

SCOPE

This Technical Guidance Note (TGN) provides an overview of best practices in the welding of attachments to crack sensitive materials. The attachments are used as lifting aids for the removal of wear liners or similar components from mining equipment when they become redundant.

Because of the known susceptibility of these materials to weld zone cracking, it has been identified that there is a need to develop and implement work instructions and welding procedure specifications that ensure the welds give optimum performance during the extraction and lifting operations.

It is recognised that wear liner materials are primarily selected for their superior performance in harsh environments subject to a variety of wear mechanisms. Weldability is a secondary consideration.

This TGN considers only the manual metal arc welding (MMAW) process since this is the most widely used for this application.

1. INTRODUCTION

During routine maintenance, worn items need to be removed from service and replaced therefore lifting aids are fillet welded to these worn items to aid removal. The materials in question are known to be crack-sensitive and therefore considered difficult to weld. This represents a significant safety hazard to personnel involved in the removal activities if the lifting aids fail. Welding should be avoided if possible, e.g. flame cut holes with slings and shackles could be used. An improvement opportunity exists therefore, within the mining industry, in this respect.

This document provides the basis for establishing a detailed work instruction (WI) and welding procedure specification (WPS) for each of the types of materials. Following the relevant WI and WPS for the material type will enable welding to be carried in a controlled and effective manner so the resulting weldment will perform with the maximum achievable safety during operation.

This TGN covers the manual metal arc welding of lifting attachments to redundant components made from difficult to weld materials such as low alloy steels, white cast iron and austenitic manganese steel.

Caution – Following the recommendations of this TGN does not ensure that welds to wear liner materials will be crack free. Due to the nature of the wear liner materials there will be an ever-present risk of weld zone cracking. These guidelines are intended to identify and address the factors that lead to cracking and provide guidance on managing those factors to minimise the risk of weld zone failure. Surface NDE should be carried out to ensure weld zones are crack free.

2. OBJECTIVES

The objective of this Guidance Note is to:

- Identify the material types for components that are frequently replaced and list the common trade names against these material types. This will enable users to associate a particular trade name to a material type.
- Describe the weldability issues of the material types used and establish appropriate welding management practices.
- Outline best practice in general work instructions and welding procedure specifications for each material type.
- Establish any training needs that may be required in order to maintain ensure reliability of the end product.

3. COMPONENTS

This TGN relates to wear liners, mechanical components and crusher parts used in mineral processing equipment. The materials under consideration are white cast irons, abrasion resistant steel, heat-treated (quenched and tempered) alloy steels, and austenitic manganese steels.

Due to process conditions these items become worn and need to be removed from service for replacement or access to enable routine maintenance to take place. Wear liners in particular generally have lifting points provided to aid their installation. The lifting points are either cast in threads to enable the use of screw in eyes, or protrusions on the wear liner for lifting shackle or hook attachment for installation. In service these lifting aids are usually destroyed by wear, rendering them unusable during wear liner removal.

In certain situations therefore, there is a need to attach lifting points to aid in the safe removal of wear liners. Attachment is usually by fillet welding carbon steel lifting attachments to the wear liners.

4. ENVIRONMENTAL AND SAFETY CONDITIONS

A full hazard identification, risk assessment and implementation of hazard reduction protocols must be undertaken before attaching temporary lifting points to wear liners. The following safety issues need to be considered:

- The materials can become embrittled after welding and are known to be crack-sensitive.
- The items may be difficult to remove after being in service thus putting the lifting attachment under considerable strain if the lifting point is used to apply excessive force to achieve removal. The degree of force needed to remove the item is not known and will vary from case to case. Therefore the force applied to the lifting attachment may be far greater than the static load of the liner suspended on the attachment.
- The welding consumables may contain high levels of chromium and other potentially harmful elements so the use of welding fume masks is recommended.

4.1 MATERIAL GRADES

Typical commercial grades are listed in Appendix A.

4.2 WHITE CAST IRONS

These materials are selected for their excellent resistance to wear.

4.3 WELD OVERLAY CLAD PLATE

These materials are selected for their excellent resistance to wear and ease of attachment by welding to supporting structures.

4.4 QUENCHED AND TEMPERED LOW ALLOY ABRASION RESISTANT STEEL

These materials are not as hard as white cast irons but generally have higher toughness so are used in areas where white iron would tend to crack due to impact loads.

4.5 QUENCHED AND TEMPERED ENGINEERING STEELS

These materials are selected for their strength, hardness and toughness and are used in components such as pins, shafts, rollers and tumblers.

They are included in this document because lifting points are often welded on to aid in extraction of worn damaged or fractured components.

4.6 AUSTENITIC MANGANESE STEEL

In the solution heat-treated condition these alloys have a metastable austenitic microstructure with medium strength and extraordinarily high toughness. The hardness of parent metal as cast and solution annealed is typically 187 HB.

In a high impact service environment, the surface subjected to impact loads will undergo plastic deformations that result in local transformations to a martensitic microstructure that is much harder than the tough supporting matrix, thus forming a hard skin supported by a tough core. The hardness of work-hardened (martensitic) areas can be up to 550 HB. The martensitic zones develop good resistance to abrasive wear.

5. WELDABILITY CONSIDERATIONS

5.1 HYDROGEN ASSISTED COLD CRACKING (HACC)

HACC occurs under the combined effects of residual stress, hydrogen absorbed into the weld zone during welding and a susceptible microstructure. Preventing HACC in the HAZ is therefore based on the following strategies:

- Selection of a welding consumable with a relatively low yield point and good ductility;
- Selection of either a low hydrogen welding consumable and welding process to limit hydrogen pickup in the weld zone; or
- Use of an austenitic welding consumable that is highly tolerant to hydrogen and permits easy migration of hydrogen away from the HAZ;
- Use of correct preheat
- Control of interpass temperature

5.2 HYDROGEN CONTROL

Where hydrogen control is required the following shall be addressed. Sources of hydrogen are:

- Welding consumables. Low-hydrogen MMAW consumables must be stored correctly and conditioned in drying ovens and held in holding ovens before use in accordance with manufacturers recommendations. Austenitic consumables must be stored in accordance with the manufacturers recommendations to ensure minimum hydrogen contamination.
- Before welding, clean surfaces by grinding.
- Air-tools such as needle guns and pneumatic chisels must be supplied with dry and oil free air.

5.3 SURFACE PREPARATION

Oxidised surfaces often contain moisture as well (hydrated oxides). Moisture breaks down in the arc to provide a source of hydrogen.

Surfaces shall be dry. Surfaces shall be free of contamination by oil or grease.

5.4 WHITE CAST IRONS

White cast irons have very poor weldability. They are prone to cracking in the heat-affected zone (HAZ) by a process known as hydrogen assisted cold cracking (HACC). White cast irons have a crack susceptible microstructure that becomes even more likely to crack after a welding thermal cycle.

Because they have very poor ductility, they are also prone to cracking due to thermal shock.

Preventing HACC in the HAZ of white cast irons is based on the following strategies:

- Selection of a welding consumable with a relatively low yield point and good ductility;
- Use of an austenitic welding consumable that is highly tolerant to hydrogen and permits easy migration of hydrogen away from the HAZ;
- Use of moderate preheat;
- Application of preheat with a gentle flame without direct flame impingement;
- Controlled interpass temperature.

5.5 WELD OVERLAY CLAD PLATE

Welding should not be carried out directly onto the overlay. Welding onto and subsequent cracking of the overlay will lead to failures. The substrate is structural carbon steel and is readily weldable with minimum precautions.

5.6 QUENCHED AND TEMPERED LOW ALLOY ABRASION RESISTANT STEEL

Alloy steels used for these applications have good weldability, providing adequate preheating and hydrogen control are used. They are prone to cracking in the heat-affected zone (HAZ) by a process known as hydrogen assisted cold cracking (HACC).

5.7 QUENCHED AND TEMPERED ENGINEERING STEELS

Alloy steels used for these applications have very poor weldability. They are prone to cracking in the heat-affected zone (HAZ) by a process known as hydrogen assisted cold cracking (HACC).

HACC occurs under the combined effects of residual stress, hydrogen absorbed into the weld zone during welding and a susceptible microstructure. Preventing HACC in the HAZ is therefore based on the following strategies:

- Selection of a welding consumable with a relatively low yield point and good ductility;
- Selection of either a low hydrogen welding consumable and welding process to limit hydrogen pickup in the weld zone; or
- Use of an austenitic welding consumable that is highly tolerant to hydrogen and permits easy migration of hydrogen away from the HAZ;
- Use of preheat to:
 - Retard cooling rates and thereby reducing the maximum hardness of HAZ
 - Retard cooling rates to promote hydrogen diffusion
 - Thoroughly dry the weld zone before welding

5.8 AUSTENITIC MANGANESE STEEL

Austenitic manganese steels are readily weldable in the solution heat-treated condition. The metastable austenitic microstructure is extremely tolerant to hydrogen pick up during welding.

Work hardened material has a martensitic structure that is unsuitable to weld onto. Martensitic material often presents with fine surface cracks. These cracks tend to arrest if they extend to austenitic material. Martensitic material has poor weldability, i.e. the martensitic material may crack and spall off when welded. Cracks should be removed. Cracks are an indicator of work-hardened material. Work-hardened material should be completely removed.

Hardness testing may give useful information on effectiveness of removal of work-hardened material.

If air carbon-arc gouging is used, carbon contamination must be avoided or removed.

This material is welded with no preheat. Interpass temperatures are kept as low as practicable.

6. BEST PRACTICE WELDING INSTRUCTIONS

6.1 WHITE CAST IRONS

6.1.1 Surface Preparation

Surfaces to be welded should be dressed to remove any oxide or other surface contaminants.

Surfaces shall be dry. Surfaces shall be free of contamination by oil or grease.

6.1.2 Preheating and Interrun Temperature

A moderate preheat is recommended. Interrun temperatures must be maintained at the preheat temperature. It is recommended that a number of runs be placed to make a three-run two-layer fillet. Refer the WPS for typical run placement. It is important to monitor the interpass temperature regularly and if necessary air-cool the weld.

Preheat temperature: Refer Appendix B.

Interpass temperature: Refer Appendix B.

6.1.3 Hydrogen Control

- Cast iron is adversely affected by hydrogen. Hydrogen controlled welding is required.

6.1.4 Consumable Selection

White cast irons may be welded with the following:

- Austenitic welding consumables (cheaper) e.g. AS/NZS 1553.3 E309L-16 or E 312-16
- High nickel austenitic welding consumables (most expensive, lowest risk of HACC) e.g. AWS/ASME-SFA A5.11 ENiCrFe-3.

6.1.5 Welding Sequence

Stringer beads must be used. Needle peen each run immediately after welding. Allow the weld zone to cool between runs. For best results a three-run two-layer fillet is used.

6.2 WELD OVERLAY CLAD PLATE

6.2.1 Surface Preparation

Surfaces to be welded should be gouged or ground to remove the overlay material and expose the substrate. Surfaces to be welded should be dressed to remove any oxide or other surface contaminants.

6.2.2 Preheating and Interrun Temperature

No preheat is required. Interpass temperatures do not need to be controlled.

6.2.3 Hydrogen control

No special precautions are necessary beyond ensuring electrodes are dry and surfaces are dry and clean before welding.

6.2.4 Consumable Selection

Hydrogen controlled carbon steel welding consumables are all that is necessary, e.g. AS 1553.1 E4816 or E4818.

Refer to Appendix B.

6.2.5 Welding Sequence

A single run fillet all around the lug is all that is needed. This is of course dependent on the mass of the component.

6.3 QUENCHED AND TEMPERED LOW ALLOY ABRASION RESISTANT STEEL

6.3.1 Surface Preparation

Surfaces to be welded should be dressed to remove any oxides spalling or other surface contaminants. Oxidised surfaces often contain moisture as well (hydrated oxides). Moisture breaks down in the arc to provide a source of hydrogen.

Surfaces shall be dry. Surfaces shall be free of contamination by oil or grease.

6.3.2 Preheating and Interrun Temperature

When fabricating from new or carrying out repairs, these materials normally require controlled preheat and interpass temperatures in order to maintain the mechanical properties.

For the purpose of this TGN however, because the components are redundant, higher preheat and interpass temperatures are recommended. If preheating is impractical it is also recommended that a number of runs be placed to make a three-run two-layer fillet. Refer the WPS for typical run placement. It is important to carry out all welding in one cycle, i.e. once welding commences, complete all welding with minimal interruptions for weld zone cooling.

Preheat temperature: Refer Appendix B.

Interpass temperature: Refer Appendix B.

6.3.4 Hydrogen control

Alloy steel is adversely affected by hydrogen. Hydrogen controlled welding is required.

6.3.5 Consumable Selection

These steels may be welded with either low tensile hydrogen controlled carbon steel welding consumables (cheapest), austenitic welding consumables (less risk of HACC) or the high nickel austenitic welding consumables (most expensive, lowest risk of HACC).

Refer to Appendix B

6.3.6 Welding Sequence

Interrun temperatures must be maintained at the preheat temperature. If preheating is impractical it is recommended that a number of runs be placed to make a three-run two-layer fillet. Refer the WPS for typical run placement. It is important to continue welding to completion. Welding with minimal interruptions prevents rapid weld zone cooling.

For best results a three-run two-layer fillet is used.

6.4 QUENCHED AND TEMPERED ENGINEERING STEEL

6.4.1 Surface Preparation

Surfaces to be welded should be dressed to remove any oxide or other surface contaminants.

6.4.2 Preheating and Interrun Temperature

A high preheat is recommended. Interrun temperatures must be maintained at the preheat temperature. It is important to keep welding once welding commences to complete all welding with minimal interruptions for weld zone cooling.

Preheat temperature: Refer Appendix B.

Interrun temperature: Refer Appendix B.

6.4.3 Hydrogen control

Quenched and tempered engineering steel is adversely affected by hydrogen. Hydrogen controlled welding is required.

6.4.4 Consumable Selection

Quenched and tempered engineering steel may be welded with either low tensile hydrogen controlled carbon steel welding consumables (cheapest), austenitic welding consumables (less risk of HACC) or the high nickel austenitic welding consumables (most expensive, lowest risk of HACC).

Refer to Appendix B

6.4.5 Welding Sequence

Interrun temperatures must be maintained at the preheat temperature. If preheating is impractical it is recommended that a number of runs be placed to make a three-run two-layer fillet. Refer the WPS for typical run placement. It is important to continue welding to completion. Welding with minimal interruptions prevents rapid weld zone cooling.

For best results a three-run two-layer fillet is used.

6.5 AUSTENITIC MANGANESE STEEL

6.5.1 Surface Preparation

Surfaces to be welded should be dressed to remove any visible cracking or work hardened material.

6.5.2 Preheating and Interrun Temperature

No preheating is used. Interrun temperatures are kept as low as practicable. Allow heat to dissipate from the weld area before placing subsequent runs.

6.5.3 Hydrogen control

Austenitic manganese steel is not adversely affected by hydrogen. Hydrogen controlled welding is not required.

6.5.4 Consumable Selection

Austenitic welding consumables must be used.

6.6 OPERATOR TRAINING

It is strongly recommended that operators are trained and understand the behaviour of the particular material when welded.

In addition welders should be tested in the use of the electrodes to be used in the welding operations, particularly when positional welding using stainless steel or nickel alloy electrodes. Welders can be tested on site by making fillet welds using test pieces made from carbon steel and in the position or positions required for the task. The welds should be mechanically tested by a fillet break test followed by assessment to ensure the welds are crack free and have 90% root fusion. A better evaluation can be made where base metal the same as the job is used as a test piece.

6.6.1 Procedure testing

It is important that welding procedure specifications be used for welding operations and that they undergo qualification and testing.

It is recommended that, as a minimum, a test piece or simulation be produced. The test piece should be the same materials to be used in the lifting operations and should be welded in all of the anticipated welding positions.

The quality of the weld should be proven by striking the carbon steel with a series of hammer blows until it bends without tearing away from the base material. Surface NDE may also be used to supplement the destructive tests.

Records of the tests should be maintained on order to verify the qualification results.

6.6.2 Production verification

Quality of production welds should undergo inspection prior to the lifting operations and should entail:

- Visual inspection; and,
- Surface NDE; or,
- Light hammer blow to ensure weld soundness

Assessment for visual inspection and NDE should be in accordance with AS/NZS 1554 Part 1 or 6 as appropriate.

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PO Box 6165, Silverwater NSW 1811
Unit 50, 8 The Avenue of the Americas, Newington NSW 2127
Ph: +61 (0) 2 9748 4443 Fax: +61 (0) 2 9748 2858
Email: info@wtia.com.au Webpage: www.wtia.com.au



APPENDIX A – WELDING PROCEDURE SUMMARY FOR EACH MATERIAL CLASSIFICATION

WELDING PROCEDURE STEPS	WHITE CAST IRON	WELD OVERLAY CLAD PLATE	Q&T LOW ALLOY ABRASION RESISTANT STEEL	Q&T ENGINEERING STEEL	AUSTENITIC MANGANESE STEEL	REMARKS
SURFACE PREPARATION	Light grind to remove oxides	Gouge or grind through clad layer. Light grind to remove oxides	Light grind to remove oxides	Degrease Light grind to remove oxides	Grind to remove visible cracking and work hardened material	Surfaces must be clean and dry Contaminants will promote cracking
PREHEAT	30°C to 50°C	Not required	120°C to 250 °C	150°C to 300°C Refer WTIA TN 01	Not required	Preheat must be applied just prior to welding
PREHEAT METHOD	Soft flame gently applied over a wide area	Not required	Soft flame or oxy-fuel gas flame applied to an area 100mm around the weld zone	Soft flame or oxy-fuel gas flame applied to an area 100mm around the weld zone	Not required	
PREHEAT CHECK METHOD	Digital contact thermometer or infra red thermometer	Not required	Thermocrayon, digital contact thermometer or infra red thermometer	Thermocrayon, digital contact thermometer or infra red thermometer	Not required	Check preheat before welding to ensure correct temperatures
WELDING CONSUMABLE	AWS/ASME-SFA A5.11 ENiCrFe-3 or AS/NZS 1553.3 E312-16 or E309L-16	AS/NZS 1553.1 E4816 or E4818 or AS/NZS 1553.3 E309L-16 or E312-16	AS/NZS 1553.3 E309L-16 or AS/NZS 1553.1 or E4816 or E4818	AS/NZS 1553.3 E309L-16 or AS/NZS 1553.1 or E4816 or E4818	AS/NZS 1553.3 E309L-16 or AS/NZS 1553.3 E312-16	The first consumable listed is the most suitable

WELDING PROCEDURE STEPS	WHITE CAST IRON	WELD OVERLAY CLAD PLATE	Q&T LOW ALLOY ABRASION RESTISTANT STEEL	Q&T ENGINEERING STEEL	AUSTENITIC MANGANESE STEEL	REMARKS
JOINT TYPE	Double fillet weld	Double fillet weld	Double fillet weld	Double fillet weld	Double fillet weld	Welding must be all around the lug
MINIMUM WELD DEPOSIT	Three-run two-layer fillet	Single run fillet	Single run fillet	Three-run two-layer fillet	Single run fillet	Fillet size to be determined according to load
MAXIMUM INTERPASS TEMPERATURE	30°C to 50°C	Not required	250°C	Minimum as per preheat. Maximum not controlled	Minimum – not required. Maximum not controlled	Minimum preheat must be established prior to welding
VISUAL INSPECTION	The welder shall visually inspect all welds. Ensure correct weld size. Ensure that welding is complete around the base of the lug. Look for any evidence of cracking at the weld toe.					Supervisors should check a percentage of welds
PROOF TESTING	To verify the effectiveness of the welding procedure, it is recommended that a test weld or welds be made and subjected to a hammer bend test. If there are weld failures, review the procedure and attempt to get an improvement in performance.					

APPENDIX B – WEAR LINER AND ENGINEERING STEEL TYPES AND TRADE NAMES

Commercial or Trade Name	Alloy Description	Typical Applications	Main Precautions for Welding	Recommended Preheat and Interpass Temperature	Recommended Welding Consumable
White Cast Iron					
Ni-Hard	Nickel Chrome white cast iron	Wear Liners	Low heat input, low interpass temperature, cool using air if required	30°C 50°C	AWS/ASME-SFA A5.11 ENiCrFe-3 Or AS/NZS 1553.3 E 312-16 Or AS/NZS 1553.3 E309L-16
Ni-Resist	Nickel Chrome white cast iron	Wear Liners	Low heat input, low interpass temperature, cool using air if required	30°C 50°C	AWS/ASME-SFA A5.11 ENiCrFe-3 Or AS/NZS 1553.3 E 312-16 Or AS/NZS 1553.3 E309L-16
Quenched & Tempered Low Alloy Abrasion Resistant Steel					
Bisalloy 80 Weldox 700 Sumiten780S JFE Hiten 780	Low alloy high strength plate	Load carrying structures	High preheat temperatures, controlled interpass temperatures slow cooling	120°C 250°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16 Or AWS/ASME-SFA A5.11 EniCrFe-3
Bisalloy 320 Weldox 900 Weldox 960	Abrasion resistant steel plate Nominal hardness	Liner plates	High preheat temperatures, controlled interpass temperatures slow cooling	120°C 250°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16

Commercial or Trade Name	Alloy Description	Typical Applications	Main Precautions for Welding	Recommended Preheat and Interpass Temperature	Recommended Welding Consumable
Creusabro 4800 JFE-EH320	300-350 BHN				Or AWS/ASME-SFA A5.11 EniCrFe-3
Bisalloy 400 Hardox 400 Fora 400 Sumihard 400 JFE-EH400 JFE-EH400A JFE-EH-SP	Abrasion resistant steel plate Nominal hardness 400 BHN	Liner plates	High preheat temperatures, controlled interpass temperatures slow cooling	120°C 250°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16 Or AWS/ASME-SFA A5.11 EniCrFe-3
Bisalloy 425 Hardox 450 Fora 450 Creusabro 8000 JFE-EH450	Abrasion resistant steel plate Nominal hardness 420 - 450 BHN	Liner plates	High preheat temperatures, controlled interpass temperatures slow cooling	120°C 250°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16 Or AWS/ASME-SFA A5.11 EniCrFe-3
Bisalloy 500 Hardox 500 Fora 500 Sumihard 500 JFE-EH500A JFE-EH500 JFE-EH500L	Abrasion resistant steel plate Nominal hardness 500 BHN	Liner plates	High preheat temperatures, controlled interpass temperatures slow cooling	120°C 250°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16 Or AWS/ASME-SFA A5.11 EniCrFe-3

Commercial or Trade Name	Alloy Description	Typical Applications	Main Precautions for Welding	Recommended Preheat and Interpass Temperature	Recommended Welding Consumable
Quenched and Tempered Engineering Steel					
AISI 4140		Crusher bodies, shafts, crawler track pins, gearing	High preheat temperatures, controlled interpass temperatures, slow cooling	250°C 300°C	AS/NZS 1553.3 E309L-16 Or AWS/ASME-SFA A5.11 EniCrFe-3
AISI 4340		Crusher bodies, shafts, crawler track pins, gearing	High preheat temperatures, controlled interpass temperatures, slow cooling	250°C 300°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16 Or AWS/ASME-SFA A5.11 EniCrFe-3
En25	Bright bar	Pins, shafts	High preheat temperatures, controlled interpass temperatures, slow cooling	250°C 300°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16 Or AWS/ASME-SFA A5.11 EniCrFe-3
En26	Bright bar	Pins, shafts	High preheat temperatures, controlled interpass temperatures, slow cooling	250°C 300°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16 Or AWS/ASME-SFA A5.11 EniCrFe-3

Commercial or Trade Name	Alloy Description	Typical Applications	Main Precautions for Welding	Recommended Preheat and Interpass Temperature	Recommended Welding Consumable
AISI 8630		Adjustment nuts, track wheels	High preheat temperatures, controlled interpass temperatures, slow cooling	200°C	AS/NZS 1553.3 E309L-16 Or AS/NZS 1553.3 E312-16 Or AWS/ASME-SFA A5.11 EniCrFe-3
Austenitic Manganese Steel					
AS 2074 Grade H1A & H1B	High alloy, non magnetic work hardening alloy 11-14% Manganese	Wear liners, crusher mantles	Low heat input, low interpass temperature	No preheating to be applied. Maximum interpass temperature 150°C	AS/NZS 1553.3 E309-16 Or AS/NZS 1553.3 E312-16
ASTM 128 Grades (11 to 14%)	High alloy, non magnetic work hardening alloy 11-14% Manganese	Wear liners, crusher mantles	Low heat input, low interpass temperature	No preheating to be applied. Maximum interpass temperature 150°C	AS/NZS 1553.3 E309-16 Or AS/NZS 1553.3 E312-16
Weld Overlay Clad Plate					
Arco Alloy 800	Mild steel plate clad with a complex chromium carbide layer	High stress abrasion resistant wear plates	Remove weld overlay material	50°C 300°C	AS/NZS 1553.1 E4816 or E4818 AWS/ASME-SFA 5.1 E7016 or E7018
Arco Alloy	Mild steel plate clad	High stress	Remove weld overlay material	50°C	AS/NZS 1553.1 E4816 or E4818

Commercial or Trade Name	Alloy Description	Typical Applications	Main Precautions for Welding	Recommended Preheat and Interpass Temperature	Recommended Welding Consumable
1600	with a complex chromium carbide layer	abrasion resistant wear plates		300°C	AWS/ASME-SFA 5.1 E7016 or E7018
Duabar	Mild steel plate clad with a complex chromium carbide layer	High stress abrasion resistant wear plates	Remove weld overlay material	50°C 300°C	AS/NZS 1553.1 E4816 or E4818 AWS/ASME-SFA 5.1 E7016 or E7018
Vidaplate	Mild steel plate clad with a complex chromium carbide layer	High stress abrasion resistant wear plates	Remove weld overlay material	50°C 300°C	AS/NZS 1553.1 E4816 or E4818 AWS/ASME-SFA 5.1 E7016 or E7018

APPENDIX C – WELDING CONSUMABLE CLASSIFICATIONS AND TRADE NAMES

Classification		Trade Name	Supplier/Manufacturer
AS/NZS	AWS/ASME-SFA		
1553.1 E4818/E4816	A5.1 E7016/E7018	These electrodes are proprietary consumables available from all major suppliers	
1553.3 E309L-16	A5.4 E309L-16	Limarosta 309S	Lincoln Electric
1553.3 E312-16	A5.4 E312-16	Limarosta 312	
	A5.11 ENiCrFe-3	NiCr 70/15	
1553.3 E309L-16	A5.4 E309L-16	Ultramet 309L	Metrode/Specialised Welding Products
1553.3 E312-16	A5.4 E312-16	Supermet 312	
	A5.11 ENiCrFe-3	Nimrod AKS	
1553.3 E309L-16	A5.4 E309L-16	Eutectrode 57	Eutectic
1553.3 E312-16	A5.4 E312-16	680 CGS Xuper	
	A5.11 ENiCrFe-3	XHD 2222	
1553.3 E309L-16	A5.4 E309L-16	Speedex 309L-16	Cigweld
1553.3 E312-16	A5.4 E312-16	Speedex 312-16	
1553.3 E312-17	A5.4 E312-17	Weldall	
1553.3 E309L-16	A5.4 E309L-16	AI 209	Alloys International
1553.3 E312-16	A5.4 E312-16	AI 240	
	A5.11 ENiCrFe-3	AI 382	
1553.3 E309L-16	A5.4 E309L-16	CARBO 4332	Wear Protection Services
1553.3 E312-16	A5.4 E312-16	CARBO 29/9	
	A5.11 ENiCrFe-3	CARBOWELD A	

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PO Box 6165, Silverwater NSW 1811
 Unit 50, 8 The Avenue of the Americas, Newington NSW 2127
 Ph: +61 (0) 2 9748 4443 Fx: +61 (0) 2 9748 2858
 Email: info@wtia.com.au Webpage: www.wtia.com.au



NDNP TECHNOLOGY DIFFUSION ACTIVITY # 27	 Welding Technology Institute of Australia ABN 69 003 696 526	Document No: 9.4.6QR-0004
	NATIONAL DIFFUSION NETWORKS PROJECT TECHNOLOGY QUESTIONNAIRE Mining Industry Group “Welding on to difficult to weld materials”	Revision No: Rev 0
		Page 1 of 2 Date: 19 June 2006

As part of the WTIA National Diffusion Networks Project the Mining Industry Sector has identified the need to weld temporary attachments to difficult to weld materials generally for the purpose of extracting the worn component from the processing environment. The WTIA has prepared a guidance note “Welding onto difficult to weld materials” that covers how to go about such welding as well as provide recommendations on the appropriate welding consumables. As a valued technology expert in this area we would like you to be part of the Technology Expert Group to review this document Please complete this questionnaire so that we can gauge the success of meeting this need.

Objective 1: Identify the need for a simple and readily available guide to welding symbols

Maintenance crews need a guide to determine the viability of welding temporary lifting lugs on to “difficult to weld” materials – particularly cast irons and how to go about such welding. How well does the document achieve these aims?

poor average good very good

Comments: _____

Objective 2: Identify appropriate technology receptors

This document was written for Welders and Welding Coordinators involved in Maintenance and Repairs for the mining Industry. Are these people the appropriate individuals we should be targeting?

yes no

What other types of companies and/or personnel do you suggest we target? _____

Objective 3: Identify current best practice for repair & maintenance welding

The document was written to reflect current best practice for temporary welded connections on difficult to weld components. Do you envisage opportunities for the use of this practice in industry?

yes no

If yes, what and where, if no why not? _____

Objective 4: Is the information provided clear, concise and accurate?

yes no

If not, why? _____

Objective 5: Broad dissemination of technology to the Mining Industry

Please indicate how best to disseminate this document to the appropriate Industry Recipients

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