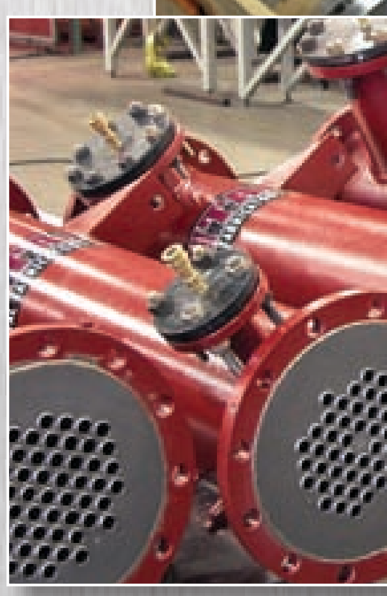
CONDENSERS FOR

PHARMACEUTICAL

APPLICATIONS



TITAN

METAL FABRICATORS INC.

PROJECT MANAGEMENT

TITAN's unique project management system gives the responsibility for the sales estimate, design and engineering management, procurement and supervision of the actual manufacturing process to one person. The system fosters an intimate knowledge of each project's design, quality and delivery requirements, ensuring that it meets the expectations of each individual customer.

SALES ENGINEERING

Our experienced sales engineers give their full attention to customers' processes and applications. Concentrating on the way design details reflect customers' needs is a crucial element in the success of any project. TITAN utilizes custom designed estimating software to quickly prepare accurate cost estimates and custom proposals to meet your project needs.

ENGINEERING AND DESIGN

As one of the world leaders in the design and fabrication of corrosion resistant heat transfer equipment for use in extremely hostile process environments, TITAN utilizes state-of-the-art computer software to thermally, mechanically and graphically design its heat exchangers to the applicable ASME, PED or TEMA standards.

TITAN

METAL FABRICATORS INC.

Founded in 1998 by industry experts with decades of experience in the design and fabrication of corrosion resistant equipment, TITAN is dedicated and uniquely qualified to give you the confidence and peace of mind that you made the right decision.

MANUFACTURING

Extensive industry experience allows TITAN to pay particular attention to the specific details involved in the manufacture of reactive metal equipment. Knowing how to machine, form and weld tantalum, niobium, zirconium and titanium is imperative. Our comprehensive knowledge of manufacturing preparations and procedures allows TITAN to fabricate reactive metal equipment in the most efficient way possible.

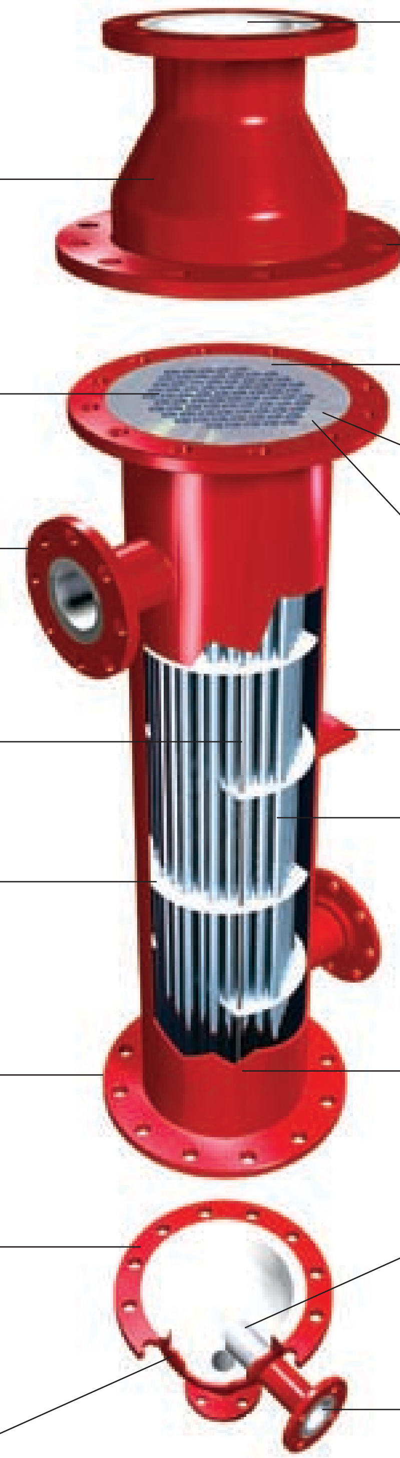
QUALITY ASSURANCE

TITAN pays particular attention to quality. In addition to our own stringent inspection process, we use AWS, ASTM, ASME, PED and TEMA standards as fabrication guidelines, allowing the equipment we manufacture to meet or exceed our customers' highest expectations. We encourage customers to personally inspect our workmanship at our plant during the fabrication process.

RESEARCH AND DEVELOPMENT

Whether it's an innovative new welding process to increase quality while decreasing fabrication time, or extensive testing to find the material that best suits your particular application, TITAN is constantly striving to produce the most rugged, cost-effective equipment possible. We have the dedication, expertise, flexibility and resources to develop whatever technology is necessary to increase quality and reduce costs for our customers.

FEATURES OF A TITAN
TANTALUM PHARMACEUTICAL CONDENSER



Glass-Lined or Tantalum Bonnets
Bonnets available in glass-lined steel or tantalum-lined steel to suit your operational preferences.

Hydro-Expanded Tube to Tubesheet Joint
Hydraulic expansion of the tube to tubesheet joint produces the strongest and most consistent seal.

Dual Containment Tubesheet Design
Eliminates the potential of cross-contamination of the process and service fluids.

Flush Face Tubesheet Design
Flush face tubesheet design allows for full drainability, greatly decreasing flush times and increasing production.

Liquid–Vapor Separator
Separates the non-condensables from the liquid condensate stream.

Helium Mass Spectrometer Leak Testing
Extremely sensitive leak detection system used to find the smallest defect.

EVOLUTION OF PHARMACEUTICAL CONDENSER DESIGNS

During the 1990s many outside factors influenced the proper design of overhead condensers for pharmaceutical installations. The FDA, EPA, product costs, downtime costs, and global competition have all affected today's condenser designs.

The FDA has been a major factor with validation, contamination and CGMP regulations.

Today's condensers need to be totally non-contaminating. This means there can be no way for the service side fluid to contaminate the process. Any possible leak must have an external leak path.

The chlorinated organics produced are highly corrosive. The condensers must handle these compounds with zero corrosion as products of corrosion can be toxic and catalytic. The condensers must fully drain as any liquid holdup can increase flush times or contaminate the next batch.

The EPA has also been a major factor as the push for decreased emissions has lowered condensing temperatures. More of the light ends and volatile solvents are taken out of the vent stream when the condensing temperature is reduced. This has dictated a change to silicone based heat transfer fluids as the service side cooling medium. These fluids are very difficult to seal and has led to fully welded condenser designs.

Global competition, the cost of pharmaceutical products and the cost of downtime has demanded that the condensers be rugged, dependable and work all of the time. The cost of maintenance, spare parts and above all downtime can no longer be tolerated. Downtime means no product is being manufactured, which is the largest cost of all.

Today's condensers must be . . .

- contamination-proof
- corrosion-proof
- fully drainable
- compatible with silicone based heat transfer fluids
- fully welded tube bundle
- rugged and maintenance free

Tantalum pharmaceutical condensers have met all of these challenges and are now the state of the art.

These companies now use tantalum in most of their installations:

- Abbott Laboratories
- Avecia
- Aventis Pharmaceuticals
- Bayer Corporation
- Boehringer Ingelhiem
- Bristol Myers Squibb
- Eli Lilly & Co.
- Glaxo SmithKline
- Hoffman-LaRoche
- Merck & Co.
- Novartis
- Park Davis
- Pfizer
- Pharmacia
- Schering Plough
- Yamanouchi Pharma

MATERIAL COMPARISON

	TANTALUM	IMPREGNATED GRAPHITE	HASTELLOY
Production Downtime	None	Often	Seldom
Maintenance Costs	None	Very High	Little
Capital Costs	High	Low	Medium
Product Purity	No Contamination	Graphite Flakes	Heavy Metals Contamination
Corrosion	None	Yes	Yes
Drainability	Complete	Liquid Holdup	Complete
Heat Transfer Fluid Compatible	Yes	No	Yes
Potential Catalyst to Process	No	No	Highly Caustic
Dual Containment Design	Standard	Impossible	Optional

TANTALUM—THE OBVIOUS CHOICE

Tantalum is a refractory metal, as its melting point is 5425˚F (2996˚C). It is a tough, ductile metal which can be formed into almost any shape. It is used in corrosion resistant applications for environmentsno other metal can withstand. Tantalum's major limitation is its reactivity with oxygen and nitrogen in the air at elevated temperatures.

CORROSION RESISTANCE

Tantalum is the most corrosion resistant metal in common use today. It is inert to practically all organic and inorganic compounds. Its corrosion resistance is very similar to glass, as both are unsuitable for use in hydrofluoric acid and strong hot alkali applications. For this reason tantalum is used with glass lined steel reactors as patches, dip tubes, piping and, of course, overhead condensers.

Tantalum is inert to sulfuric and hydrochloric acid in all concentrations below 300˚F. Attack up to 400˚F is not significant and it is in common use up to 500˚F. The main problem in pharmaceutical overhead condensers is often not the acids themselves, but the chlorinated organics they produce. Tantalum has proven itself to be totally inert. Some condenser applications have been in continuous use for over 40 years in multi-product research environments without so much as a gasket change.

NO PRODUCTION DOWNTIME

Tantalum condensers are exceptionally durable with fully welded designs, and will perform for many years without any lost production time for repairs or replacement. The traditional material of construction (graphite) is a fragile material susceptible to mechanical damage and frequent breakdowns. The greater failure rate of carbon block condensers results in higher maintenance costs, scrapped product and lost production. Long term cost comparisons demonstrate that despite higher capital costs, tantalum is more economical than graphite. The break-even point in comparing tantalum to graphite has been documented to be about eighteen months. The tantalum advantage will then continue for decades.

PRODUCT PURITY

Pharmaceutical product purity is mandated by stringent regulation at the federal, state and local levels. Resin impregnated graphite often fails to meet these requirements. As the impregnated graphite surface heats up and cools down, the difference between the thermal expansion rates of the graphite and the phenolic (or Teflon) impregnant creates stress. This erodes the graphite surface in much the same way that water's freeze-thaw cycle erodes a concrete surface. As a result, minute graphite particles and resins flake into the process batch, contaminating the end product.

The nickel based alloys have an even more severe problem. The corrosion resistance of these alloys comes from their high nickel and molybdenum content. They corrode slowly and predictably and are used with thicker cross sections to allow for this corrosion. Such corrosion produces heavy metal contamination including nickel, cobalt, iron, silicon, sulfur and molybdenum. These contaminants can be toxic and a catalyst in your process.

Tantalum is corrosion resistant in the most severe acid environments, particularly those involving corrosive inorganics at elevated temperatures, and is completely resistant to chlorinated organics. This superior corrosion resistance which results from an oxide film naturally occurring on tantalum's surface, meets the pharmaceutical industry's strictest quality control standards.

LONGER EQUIPMENT LIFE

The naturally occurring oxide film on tantalum's surface makes it resistant to corrosion in the most severe acid environments and completely resistant to organic compounds. This equates to much longer service life and maintenance-free dependability.

STANDARD DESIGN PHARMACEUTICAL CONDENSERS

	SHELLSIDE	TUBESIDE
Design Pressure PSI (BAR)	150/FV (10.34 BAR/FV)	150 (10.34 BAR/FV)
Max. Design Temp. ˚F (˚C)	400˚F (204.4˚C)	400˚F (204.4˚C)
Min. Design Temp. CS/SS—˚F (˚C)	–20˚F/–150˚F (–28.9˚C/–101.1˚C)	–20˚F/–150˚F (–28.9˚C/–101.1˚C)
Design Corrosion Allowance: IN (MM)	.0625" (1.58 MM)	0" (0 MM)
Materials of Construction	Carbon Steel or Stainless Steel	Tantalum with $2\frac{1}{2}$% W
Hydrotest Pressure PSI (BAR)	195 (13.44 BAR)	195 (13.44 BAR)

THERMAL SIZING OF OVERHEAD CONDENSERS

The proper sizing of an overhead condenser used with a glass-lined steel reactor is always difficult. The problem is that during the life of the reactor, it is frequently used for many different production campaigns. Even during the same production cycle, the reactor and condenser may be asked to perform properly using many different operating chemicals, temperatures and pressures.

The simple concept of *(heat in) equals (heat out)* makes the thermal sizing process possible. The heat input into the reactor through its jacket, together with the heat input from the hot fluids or reactions, needs to be taken out by the condenser. It is a simple matter to determine the worst-case operating conditions. The condenser needs to be sized using the lowest boiling point conditions. The mean temperature difference across the reactor heating surface is the highest when boiling at low temperatures. This puts the maximum amount of heat into the reaction. This is also the point where the mean temperature difference in the condenser is the lowest, maximizing the surface area.

DO THE MATH FOR YOURSELF

For example purposes, let's assume the following conditions for the design of a tantalum condenser for pharmaceutical use:

PROCESS CHEMICAL INFORMATION	
Process Chemicals	Organic Solvents
Process Pressure	Full Vacuum
Non-Condensables	Low

TANTALUM CONDENSER INFORMATION	
Condenser Cooling Medium Temperature	0˚F
Heat Transfer Rate (From Figure A)	100 Btu/Hr ˚F

GLASS-LINED STEEL VESSEL INFORMATION	
Volume	300 Gallons
Jacket Heat Transfer Area	53 Sq. Ft.
Jacket Heating Medium Temperature	300˚F
Boiling Point Of Liquid In Vessel	100˚F
Heat Transfer Rate	50 Btu/Hr ˚F

Use the basic heat transfer equation to solve for the heat output of the vessel:

$$Q = A \times MTD \times U$$

Q = *Heat Load (BTU/HR)*
A = *Heat Transfer Surface Area (Sq. Ft.)*
MTD = *Mean Temperature Difference (˚F)*
U = *Overall Heat Transfer Coefficient*

$$Q = (53\ \text{Sq. Ft.}) \times (300^\circ F - 100^\circ F) \times 50$$

$$Q = 530{,}000\ \text{BTU/HR}$$

Now use the basic heat transfer equation to solve for the tantalum condenser surface area:

$$A = \frac{Q}{MTD \times U}$$

$$A = \frac{530{,}000\ \text{BTU/HR}}{(100^\circ F - 0^\circ F) \times 100}$$

$$A = 53\ \text{Sq. Ft.}$$

(Required Surface Area of Tantalum Condenser)

For this example, the ratio of vessel jacket heating area to condenser surface area is 1:1. Indeed, many pharmaceutical plants use this as a rule of thumb. You can estimate the size of a tantalum condenser using these charts and tables. A glass-lined steel reactor will always have a "U" value of 50 or lower. The condenser "U" value can be estimated from Figure A.

FIGURE A

APPROXIMATE OVERALL "U" VALUES FOR TANTALUM CONDENSERS

HOT SIDE	COLD SIDE	OVERALL "U"
Steam (Pressure)	Water	350 to 750
Steam (Vacuum)	Water	200 to 600
Saturated Organic Solvents (Atmospheric)	Water—Brine	100 to 200
Saturated Organic Solvents (Vacuum / Low Non-Condensables)	Brine—HTF	50 to 120
Organic Solvents (Atmospheric / High Non-Condensables)	Brine—HTF	20 to 80
Organic Solvents (Vacuum / High Non-Condensables)	Brine—HTF	10 to 50

If you already have an installation, another way to approach the condenser sizing is to analyze your existing condenser. Surface areas of impregnated graphite or borosilicate glass can simply be converted to tantalum using a ratio. See the table below for details.

FIGURE B

RATIO OF SURFACE AREA OF TANTALUM CONDENSERS TO IMPREGNATED GRAPHITE AND GLASS CONDENSERS

CONDENSER TYPE	HIGH VACUUM PROCESS	SLIGHT VACUUM / POSITIVE PROCESS
Impregnated Graphite	90%	33%
Borosilicate Glass	60%	20%

* Please note these ratios are to be used as a check to other more reliable methods of thermal sizing. Please call us for assistance.

Tantalum condensers are more thermally efficient than impregnated graphite, PTFE or glass because of many factors, including fouling factors and heat transfer wall resistance. This increased thermal efficiency varies, however, depending upon the overall "U" value of the operation. The best method is to determine your worst-case condition and then call us. We will use our state-of-the-art modeling software to design your condenser.

EP

Corrosion resistant process equipment for the **Chemical Processing, Pharaceutical** and **Steel Industries**

OIL & GAS

Nickel Alloys, Stainless and Titanium Heat Exchangers and Vessels for **Refinery and LNG Applications**

P&A

Anodes, Baskets, Steam Immersion Coils and Auxiliary Anodes for the **Plating and Anodizing Industry**

THE TITAN FAMILY

EMD

Anodes and immersion coils for use in **EMD Production**

MARINE

Corrosion resistant and high performance Titanium products for the consumer and industrial **Marine Industry**

TITAN Metal Fabricators was created to bring innovative reactive metal products to industry to solve corrosion problems.

TITAN designs and fabricates corrosion resistant products using the reactive metals—Tantalum, Titanium, Zirconium, Niobium and Hastelloy—in order to reduce or eliminate corrosion in highly aggressive applications.

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