

STI / SPFA
Pressure Vessel Conference

May 15, 2008

A Presentation By John Curry

Trends in Clad Vessel
Fabrication

Rolled Bonded Clad

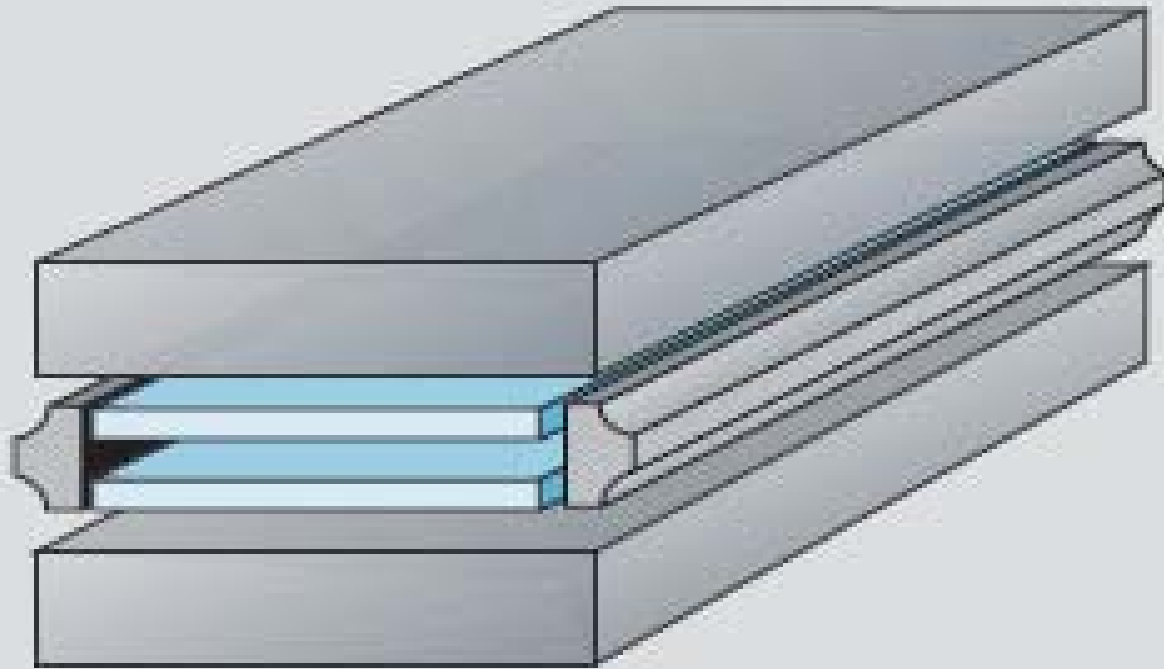
Rolled bonded clad has been around for sixty years or more. During that time, both the manufacture and fabrication of clad vessels has changed dramatically.

Structure of Roll Bonded Clad

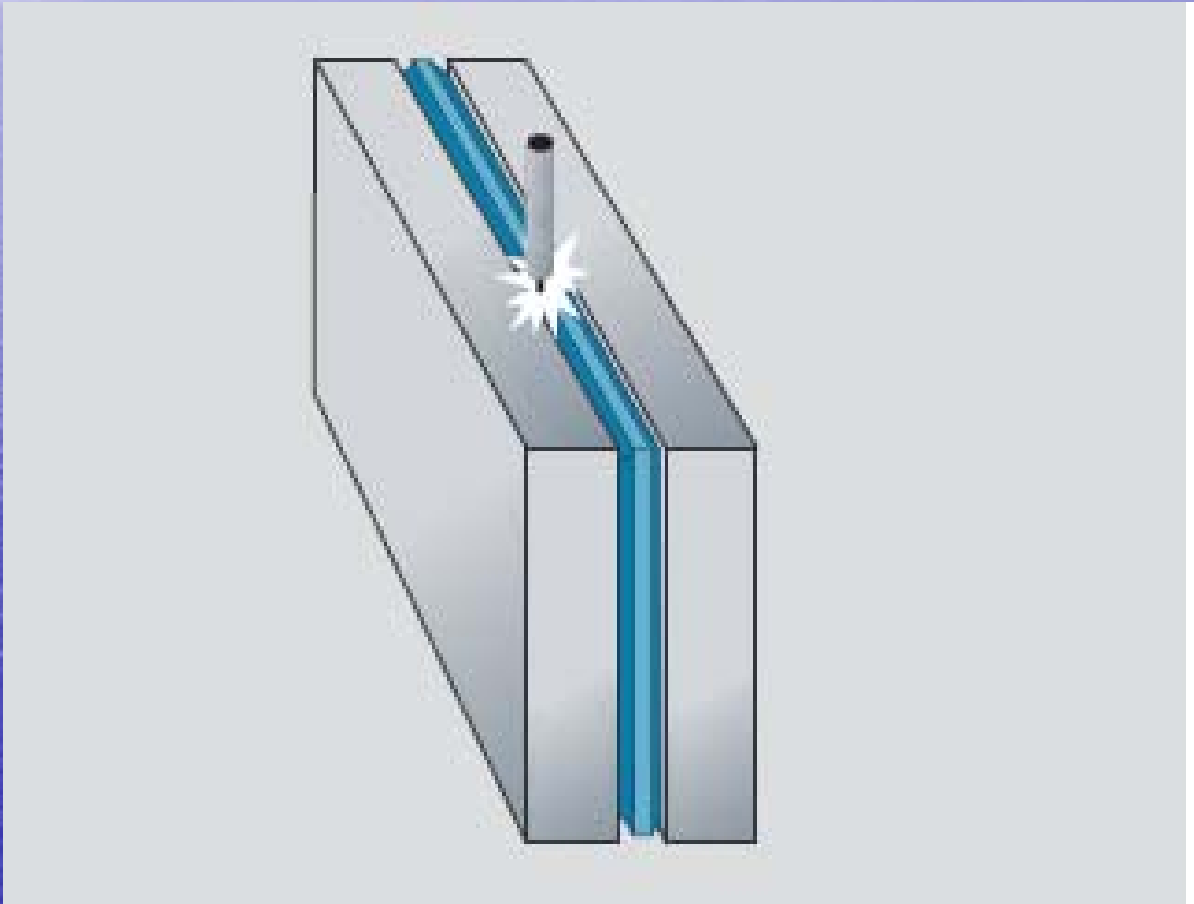
Roll bonded clad is metallurgically bonded by rolling two plates face to face separated by a layer of Chromium Oxide.

In fabrication, it is possible to peel back the clad layer to get to the base metal for welding.

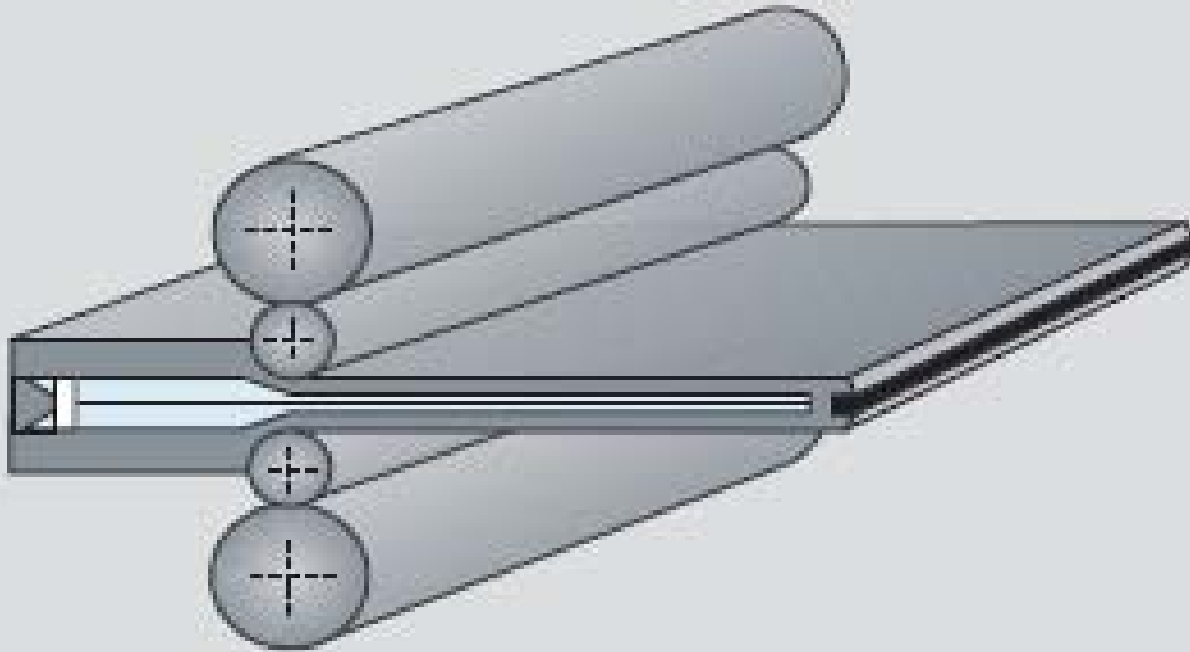
Rolled Bonded Clad Assembly



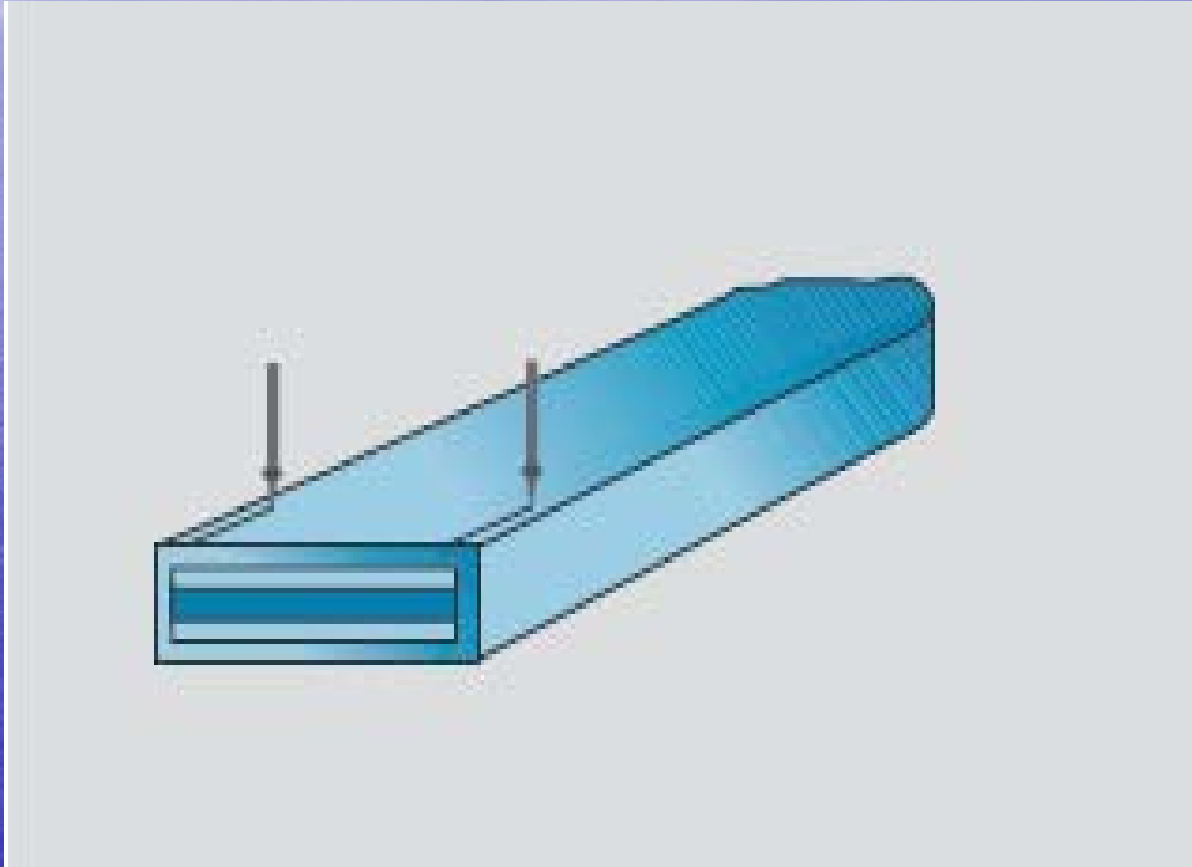
Welding of Package Assembly



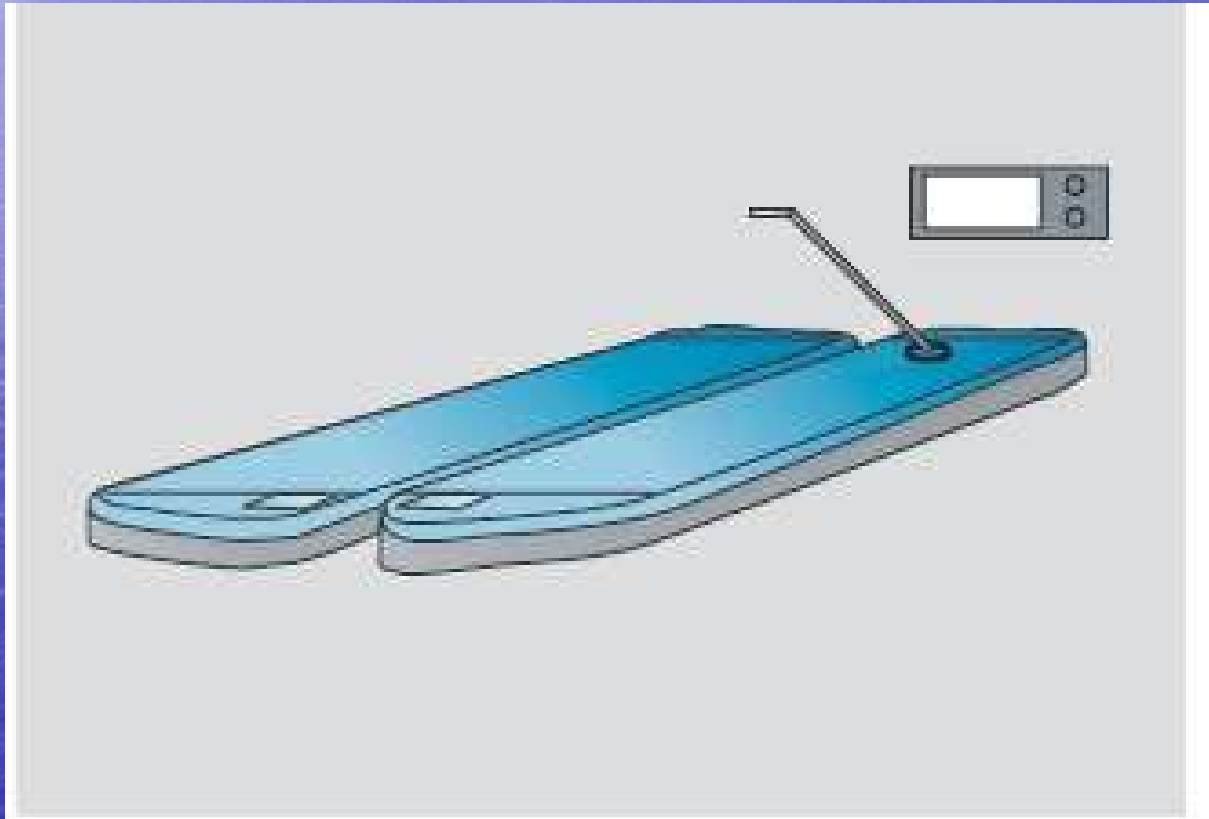
Rolling of Clad Package



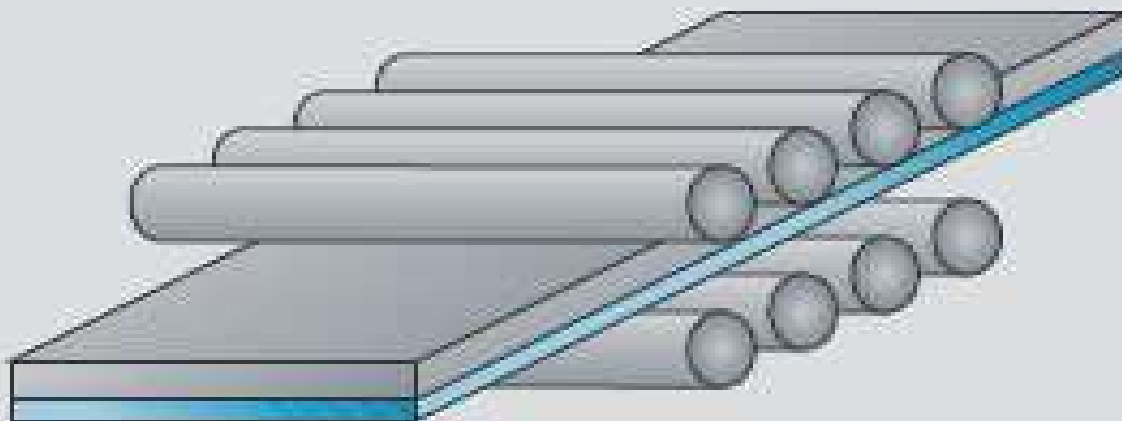
Plasma Torch Cutting



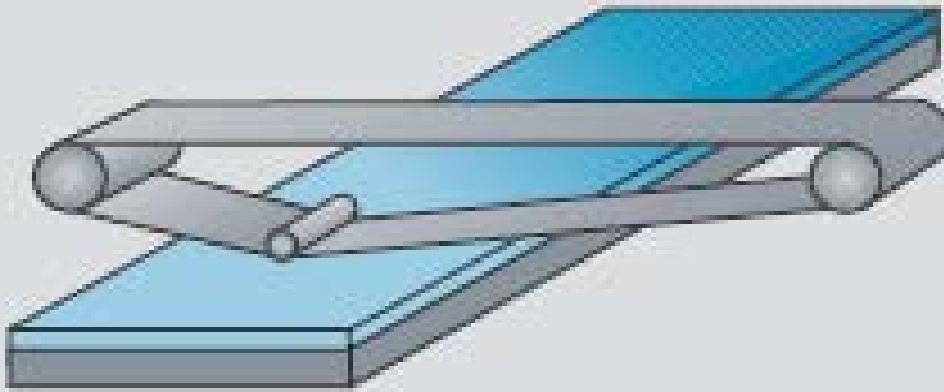
Ultrasonic Testing



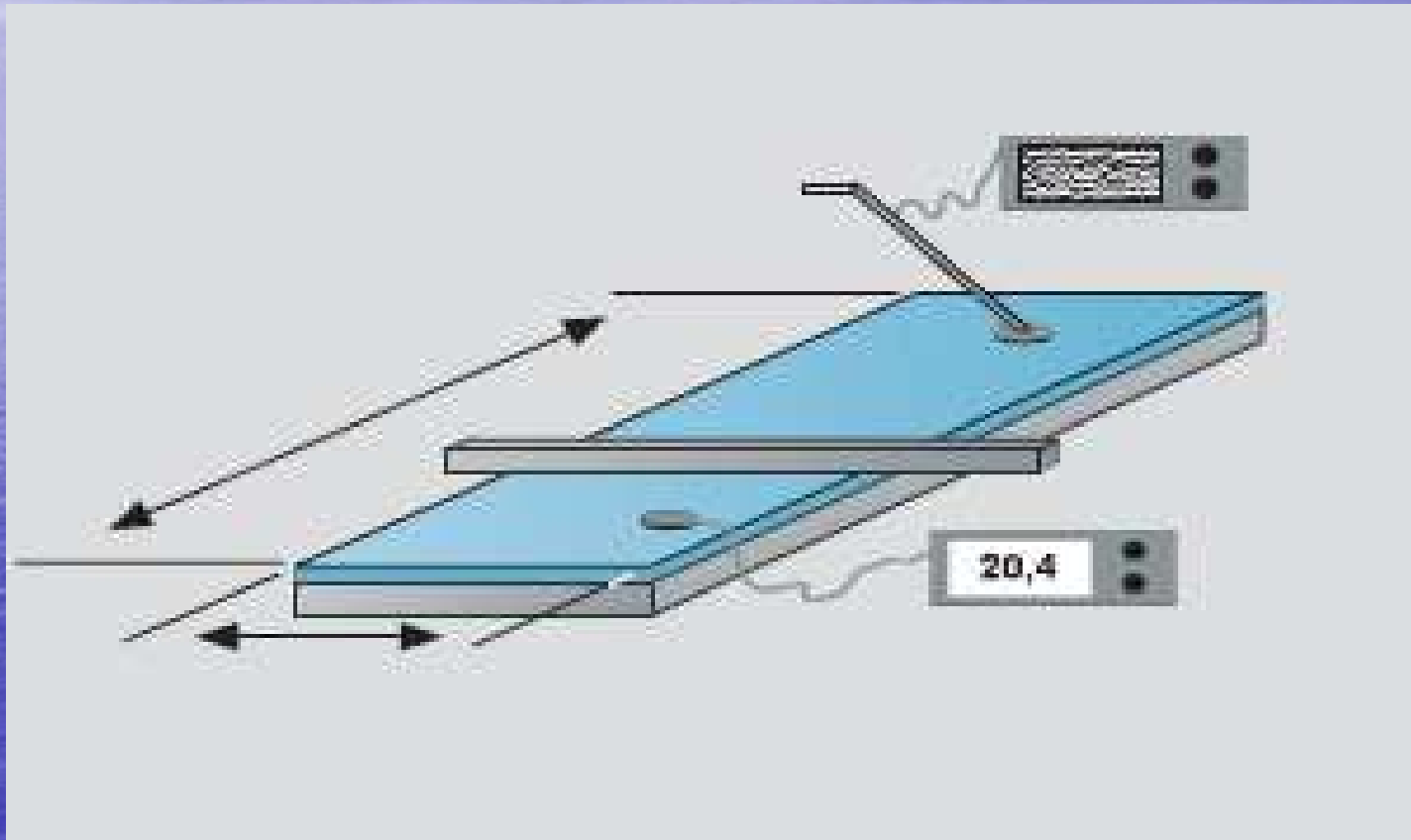
Leveling



Grinding



Final Inspection



Early Clad Vessels

During the 1950's, conditions were vastly different from today in several ways. Wages were about \$2.00 per hour and relatively speaking, steel, especially stainless, was much more expensive in comparison to labor.

The Cheapest Approach

Process Engineers designed vessels to be the least expensive. Hence they used more labor and made less use of expensive steel.

Early Crude Columns and Reactors

The typical main crude column in the 1950's was made of SA-285C or SA-212B and clad with 410 stainless to a thickness of .109" (12 gauge). In some old refineries you can find original clad thicknesses as low as .0625"

Problems in Old Clad Vessels

Since fabrication and welding methods were less sophisticated fifty years ago, it is now common to find cracks and carbon contamination in nozzle welds made in the original fabrication of old clad vessels.

Failures of Old Vessels

Many of the old clad vessels are beginning to fail after many years of service and countless heating and cooling cycles. The failures are occurring at the fillet welds on the inside of nozzle penetrations.

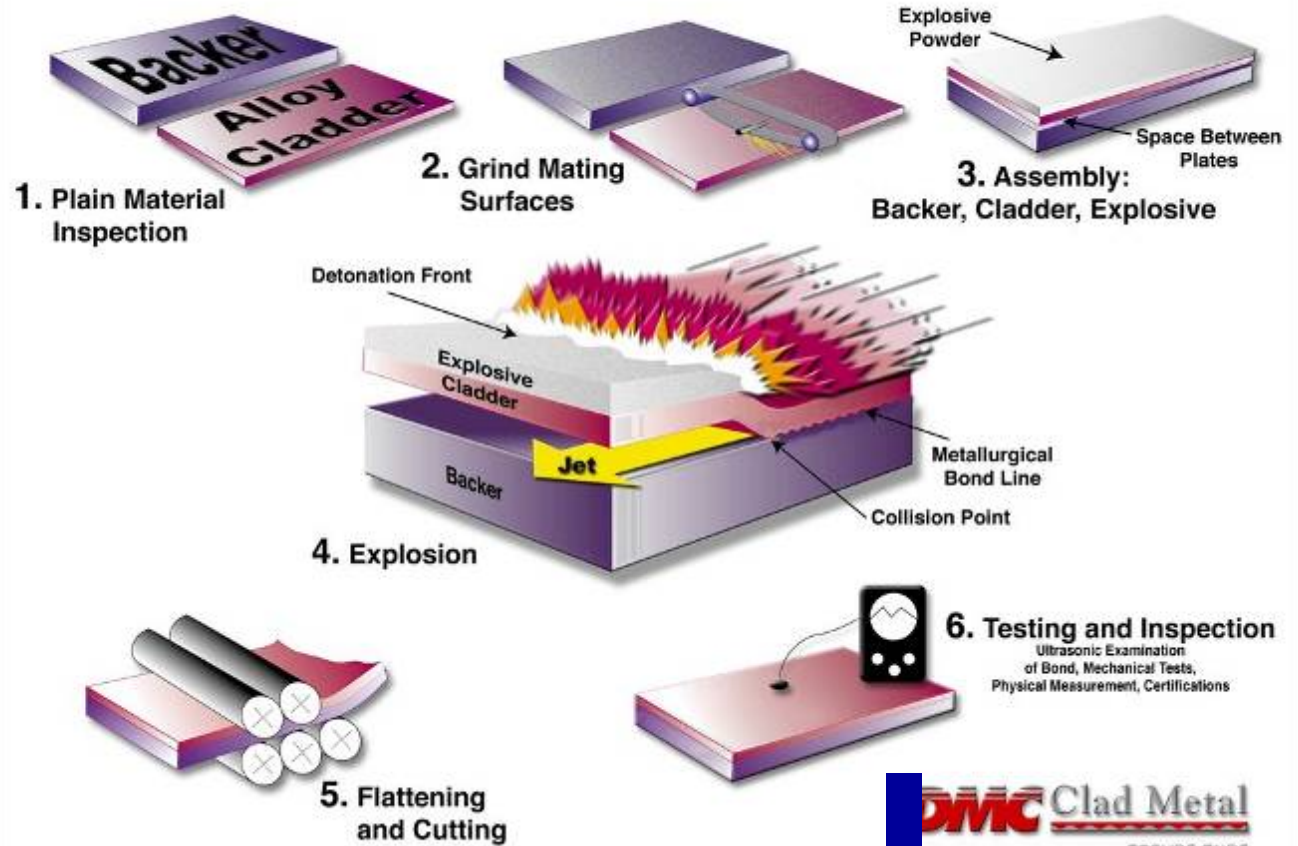
Why Such Failures?

The original 410 stainless cladding material is a hard metal. It has 12% Chrome and only a trace of Nickel. It is a good corrosion resistor, but it is brittle and difficult to fabricate and even more difficult to weld. You never see a solid 410 stainless vessel fabricated today.

Explosion Bonded Clad

Explosion bonded clad was introduced by DuPont some 45 years ago. The bond between the clad and the backing plate is not able to be peeled by due to the way the two plates are welded together.

Explosion Clad Plate Manufacturing



Pre-clad
Operations

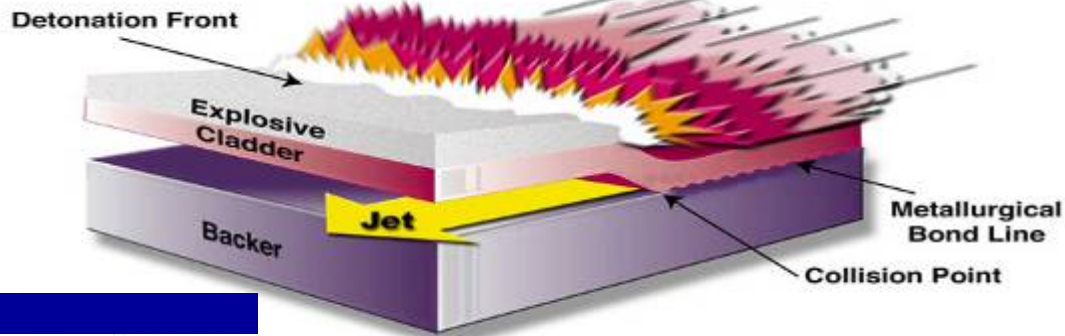
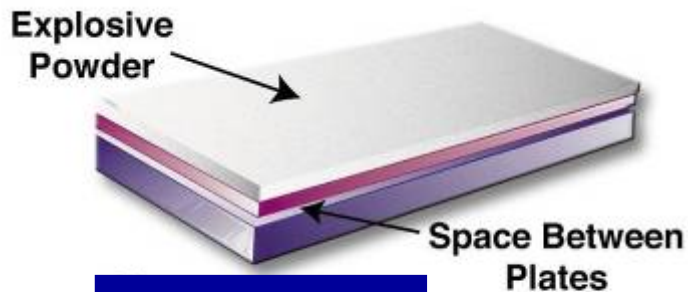
Cladding

Post-clad
Operations

The Detaclad[®] Welding Operation

Explosion Cladding Event

Pre-clad Assembly



- Cladding and Base Metal Plates are positioned parallel with a preset separation distance.

- Explosive is placed on top

- Detonation sweeps across the plate at ~7000ft/sec

- Cladding plate collides with the base plate at a high velocity

- Welding conditions result at the collision point

- 100% welding of the mating faces

Post-Cladding Operations

The specific operations depend upon specifications, metal types & order requirements



- Heat Treatment
- Press Flattening
- Roller Leveling
- Cutting
- Machining
- Final Conditioning

Explosion Bonded Clad vs. Rolled Bonded Clad

Roll bonded clad usually produces a thinner backing and cladding layer since roll bonded material can be rolled to a precise thickness. Explosion bonded clad starts with a thicker backing and cladding plate and usually ends up with a thicker product to meet the required minimum thickness.

Strip Lining

The 1960's and 1970's saw the use of 410 stainless sheet and strip lining as an inexpensive alternative to true cladding.

In 1979, my old company fabricated a main crude column and strip lined the bottom head. It was a beautiful job, but failed in a few years with all the plug welds cracking and the internal lining failing because of thermal expansion and contraction.

Thicker Clad Linings

Failures began to occur on the inside of nozzle penetrations in old vessels.

Because of this, the industry adopted the use of thicker clad layers and specified more stringent testing of internal welds for base metal contamination.

Process Engineers Viewpoint

Process Engineers are calling for thicker clad layers, but are not up to date on the choice of cladding materials. The use of 410 stainless clad should be declining because both Mittal and DMC are charging more for 410 clad than 304 clad. 410 is more difficult to fabricate than 304.

Ease of Fabrication

For the vessel fabricator, it is a lot easier to work with 304 clad than 410 clad. Since 304 has 18% Chrome and 8% Nickel, whereas 410 has 12% Chrome and almost no Nickel, it is plain to see that in today's marketplace, 304 clad is a better deal for everybody.

Design Improvements

Process Engineers have come to realize that with wage rates rapidly increasing, it is more economic to be less labor intensive and more steel intensive. Hence the use of integral forgings rather than re-pads and thicker vessel shells rather than vacuum stiffeners.

Clad Supply Problems

Unfortunately, clad vessel fabrication is hindered by a supply bottleneck. Mittal's roll bonded clad capacity and Dynamic Materials explosion bonded capacity are both producing extremely long lead times, especially for unusual alloys.

Rising Steel Prices

As we all know, steel plate prices have increased just as fast as a gallon of gasoline. “As rolled” SA-516-70 plate was about \$.46 per lb in December 2007 and now runs close to \$.70 per lb. It is hard to believe that the same plates were selling for \$.15 per lb in 2003.

Our Future

High energy prices have traditionally been good for the fabrication industry and the past four years have been exceptional good. But will the high cost of energy and increasing steel prices begin to squeeze our client's bottom line to the extent that capital spending will decline?