

# TIMETAL<sup>®</sup> PGMA<sup>™</sup>

Platinum Group Metal Appliqué



*First in Titanium Worldwide*



Delivering common-grade titanium with uncommon corrosion protection

# It's proven.

## Tested, applied and confirmed.

### High-grade titanium performance with everyday-grade efficiencies.

Palladium prices have more than quadrupled since 2009, and prices are forecast to continue rising. Yet, for challenging corrosive environments typical in chemical process plants, there seems no way around this expense – nothing less than grade 7 corrosion resistance will do.

But now you have an alternative that nearly eliminates your exposure to palladium pricing volatility. From the world leader in titanium metal product manufacturing, TIMET brings the chemical process industry an innovative way to extend the corrosion resistance of commercially pure titanium.

TIMETAL PGMA (Platinum Group Metal Appliqué) patch technology is the only low-cost alternative to extend titanium corrosion resistance. For nearly a decade, PGMA has delivered enhanced protection from pitting, stress fractures, hydrogen-induced corrosion fatigue, acid attacks and other forms of aggressive corrosion of commercially pure titanium in different environments around the world. Most recently, PGMA has solved corrosion challenges in Australia (nickel recovery) and the Kingdom of Jordan (bromine chemicals production).

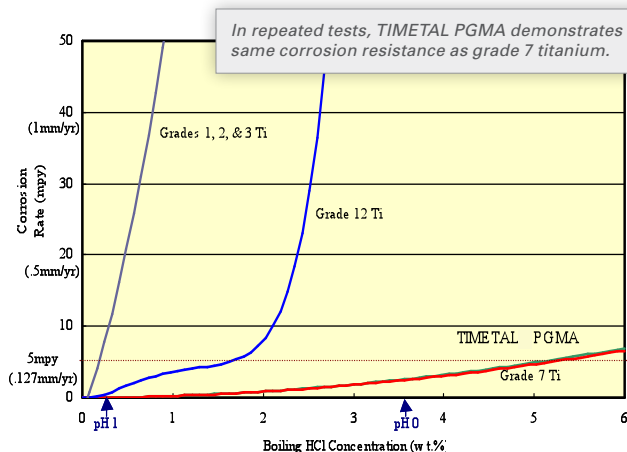


Albemarle Corp. (Jordan) replaced grade 7 titanium sections of bromine distillation columns with lower-cost, grade 2 titanium enhanced with TIMETAL PGMA patches in early 2008. The vessel has since shown no signs of corrosion.

### The Science Beneath the Patch

Titanium is very reactive and readily forms an oxide film after exposure to oxygen in the atmosphere. Once formed, the tenacious passivating oxide film prevents further reaction and becomes corrosion resistant. Adding PGM alloying elements to commercially pure titanium extends the stability of the oxide film to more severe reducing acid conditions. But the high cost of PGM means distributors are unwilling to stock and only build to order, making mill lead times unacceptable.

PGMA, on the other hand, ennobles the base metal with powerful corrosion resistance rather than relying solely on the PGM as an alloying element. This patented technology involves attaching a relatively small PGM alloy appliqué by fusion or resistance welding onto a titanium substrate. It's like a reverse anode that drives the titanium surface to form a more stable oxide film.



At a typical area ratio of 100:1, PGMA's throwing power establishes the distance over which the galvanic interaction between substrate and appliqué extends. Repeated studies show that titanium with the TIMETAL appliqué can maintain its throwing power over very large distances due to polarization of the entire surface towards noble potential as shown in Table A. The result: TIMETAL PGMA applied to grade 2 imparts similar corrosion resistance to that found in more expensive grades of titanium, including grade 7.

Table A – Area Ratio (100:1)

Throwing Power (in)	20	30	40	50	80	100
Corrosion Rate (mpy)	4.9	4.7	5.3	5.8	3.7	4.3



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## Before & After – See the PGMA Difference

In hundreds of tests, PGMA has demonstrated its effectiveness under various chemical conditions – especially reducing acids or situations where oxygen is limited. Images below show the effect of TIMETAL PGMA patches in protecting a titanium substrate from the corrosive effects of mineral acid, low pH and extremely high temperatures over 12 months.



## Key Benefits of PGMA

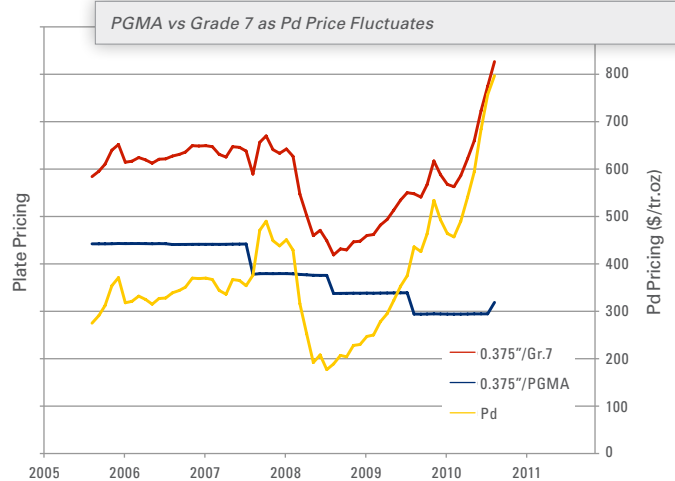
TIMETAL PGMA patches are proven to render titanium's surface oxide film impervious to all but the most severe conditions in many chemical conditions – from reducing acids (like hydrochloric and sulfuric) and bromine distillation to high temperature, aggressive chlorides, even nitric acid service. Benefits to you include:

- Reduced Raw Material Costs
- Decreased Mill Lead Times
- Enhanced Corrosion Protection
- Increased Equipment Life
- Extended Service/Inspection Intervals
- Increased Throughput (with less downtime)
- Easy Patch Repair & Replacement
- Simple Retrofit of Existing Equipment

## The Dollars & Sense of PGMA

It's no secret that Platinum Group Metal pricing is extremely volatile. Palladium prices dipped in the late 2000s but have been rising steadily ever since. In fact, French bank Société Générale just recently upped its price forecast to a staggering \$840/oz.\*

Now you can save on project capital costs with the TIMETAL PGMA solution. As the graph below illustrates, the PGMA alternative is on average 25% more cost effective than the equivalent grade 7 plate product over the last five years. With palladium prices still skyrocketing, that gap is expected to grow in kind.



PGMA patches stopped corrosion damage in a high-pressure, acid-leaching nickel autoclave for Minara in the western outback of Australia. The patch has continued to enhance corrosion protection in this harsh environment since 2004.



\* Platts, February 2, 2011, "Palladium Prices Seen Rising," <http://www.platts.com/RSSFeedDetailedNews/RSSFeed/Metals/8488631>



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