ARCOPLATE™

The World’s most Wear Resistant
Fused Alloy Steel Plate

YOUR GUARANTEE AGAINST
WEAR – HANG UP – CARRY BACK
- Operating for over 25 years.
- An Australian Independent, International company.

- *ARCOPLATE* manufacturing facility and head office in Perth, Western Australia.

- Accredited to latest ISO Standards for Production & Design.

- *ARCOPLATE* is complimented by our Metallurgical, Engineering & Design Service.
ARCOPLATE
FUSED ALLOY STEEL PLATE
The unique and patented ARCOPLATE Fused Alloy process was introduced into the market in the early 1990’s.

The base metal temperature is gradually increased. At a predetermined temperature the high alloy hardfacing is bonded to the base metal.

The fusion temperature is maintained for a set time so that stresses between the alloy and the base metal are equalised.
ARCOPLATE Fused Alloy Steel Plate
ARCOPLATE’s Fused Alloy process gives:

- Smooth deposit – no weld beads.
- Very low residual stress.
- Single pass alloy deposition from 4mm to 20mm.
- Uniform microstructure down to the fusion line.
- Minimal metal dilution.
- No plate distortion.
- Available in Mill or Pre-Polished Finish.
RELIEF CRACKS
Relief Cracks
Relief Cracks

- Relief cracks in the alloy surface of Arcoplate are common.
- Caused by the different cooling rate between the alloy and the backing plate which occurs during the manufacturing process.
- Stop at the fusion line between the alloy and the backing plate.
- Relief cracks in Arcoplate do not propagate into the backing plate.
- do not affect the structural integrity.
- do not affect the abrasion resistance.
- do not affect fabrication or formability.
- do not affect the anti hang / carry back properties.
BULK WELD OVERLAY
CLAD PLATE
Disadvantages of Bulk Weld Overlay Clad Plate

- Hardfaced or Overlay plate became commercially available in 1965 when the bulk weld process was invented.

- Hardfacing applied by either the Submerged Arc or the Open Arc method.

- Method 1: Clamp a carbon steel plate to a wet or dry weld table.

- Method 2: Roll carbon steel plate into a drum, rotate drum and commence welding.

- Both methods result in a product that requires extensive re-rolling and flattening due to major distortion and substantial residual stresses.
Disadvantages of Bulk Weld Overlay Clad Plate

- Base metal distortion.
- High residual locked in stress.
- Severe Underbead Cracking
- Multi Pass for thick alloy deposition
- Uneven hardness due to variable base metal dilution.
- Rough uneven surface.
ABRASION RESISTANCE
Microstructure vs Hardness

- Abrasion resistance is not related to hardness.
- The materials microstructure and not its hardness determines abrasive resistance wear characteristics.
- Hardness values only become relevant when comparisons are made within a family of steels.
- Chemical composition, microstructure & bulk hardness influence abrasion resistance.
- Abrasion resistance is not apparent in a hardness test but in a actual wear test such as ASTM G65
ABRASION RESISTANCE
Wear Testing
ASTM G65 – Dry Sand Rubber Wheel Test

- Low Stress or Scratching Abrasion is the most predominate in the mining industry.

- The ASTM G65 test characterises materials in terms of weight loss under a controlled set of laboratory conditions.

- Actual field conditions may be influenced by other factors such as impact, corrosion or heat.

- The ASTM G65 test gives a valuable insight into field performance.
Wear Testing
ASTM G65 – Dry Sand Rubber Wheel Test

Table 1. Dry sand rubber wheel low stress sliding abrasion test data for Arcoplate 1600D and typical ranges for other ferrous wear plates

<table>
<thead>
<tr>
<th>Material</th>
<th>ASTM G65 (Proc. A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight Loss - g</td>
</tr>
<tr>
<td>Arcoplate 1600D</td>
<td></td>
</tr>
<tr>
<td>Test 1:</td>
<td>0.1155</td>
</tr>
<tr>
<td>Test 2:</td>
<td>0.1215</td>
</tr>
<tr>
<td>450-500 HB, Q&amp;T AR steel plate</td>
<td>0.980-1.40</td>
</tr>
<tr>
<td>Traditional CrC bulk weld overlay plate</td>
<td>0.158 – 0.196</td>
</tr>
<tr>
<td>Cr and CrMo cast white irons and laminated wear plates</td>
<td>0.136-0.227</td>
</tr>
</tbody>
</table>
**Abrasion Resistance**

**High Carbon Q & T Plate**

- Particle erodes matrix unhindered

**ARCOPLATE**

- Carbides limit extent of erosion to matrix
Microstructure

Quenched & Tempered Plate

ARCOPLATE
PREDICTABLE WEAR RATE
Predictable Wear Rate

ARCOPLATE
Unique manufacturing process produces a flat fusion line

- Consistent microstructure and hardness down to the fusion line
- Alloy dilution with the backing plate is kept to a minimum – wear rates become consistent and predictable

BULK WELD OVERLAY PLATE

- Uneven fusion line resulting in poor microstructure and hardness
- Abrasion rates greatly increase as overlay begins to wear
Arcoplate Hardness Testing

**ARCOPlate Arco Alloy 1600**

**Hardness Results**

<table>
<thead>
<tr>
<th>Sample/Location</th>
<th>Vickers Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary carbide</td>
<td>1714-1931 HMV&lt;sub&gt;100&lt;/sub&gt;</td>
</tr>
<tr>
<td>Matrix free from carbide</td>
<td>401-532 HMV&lt;sub&gt;50&lt;/sub&gt;</td>
</tr>
<tr>
<td>Overall – 1mm below overlay surface</td>
<td>614-700 HV&lt;sub&gt;30&lt;/sub&gt;</td>
</tr>
<tr>
<td>Overall – 5mm below overlay surface</td>
<td>675-690 HV&lt;sub&gt;30&lt;/sub&gt;</td>
</tr>
<tr>
<td>Overall – 1mm above fusion line</td>
<td>775-792 HV&lt;sub&gt;30&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

**Microstructural Results**

Top LH – 100 X magnification
Top RH – 200 X magnification
Bottom LH – 500 X magnification

Microstructure consists of Primary and Secondary M₇C₃ carbides in a matrix of retained austenite, with possibly some martensite. The exact structure and percentages of the various phases has not been determined.
Bulk Weld Overlay Hardness Testing

EXAMINATION OF A WELD OVERLAY SAMPLE

INTRODUCTION

A weld overlay sample, identified as D80 70mm x 23mm x 15mm thick, was received for metallographic examination and hardness testing.

METALLURGICAL EXAMINATION

1.0 Metallographic Examination (etched in Picric Acid)

Microscopic examination remote from the fusion boundary of a section cut through the overlay showed a microstructure consisting of primary chromium rich carbides in a matrix of austenite and predominately angular light pink carbides (figure 1). The light pink carbides may be niobium rich, however further analysis would be required to confirm the actual chemistry.

2.0 Hardness Test

Vickers hardness testing (using a 30kg load) of the section prepared for microscopic examination gave results as follows:

<table>
<thead>
<tr>
<th>Test Location</th>
<th>Hardness Range (HV30)</th>
<th>Average Hardness (HV30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mm below overlay surface</td>
<td>631 – 652</td>
<td>642</td>
</tr>
<tr>
<td>3 mm below overlay surface</td>
<td>610 – 626</td>
<td>618</td>
</tr>
<tr>
<td>5 mm below overlay surface</td>
<td>610 – 657</td>
<td>634</td>
</tr>
<tr>
<td>7 mm below overlay surface</td>
<td>622 – 648</td>
<td>635</td>
</tr>
<tr>
<td>Just above weld fusion line</td>
<td>568 – 679</td>
<td>564</td>
</tr>
</tbody>
</table>
ARCOPlate’s Performance

Laboratory & field tests show that millimetre for millimetre ARCOPlate will outlast

- Quenched & Tempered steel plate by greater than 5:1
- Bulk weld overlay plate by 2:1
ARCOPLATE
GRADES & THICKNESS
ARCO ALLOY 1600  –  High Abrasion and High Impact.
Nominal Hardness : 725Hv – 60Rc – 650BHN

ARCO ALLOY 1040  –  High Abrasion, Moderate Impact and Cyclic temperatures up to 500 C.
Nominal Hardness : 725Hv – 60Rc – 650BHN

ARCO ALLOY 800  –  Moderate to High Abrasion and Impact.
Nominal Hardness : 650Hv – 56Rc – 585BHN

ARCO ALLOY 8668  –  High Abrasion and Moderate to High Impact. Cyclic temperatures up to 700°C
Nominal Hardness : 650Hv – 56Rc – 585BHN

All grades can be pre-polished to eliminate Hang Up / Carry Back

Other grades are manufactured to maximise abrasion resistance no matter what the operating conditions.
## ARCOPLATE Thickness

<table>
<thead>
<tr>
<th>Alloy Thickness (mm)</th>
<th>Base Metal Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>7, 9, 11</td>
</tr>
<tr>
<td>8</td>
<td>7, 9, 11</td>
</tr>
<tr>
<td>10</td>
<td>9, 11</td>
</tr>
<tr>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>20</td>
<td>11</td>
</tr>
</tbody>
</table>

**Standard Plate Size:** 610 x 3080

*Other thicknesses are available upon request*
COMBATING WEAR
Design Criteria

- Wear is greatest in the area where the flow of material is biggest and where material flow changes direction.

- Design & material flow velocities influence the rate of wear.

- Turbulence can cause an increase in wear rates of up to 600% over a smooth flow
Design Criteria

- Wear patterns generated by turbulence flow over conventional bulk weld overlay clad plate.
Design Criteria

- Smooth surfaces do not create turbulence and allow material to slide freely.
Design Criteria

- Designs using stud bolts eliminates turbulence.
- Designs using countersunk bolts creates turbulence and leads to comet trail wear patterns.
ARCOPlate Applications
### ARCOPLA  TE APPLICATIONS

**Equipment protected by ARCOPLATE**

<table>
<thead>
<tr>
<th>Conveyor Side Liners</th>
<th>Sizing Screens</th>
<th>Transfer Chutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screens</td>
<td>Feed Bins</td>
<td>Dredging Pipes</td>
</tr>
<tr>
<td>Dredging Pump Parts</td>
<td>Load Out Bin Liners</td>
<td>Rock Chutes</td>
</tr>
<tr>
<td>Sizing Screens</td>
<td>Ore Dump Chutes</td>
<td>Reclaimer Liners</td>
</tr>
<tr>
<td>Transfer Chutes</td>
<td>Hopper Doors</td>
<td>Rock Bin Liners</td>
</tr>
<tr>
<td>Skip Cars</td>
<td>Crusher Liners</td>
<td>Bucket Liners</td>
</tr>
<tr>
<td>Dragline Bucket Liners</td>
<td>Dozer Liners</td>
<td>Truck Body Liners</td>
</tr>
</tbody>
</table>
COMBATING HANG UP
Pre-Polished Arcoplate has a Low Friction Coefficient offering better flow properties and performance when compared against Quenched & Tempered or Stainless Steel plate.
Pre-Polished Arcoplate
Traditionally Quenched & Tempered or Stainless Steel plate has been chosen to stop hang up because there is a long history of use.

Tradition may be comfortable when it comes to material flow methods however tradition may not be optimal in terms of performance.

Pre-Polished Arcoplate has a Low Friction Coefficient which offers better flow properties and performance.

Pre-Polished Arcoplate has up to 23% less friction resistance than mill finish Utility Stainless Steel UNS S41003 or 400HB Q&T Plate.
Pre-Polished ARCOPLATE

As a bulk solid flows the surface wears resulting in a change to the angle of sliding friction.

Worn Arcoplate increases the friction coefficient by up to 16% over Pre-Polished Arcoplate
Friction Testing

Rockfield Technologies Australia Pty. Ltd.

TECHNICAL REPORT
MEASUREMENT OF BULK COAL SLIDING
FRICITION ON VARIOUS WEAR PLATE
PRODUCTS

FOR
ALLOY STEEL INTERNATIONAL PTY LTD
APRIL 2008
Friction Testing

Conclusions
The following conclusions are made regarding the measured bulk coal frictional performance of the various wear plate products tested:

- In the as-supplied, pre-polished condition, the ARCO ALLOY 1600 exhibited 23% less frictional resistance than the Utility Stainless Steel - ASTM A240 UNS S41003.

- In the worn condition, the ARCO ALLOY 1600 exhibited even greater performance, exhibiting 39% less frictional resistance than the Utility Stainless Steel ASTM A240 UNS S41003.

- In the as-supplied, mill-finish condition, there was little discernable difference between the frictional performance of the Utility Stainless Steel - ASTM A240 UNS S41003 and the 400HB Q&T Plate.
Bin & Hopper Design

Handling bulk solids that do not flow reliably or uniformly through bins, hoppers and chutes can be costly for companies that have processes requiring continuous feed rates.
The common flow problems occurring in gravity feed operations such as funnel flow, arching, ratholing, have a variety of effects on a particular process that can result in quality problems, lost production, fire, product spoilage, structural damage, personnel injuries and wasted time and money.
Pre-Polished *Arcoplate* has proven through laboratory and field experience, to be a cost-effective wall surface lining that provides consistent flow of solids. Due to its low wall friction and superior sliding abrasion resistance, prominent engineering firms have specified Pre-Polished *Arcoplate* as the primary sliding wear surface in new and existing bulk material handling systems.
Bin & Hopper Design using Arcoplate

Engineers are able to design hoppers and bins with shallower wall angles and still achieve mass flow.

Reduce construction costs by building a more efficiently designed hopper or bin by lowering the overall height of the structure.
Bin & Hopper Design using Arcoplate
Applications

- Zinc Cyclones
Applications

Magnetite Concentrator Raw Feed Bin
Applications

- Coal ROM Bin
Applications

- Piping
Applications

- Chutes & Liners
Applications

- Assorted Wear Plates
MAJOR PROJECTS
Major Projects

- Onesteel - Project Magnet - South Australia – Magnetite Ore - Plant and Feed Bins
- Fortescue Metals – Western Australia - Iron Ore – Screening & Crushing Vaults, Train Load Out Stations
- Pilbara Iron Ore – Western Australia – Iron Ore – Transfer Station Chutes
- Xstrata Project Koniambo – New Caledonia – Nickel Ore - Tertiary Surge Bin, ROM Dump Hopper
- Tata Steel – India – Train Load Out Station
- PT Adaro Indonesia – Coal – ROM Hopper
- SMEC International – Sudan - Roseiers Dam Deep Sluice Liners
MOBILE EQUIPMENT
Applications

- Truck Liner Plates
Arcoplate Wear & Anti Carry Back Kit

- **ARCOPLATE** at Headboard eliminates carry back.
- Loading Zone no Arcoplate Liners
- **ARCOPLATE** on Tail Section reduces abrasion & allows materials to quickly discharge.
Applications

Your Complete Solution to Combating Wear

**ARCOPLATE™ Dozer Wear Kit**

- ARCOPLATE™ Blade Protection Wear Kit
- ARCOPLATE™ Ripper Frame Protection Wear Kit
- ARCOPLATE™ Push Arm Protection Wear Kit
Applications

- Dipper Buckets
Applications

- Buckets
Applications

- Graders
Carry Back

- Carry Back without ARCOPLATE
- After installation of ARCOPLATE
Carry Back

- Carry Back without ARCOPLATE
- After installation of ARCOPLATE
Carry Back

- Carry Back without ARCOPLATE
- After installation of ARCOPLATE
TESTIMONIALS
USA Mining Expo – October 2004
Caterpillar Stand

- **ARCOPLATE** Anti Hang Up Kit on a D11R Carry Dozer
As per our conservation I am very happy with the life we have achieved since we started to replace the rear third of our wear package in the 830E bodies with Arcoplate.

Previously we had fitted 20mm 400 grade Q&T plate which would only achieve 5,000hrs before requiring replacement.

The first sheets of Arcoplate were fitted back on the 11/06/2001 and these plates are still in service with currently 14,518hrs on them.

These are now due for replacement which means we are achieving 3 times the life of 400 grade Q&T.

This has reduced our costs with labour, down time and material having not had to revisit this wear package every 5,000hrs this is a big saving over the 19 x 830E trucks we have on site.

Currently all trucks have had Arcoplate fitted to the rear wear package area of our bodies.

Regards,
Greg Burgess
Ernest Henry Mine
Wesfarmers Premier Coal – Western Australia.

Background

Wesfarmers Premier Coal; the largest coal mining operation in Western Australia, mines black coal at Collie, a location 200 kilometres from Perth. The operation is open cut mining a product of a low ash and sulphur content.

Approximately 25 million tonnes of overburden and 3.5 million tonnes of coal are mined each year.
Wesfarmers Premier Coal – Western Australia.

P & H 2800 Shovels

The first trials were carried out in 1997 on P & H 2800 Shovel dippers. Arcoplate replaced a range of different wear applications primarily being Quenched & Tempered (AR Plate) products and various heat-treated and weld overlayed materials.

Arcoplate – Installation Advantages

Weight:

The first immediate advantage was a reduced weight factor. The Arcoplate used was 10 on 9 while other products previously used had been up to 40MM thick. This resulted in a weight saving of up to 50% on AR wear plate.

Currently results achieved on these shovels are:

Shovel 6 - 25 Millions BCM’s of material; wear plate approximately 50% worn.
Shovel 12 - 20 Million BCM’s of material; wear plate approximately 40% worn.
Shovel 14 - 42 Million BCM’s of material (28,000 hours) wear plate approximately 65% worn.
Haul Trucks
With excellent results being achieved using Arcoplate on the shovels it was decided to trial Arcoplate in the trays of the Euclid 260 haul trucks being used in the mine.

Prime reason for the use of Arcoplate in the trucks was to reduce and minimise carry back.

Results Achieved
Whilst the initial installation greatly reduced carry back after modification and design, carry back has been reduced to a minimum. It was not uncommon to see 30 – 40 tonne of carry back in the trays pre Arcoplate. Now the amounts we see are negligible.

Life Span
It has been found that tray liner kits of Arcoplate fitted to the trucks have been able to withstand impact loading over the life of the truck. Premier Coals Truck Fleet at the moment has 30,000 hours plus of usage time.

Conclusions
Wesfarmers Premier Coal have found that the utilisation of Arcoplate in our truck fleet has been extremely successful in increasing the productivity of the fleet, which has resulted in time and of course cost savings.

Neil Richards – Mobile Fleet
Premier Coal – Collie – Western Australia
FABRICATION
Fabrication

- *ARCOPlate* can be plasma cut, welded, rolled or formed using conventional methods.

- Full assistance is provided by Alloy Steel International or your nearest *ARCOPlate* dealer.
CONCLUSION
The unique & patented ARCOPlate Fused Alloy process gives:

- Smooth Deposit – no weld beads.
- Very Low Residual Stress
- Single pass alloy deposition.
- Consistent microstructure.
- Minimal metal dilution.
- No plate distortion.
- Mill or Pre-Polished Finish.

Wear rates can be predicted because of the unique ARCOPlate Fused Alloy process thus enabling ARCOPlate to be your

Your guarantee against Wear - Hang Up - Carry Back