remaining on the protective film
Wipe off adhesive using a sponge or cloth moistened with alcohol, benzene, or thinners, or a mixed solution consisting of alcohol and toluene or benzene (in sequence from the weakest acting liquid). It is important to wipe the surface of the titanium with an unused, clean cloth before these solvents have dried.

②Removing contamination due to finger marks or dirt from the hands
In almost all cases, you can remove contamination using a neutral detergent or soapy water. If you are unable to do so, use an organic solvent (alcohol, benzene, etc.).
In this case, you must observe the abovementioned precautions.

③Removing contamination due to roofing material and concrete
Wipe away contamination using a sponge or cloth moistened with a 5% solution of hydrochloric acid in water.

④Removing contamination due to zinc from scaffolding material
Wipe away contamination using a sponge or cloth moistened with a 15% solution of nitric acid in water.

⑤Removing contamination due to rainwater or dust
In almost all cases, you can wipe away contamination using a sponge or cloth moistened with a neutral detergent or an alkaline detergent. If you are unable to do so, you may be able to remove the contamination by applying a cleaner containing an abrasive to soft cloth, and then rubbing gently and uniformly.

The above is a description of the various cleaning methods.
In all cases, thoroughly wash the surface with water after cleaning, and ensure that no traces of cleaning agent remain.

⑥Removing contamination from colored titanium
Of the abovementioned cleaning methods, do not remove contamination using hydrochloric acid, nitric acid, or a cleanser, because the film that produces the color will be affected, preventing the surface from being restored to its original condition.

Precautions for cleaning

① There are various causes of contamination and discoloration of titanium building material, so it is necessary to use a cleaning method that matches the particular circumstances. Do not abruptly start cleaning the entire surface. First carry out test cleaning on a small area, and check the removal of the contamination or discoloration. If the result of the test is satisfactory, use that method to clean the entire surface.

② When using a cleaning implement such as a cloth, sponge, loofah, scrubbing brush, cleaning brush, fire nylon pad, and so on, be sure to move it in the direction parallel to the polishing marks on the titanium. Also, move your hand in such a way as to apply a uniform force as far as possible. If you move the cleaning implement in circles, the contamination will be difficult to remove, and also the luster lines will be erased and color irregularity will occur, marring the appearance of the titanium surface.

③ Even in the case of fairy stubborn contamination, avoid using a coarse polishing agent, sandpaper, steel wool, or the like. Not only will this erase the luster lines on the titanium, but also the surface will become scratched, which may cause it to become contaminated.

④ When using a commercially available cleaning reagent to remove contamination from the surface of titanium, clean not only the contaminated part but also the vicinity as well. If you clean the titanium surface only partially, irregular color will occur, marring the appearance of the titanium.

⑤ When cleaning building tiles, marble, aluminum, and so on, if the cleaning reagent that you used splashes on the surface of the titanium, be sure to wipe away the reagent with a damp cloth. If you leave the reagent on the titanium, discoloration may occur.

⑥ In the case of colored titanium, consult with the manufacturer prior to use.

(Source: Japan Titanium Society)

S-Tajima ARCHITECTURAL METALS

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All Sanwa Tajima offices are capable of providing a full range of technical support services including assistance during initial project design phases, complete drafting and engineering work, abrication from the widest range of quality materials and finishes, and job site supervision by trained personnel.
As all cost estimates and delivery schedules are quoted on an individual basis, please contact your nearest Sanwa Tajima's group office for complete information.

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