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Track gas usage with contents indicator, showing the amount of gas left in the cylinder.

Standard 5/8” fitting works with existing hoses and connections (provided they meet the relevant Australian standards).

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Subscription to the Australian Welding Journal is a WTIA member benefit included in annual membership fees. It is also available through the WTIA at a cost of AU$220 (or NZ$230) per annum within Australia, or $265 internationally.
From the WTIA CEO

Since 2005, the annual weight of fabricated steel imported into Australia has risen from 100,000t to over 600,000t or 30% of the total market. This has had a significant negative impact on the fabrication industry, leading to fewer employment opportunities for welders. As older workers have left the industry and apprentice numbers have dried up, the quality and quantity of skilled welders available to deliver projects has reduced.

This situation has been exacerbated by successive governments placing far greater emphasis (and therefore funding allocation) on university degrees, at the expense of vital Vocational Education and Training.

Furthermore, state government free market policies that encourage competition between private Registered Training Organisations (RTOs) and TAFEs, coupled with cut backs throughout the TAFE system, has left Australian industry with a severe shortage of highly skilled welders.

As a result, asset owners and prime contractors are faced with pass rates for welding tests of less than 10%. And, at $1,000 per test, costs are quickly becoming restrictive.

This is certainly not the fault of welding tradesmen. It has been many years since the trades of welder and boilermaker were taught at Australian TAFEs. Instead, they have been replaced by courses such as light and heavy fabrication, in which the welding modules are of varying degrees of complexity, and are usually optional.

In addition, there is simply no continued professional development, incentive or career structure for welders and fabricators in Australia.

To combat these problems, the WTIA will soon be launching the Australian Welder Certification Register (AWCR).

The AWCR is similar to ‘Welder Passport’ systems used in Europe. Welders are invited to complete a weld test, at an approved testing centre, which will qualify them to a welding procedure according to the process set out in ISO9606-1 (AS/NZS2980).

Once qualified, the welder will be certified to that procedure and this information recorded in the AWCR. Once on the AWCR, the welder will be a “Registered Welder” (RW). Access to the certification database is free to WTIA Corporate Members.

By testing and certifying welders to ISO9606-1 we hope to:
• Create welding jobs by increasing the efficiency and profitability of Australian industry
• Provide a framework for upskilling Australian welders and improving their employability
The benefits offered to employers by the AWCR are numerous, and include significantly reduced costs. Through the AWCR employers will be able to check the competence level of any RW against an internationally recognised standard, minimising the number of expensive tests required to qualify to specific weld procedures.

Employer risk will also be minimised. The introduction of this industry-wide certified competency level significantly reduces the risk of a welder failing a weld procedure.

As a Registered Welder must retain currency to remain on the AWCR, employers will be able to assess their skills against current, rather than past performance. In fact, employers will have access to an unparalleled welding skills database.

The benefits offered by the AWCR are just as significant for welders and fabricators, as they are to employers.

Registered Welders will enjoy greater employability, in Australia (where employers can readily access verified work history and qualifications) and throughout Europe and North America, where ISO9606-1 is also the recognised industry standard.

In conjunction with the testing framework established as part of the AWCR, training providers will offer short courses to upskill welders, enabling them to tackle more demanding weld tests.

Registered Welders will also have the opportunity to test themselves on more complex weld procedures. This will in turn lead to greater recognition by employers and more satisfying and rewarding career opportunities.

It is in response to feedback from its members, that the WTIA has undertaken this bold initiative and invested in state-of-the-art software to manage the AWCR. The system we have developed will be one of the most advanced available anywhere in the world.

However, the time and effort taken to design and implement the AWCR will be wasted without the support of WTIA members.

I encourage all WTIA Corporate Members to become Supporter Companies, to incentivise their staff to become Registered Welders, and to promote the scheme wherever possible. And I urge all Individual WTIA members to become Registered Welders.

It is only together that we can reinvigorate the trade of welding in Australia.

Become A Supporter Company

WTIA Corporate Members are being given first option to be listed on the AWCR website as a Supporter.

Supporters will receive logo acknowledgment on the AWCR website, as well as a link to your own company’s website.

Please contact the WTIA on membership@wtia.com.au to become a Supporter Company.
Inside the Industry: Breaking News

Greens Steel Bill Gets Through NSW Upper House

The future of the Australian steel industry is one step closer to being secured, with the Greens Steel Industry Protection Bill passing through the New South Wales (NSW) Upper House in late August.

The bill calls for the NSW government to use 90% Australian steel in all projects, and will also create the position of Steel Industry Advocate, which would be tasked with ensuring that Australian standards and certification for Australian-made steel is monitored and complied with by manufacturers and contractors.

Every political party in the NSW Parliament, except the Liberal and National Coalition, voted in support of the bill.

Greens MP David Shoebridge said, “This is an historic day for the Illawarra region, the steel industry and politics, with the NSW Upper House passing a bill that requires all state-funded infrastructure projects to use Australian steel.

“This is the first time that a procurement policy, designed to ensure the ongoing viability of a key manufacturing industry, has passed any parliamentary chamber in Australia in the last 30 years.”

IIW and EWA Sign Memorandum of Understanding

The IIW (International Institute of Welding) recently signed a Memorandum of Understanding (MoU) with the EWA European Welding Association (EWA).

The MoU will see the two organisations collaborate on a number of projects, with the objective of sharing technical information and promoting solutions, particularly in relation to health and safety issues within the global welding industry.

DCNS and University of New South Wales Boost Collaboration on Research and Development

DCNS and the University of New South Wales (UNSW) have signed an agreement to collaborate more closely on engineering and marine technologies for Australia’s Future Submarine Program.

The Memorandum of Understanding (MoU) signed in Sydney by DCNS Australia Chief Executive Officer Sean Costello and UNSW Vice Chancellor Ian Jacobs enters the two organisations into a relationship and establishes a framework for cooperation. This agreement builds on the existing relationship between DCNS and UNSW developed over a number of years.

Co-operation between DCNS and UNSW in the areas of submarine technology will operate under stringent security requirements that govern the manner in which all information and technical data is managed. As part of DCNS’s industry plan, the investment in technologies to support Australia’s Future Submarine Program will take place in close consultation with the Department of Defence.

“The signing of this MoU maps to our Australian Industry Capability Plan which aims to cultivate an innovation environment around our scientific, education and industrial community,” said Mr Sean Costello, CEO, DCNS Australia. “This signing is in lockstep with the Turnbull government’s national innovation agenda which encourages the forging of stronger links between industry and universities as one of its key pillars.”

DCNS was announced in April as the successful bidder to build 12 submarines for the Royal Australian Navy.
Monadelphous Secures Ichthys Contract

Engineering company Monadelphous has secured an additional contract for works on the INPEX-operated Ichthys LNG Project.

The contract was awarded by project construction contractor JKC Australia and involves electrical and instrumentation works for the product loading jetty at the project's onshore facilities in Darwin in the Northern Territory. It follows on from the $680 million contract awarded to Monadelphous in 2014 for mechanical works at the onshore LNG facilities at the Ichthys Project.

The Ichthys LNG Project comprises an onshore LNG processing plant, offshore processing facilities, condensate storage, a 500 MW combined-cycle power plant and an 889 km, 1,050 mm diameter offshore pipeline. The project will develop gas from the Ichthys gas field, located approximately 200 km offshore northwest Australia.

Caterpillar to Cease Production of Underground Mining and Drilling Equipment

Caterpillar recently announced that it will discontinue production of track drills, and room and pillar products, used by underground soft rock mining customers.

“These moves, which align with Caterpillar’s ongoing restructuring, will allow us to focus resources on those areas of the business that provide the highest, sustainable growth and best long-term returns,” said Denise Johnson, Group President, Resource Industries.

The room and pillar underground mining products under review include continuous miners, feeder breakers, coal haulage systems, highwall miners, roof bolters, utility vehicles and diesel vehicles. While under review, Caterpillar will stop taking new orders.

Production of track drills will be discontinued, and no new orders will be taken.

New Warship Alliance Management Agreement

The new sustainment agreement between the Australian Government and Defence industry to support the Royal Australian Navy’s ANZAC class frigate fleet came into effect on 1 July. As a result, BAE Systems Australia has received its first order, worth approximately $200 million.

The partnership, which includes BAE Systems Australia, Saab Australia, Naval Ship Management and the Commonwealth of Australia is valued at over $2 billion over eight years. Central to the new agreement is the RAN’s requirement for improved capability and availability of the fleet.

BAE Systems’ involvement in the partnership (known as the Warship Asset Management Agreement) includes asset management in Rockingham (Western Australia), platform engineering and integration support in Williamstown (Victoria), and major refit and upgrade implementation at Henderson (Western Australia).

BAE Systems Australia Chief Executive Glynn Phillips said, “BAE Systems' involvement in this agreement reflects the work that the Company has done to date in the sustainment of the ANZAC class fleet over the last 15 years, including the upgrade of these frigates with a world leading Anti-Ship Missile Defence capability. Our work on this program allows industry to retain important skills in engineering and program management.”
$31.6 Million for Next Generation Manufacturing in South Australia and Victoria

Manufacturers in South Australia and Victoria will share in $31.6 million to boost their high value manufacturing capability as part of the Turnbull Government’s $90 million Next Generation Manufacturing Investment Program.

The second round of funding under the program will help 22 firms to undertake capital projects to support technological innovation, expand capability and develop state-of-the-art processes and equipment.

A complementary investment of $104.5 million from the firms will result in a $136 million injection to the manufacturing sector across both states, delivering strong economic benefits and creating over 500 jobs.

Funded projects will boost advanced manufacturing capabilities across several industries including the pharmaceutical and medical device sectors, precision engineering and tooling, industrial textiles and engineered timber building products.

Thirteen Victorian firms will be offered total funding of $16.2 million, which is expected to leverage more than $78 million in investment. A further $15.4 million will be offered to nine South Australian firms for projects with a total investment of over $57 million.

The $90 million Next Generation Manufacturing Investment Program is a key part of the Australian Government’s $155 million Growth Fund to assist employees, businesses and regions affected by the closure of Australia’s car manufacturing industry by 2017.
**Pyne Prioritises Cairns for Defence Industry Production**

Minister for Defence Industry, The Hon Christopher Pyne MP, recently met with key Defence related companies based in Cairns, Queensland, to discuss the opportunities for local industry in the delivery of Australia’s Defence capability.

The Minister visited BAE Systems Australia and was briefed on the support they provide to the Royal Australian Navy. He also toured Norship Marine’s vessel maintenance and storage facility and Tropical Reef Shipyard’s ship repair facilities to see first-hand the important work they do to maintain Royal Australian Navy vessels based in the region.

“Cairns is absolutely vital to our plans for Australia’s defence industry,” Mr Pyne said. “Australia has vast areas of coast line to protect and Cairns has an essential role safeguarding Australia’s maritime approaches and borders.”

“This Government is implementing an unprecedented continuous build of surface warships and minor war vessels in Australia, including our Offshore Patrol Vessels (OPVs), some of which will be based here in Cairns.”

“The deep maintenance of the Pacific Patrol Boats being built in Western Australia will also happen right here in Cairns, with the total support and sustainment investment estimated at more than $400 million across the life of the vessels,” said Mr Pyne.

In addition to the $400 million for the Pacific Patrol Boats, the Prime Minister has committed $24 million to upgrade the Cairns Marine Precinct. “The strengthening of our Defence capabilities will have a significant positive flow-on effect for local business and the Cairns economy,” said Mr Pyne.

The Minister also met with Navy members based at HMAS Cairns and inspected the facilities that support Defence operations.

“As the Minister for Defence Industry, my first duty is to ensure the investment this Government is making in Defence capability will enable the serving men and women to continue to protect Australia’s interests in the region,” said Mr Pyne.

**BlueScope Steel Seeking Cost Savings Despite 160% Year-on-Year Profit Increase**

BlueScope Steel’s turnaround has gained further traction, with the company reporting a full year profit of $354 million — a 160 per cent improvement on last year, which saw a net loss of $82.4 million.

“Our direct interventions in reducing costs have significantly lifted performance of our steelmaking operations in Australia and New Zealand despite continuing global overcapacity and production,” said CEO Paul O’Malley, according to *The Australian*.

However, O’Malley said that the decrease in global steel prices and Chinese demand, as well as increase in global production, were all creating a squeeze.

“At these prices, it would be more competitive to externally source steel substrate than to continue to operate our Australian and New Zealand steelmaking operations – unless we deliver a game-changing approach to costs to improve their competitiveness,” said O’Malley. BlueScope is seeking to save $200 million in Australia by June 2017 and $50 million in New Zealand.

Sources:
- www.manmonthly.com.au
- www.abc.net.au
- www.businessinsider.com.au

**Australian Institute for the Certification of Inspection Personnel**

The WTIA is no longer acting as the Secretariat for the Australian Institute for the Certification of Inspection Personnel (AICIP). WTIA has operated the AICIP Secretariat since its inception in 1997.

Following a tender process instigated by AICIP, operation of the secretariat was awarded to the AiGroup. Consequently, as of 30 June 2016, all AICIP Secretariat matters are being handled by the AiGroup.

All inquiries regarding AICIP including examinations, renewals (such as re-certifications, payments and accounts) should be addressed to Lara Hubczenko via:
- A: AiGroup, PO Box 7622, Melbourne 3004
- E: associations@agroup.com.au
- T: (08) 8394 0008
- W: www.aicip.org.au
By way of this agreement, the Institut de Soudure Group will be able to extend its activities, which are currently focused mainly on metal materials, to composite materials. The Group thus positions itself for success within a high-growth market, particularly in the aeronautics and automotive industries.

Thanks to its national and international network, as well as PPE’s portfolio of over 8,000 clients, this agreement will greatly improve the Institut de Soudure Group’s developments within the composite materials sector. The objective of the Institut is to become a leader in the fields of multi-material assembly and associated non-destructive testing.

By integrating PPE’s research and development and engineering activities into its scope of services, the Institut de Soudure Group forms its fourth industrial platform for developing assembly and inspection technologies for industrial companies. The composite platform, which will allow development of transformation processes for continuous-fibre composite materials completes the assembly, mechanical and corrosion and industrial maintenance platforms.

The Institut de Soudure Group and PPE have been working together since 2007 on European research and developments projects and also via their joint subsidiary, Composite Integrity. Composite Integrity was created in 2010 and specialises in the non-destructive testing of composite parts. As part of the newly signed agreement, the Institut de Soudure will gain full control of this subsidiary, which will have a mechanical testing and analysis lab for material composites transferred by PPE. This lab is undergoing substantial investment to bring its aeronautical certifications up to standard and to acquire new chemical and mechanical characterisation equipment.

According to Sylvain de Lescazes, President of Institut de Soudure Group, “This agreement is part of the Group’s strategy which involves diversifying its activities, external growth operations and its continued effort in terms of research and innovation. It allows the Group to develop its expertise and its support to industrial companies in the fields of materials, assemblies and associated techniques. Thanks to the strength of the Institut de Soudure Group’s network, the agreement also contributes to sustaining jobs in the Saint-Avold and Porcelette area”.

About the Institut de Soudure Group

The French Institut de Soudure Group has 28 centres in France and nine abroad; it employs over 1,000 people and lends its expertise to the world of industry. Renowned for its experience, research and development platforms for over 100 years, the training provided by the Group caters to all branches of welding and related controls. The Group provides innovative solutions to companies all over the world, during design, manufacture and maintenance of welded equipment and assemblies. To ensure risk control and product quality, it offers inspection and testing services, and metallurgic expertise.
The welding equipment, accessories, and consumables market is expected to be worth $24 billion by the year 2021.

This prediction is according to the recently published report, *Welding Equipment, Accessories, and Consumables Market by Technology (Arc Welding and Oxy-Fuel Welding), Equipment Type (Welding Electrode, Filler Metal, and Oxy-fuel Gas), Accessory, Consumable, End-Use Industry, and Region - Global Forecast to 2021*.

Released by MarketsandMarkets in late August, the report predicts the market size to grow from $19.57 billion in 2016 to $24 billion by 2021 at a compound annual growth rate of 4.23%.

Factors such as increased demand for welding equipment, accessories, and consumables in the Asia-Pacific market and increased demand from such industries as construction, automobiles, steel, and oil and gas are expected to contribute to the upswing.

The shielding gas segment dominated the market in 2015 and is projected to be the fastest-growing segment in the next five years as a result of the rising demand for argon gases by the industries to meet the demand. Furthermore, the oxyfuel segment is projected to be the second fastest-growing industry.

Arc welding is projected to grow at the fastest compound annual growth rate because of increased rates of demand from emerging countries such as China and India, which are ranked first and second, respectively, in the global welding equipment, accessories, and consumables market.

The second fastest-growing sector is that of oxyfuel welding.
Submarine Boost for Australian Advanced Manufacturing

By the Hon. Christopher Pyne MP
Minister for Defence Industry

In 1993, at the age of 25, the Hon. Christopher Pyne was elected to the House of Representatives for the seat of Sturt. Today, Mr Pyne is the Minister for Defence Industry, and the Leader of the House of Representatives. Previously, Mr Pyne was the Minister for Industry, Innovation and Science and was responsible for the development of the National Innovation and Science Agenda in 2015, a transformative economic plan to encourage Australians to embrace risk and commercialise their ideas.
The Government’s recent announcement that the nation’s next generation of submarines will be built in Adelaide is tremendous news for defence but also a very positive development for advanced manufacturing. At more than $50 billion, it is the largest and most complex defence acquisition Australia has ever undertaken. Crucially, it represents significant opportunities for Australian firms and workers across a range of sectors and professional and technical trades.

The Future Submarines will be superior in terms of sensor performance, stealth and endurance. There will be a new design to meet our defence capability requirements, drawing on the latest technology. In short, the Future Submarine will be a highly complex and impressive piece of machinery.

Building it is going to take advanced skills, materials, engineering, systems and technology—but Australia is ready for the challenge. We have a reputation for building cutting-edge defence capability.

Australia has developed computer systems for the Air Warfare Destroyer, manufactured high-technology sub-assemblies for the Joint Strike Fighter and the Super Hornet, and developed a ballistic correction system for the Bushmaster. That reputation is set to be enhanced as we embark on building the Future Submarine.

The Government anticipates the Future Submarine Project will create 2,800 high-tech and manufacturing jobs. An anticipated 1,100 direct jobs will be in Adelaide, where the submarines will be constructed, and a further 1,700 jobs will be created through the supply chain. We’ll need to utilise the skills of naval architects, mechanical, electrical and marine engineers, electricians and painters, as well as system integrators and project managers.

The program will be managed to maximise the opportunities for Australian firms to supply key materials, components and equipment, including the use of Australian steel.

Manufacturing matters to Australia’s economy—it remains integral to our nation’s economy. In 2014-2015, Australian manufacturing employed around 900,000 Australians and contributed about $100 billion in Gross Value Added in real terms to Australia’s GDP.

The Future Submarine Project is a shot in the arm for Australian manufacturing. The commitment to an Australian build will create a sustainable Australian naval shipbuilding industry and provide the certainty that industry requires to invest in innovation and technology and grow its workforce.

It complements initiatives in the Defence Industry Policy Statement, which was released in conjunction with the Defence White Paper in February 2016. Measures announced in the statement will transform the defence industry. They will also help us to continue to capitalise on our strengths and enhance our global reputation for developing breakthrough defence technologies.

The Centre for Defence Industry Capability, an Investment of $230 million, is at the cornerstone of the statement. The Centre’s aim is to ensure the Australian defence industry is sustainable, internationally competitive, and aligned with our defence capability requirements. The Centre, which will be headquartered in Adelaide, will commence operations in the second half of 2016.

Advanced manufacturing is also one of six key high-growth industry sectors of competitive strength and strategic priority where the Government is concentrating its investment through the $248 million Industry Growth Centres Initiative. Growth Centres are working to lift the levels of collaboration between businesses, industry, research organisations and government in order to better capitalise on the excellent research and development undertaken and scientific knowledge generated in Australia.

The Future Submarine announcement, along with our other commitments in this area, means the road ahead for Australian manufacturing is rich with opportunity. Subject to further commercial discussions, the Department of Defence expects to commence the design of the Future Submarines with DCNS this year.

We live in a rapidly changing world. Australia’s defence forces need the highest levels of capability as they work to protect our interests nationally and overseas. The Government has the right policies and programs to ensure that Australian firms can meet the challenges and provide defence with the best equipment to carry out its mission.

The Government’s continued investment in locally produced defence technology will generate benefits beyond local defence firms, it will also deliver jobs and encourage innovation for businesses and communities right across Australia.
Business Essentials: Tips for Air-Tight Contracts

A clear, comprehensive, and air-tight contract is the lynch-pin of a professional business relationship. Contracts are legally enforceable, and come in two forms: written and verbal. Verbal contracts are notoriously unreliable, but written contracts will place you on much surer ground. Once you’ve got something in writing, signed by both parties, there can be no dispute over the terms explicitly stated in that specific agreement.

But you haven’t necessarily got an air-tight contract yet. Indeed, even written contracts can have clumsy and misleading language, and must be carefully written so as to protect your interests.

**Contract Essentials: Clarity, Understanding, and Detail**

For contracts to do their job properly, they must provide effective communication. We’ll get to the particulars of what air-tight contracts should cover later, but if a contract fails at communicating effectively, you’ll likely to find yourself on a slippery slope.

The first thing you’ve got to realise is that language must be clear. There is no place for pretty synonyms. Use terms that clearly reference what you’re trying to say.

**Write With Clarity**

The clarity and consistency of your language will aid understanding, but don’t leave anything to chance. By writing in plain English and defining terms where necessary, you’ll be one step closer to an agreement that leaves both parties on solid ground.

Effective communication, then, demands understandable terms that provide sufficient detail. But how much detail is enough detail? After all, there’s no need to re-vamp War and Peace to pen a legally enforceable welding contract. Fortunately, detailed contracts don’t have to be novels—far from it. What we’re getting at here is precision. Writing with sufficient detail will eliminate vagueness from your contract, and it’s vagueness that could land you in trouble.

**Don’t Be Vague**

Here’s an example to make things clear. If one party is agreeing to complete an element of work by a certain date, make sure to reference a specific date. A vague contract might say something like: ‘…to be completed by the middle of April.’ Well, when is that exactly? Don’t leave room for confusion. If you mean ‘…to be completed by April 15th’, then say so explicitly. Contracts don’t have to be set in stone, of course. And if both parties agree to alter a contract once signed, then make sure to explicitly state the changes to the contract by writing—and signing—an amendment.

**Contract Essentials: Payment and Termination**

It’s no surprise that many contract

A clear, comprehensive, air-tight contract is the lynchpin of a professional business relationship.
disputes revolve around money. So it’s vital to include clear stipulation about payment details. It might be that one party wishes to pay via instalments, or has a preference for a certain payment type. Each of these provisos must be clearly stated.

**TIP:** Sometimes work must be completed to a specific timeline in order to be valuable. In such cases, one party might want payment to depend on whether this time constraint is met. Conditions are the name of the game in contracts, but you must make sure to be clear and direct about these instances.

An air-tight contract must be explicit about payment details, but equally as explicit about the reality of termination.

There are a number of common methods of termination:
- A mutual termination agreement will apply when the objectives of each party have been realised.
- A frustration clause will allow a party to terminate the contract due to unforeseen events.
- A convenience clause allow either party to terminate the contract by providing the agreed upon notice period.
- It’s also common practice to pen agreements that allow either party to terminate the contract should the other party fail to meet defined commitments. Above all, make sure to be clear and detailed about this information.

**Legal Advice**
It’s important to stress that there is no substitute for consultation with a legal professional. Whilst you can find a great deal of information to inform you about contract best-practices, a qualified contract lawyer will ensure valuable peace of mind.

**The Australian Construction Standards General Condition of Contract**
A comprehensive and informative source of information is the newly provisioned AS11000: General conditions of contract. This document replaces two prior Standards, AS2124–1992, and AS4000–1997. AS11000 provides broad guidance on legal contracts across all aspects of the construction industry.

When AS11000 was released last year, Standards Australia issued a statement, saying that the new contract is intended to provide ‘a broadly balanced approach to risk allocation, in language which is focused on brevity and certainty’. In other words, the new contract is intended to evenly and fairly allocate the various and inevitable risks in the construction industry in clear and simple terms.

By adhering to the requirements and stipulations of AS11000, which features a number of changes to its predecessors, you will be well placed to uphold the legal standards of the industry.

For more information on AS11000, please visit www.standards.org.au

*It is important to note that this article provides general information only, and should not be construed as specific legal advice.*

**STAY AHEAD OF THE CURVE**
Smithweld Enterprises has been designing and manufacturing quality mechanised welding equipment and accessories for over 23 years. Our products give you the edge over your competitors in terms of productivity, reliability, and efficiency. Our superior quality, Australian-made product range, industry knowledge and genuine customer service means you get the best possible equipment for your job, every time.
The Australian Welder Certification Register

Developed by the WTIA, the Australian Welder Certification Register (AWCR) is similar to the ‘Welder Passport’ systems used in Europe and North America. The software system (WeldQ) is a fully internet enabled e-commerce platform with a supporting mobile app, which is one of the most advanced in the world. The benefits to both welders and employers alike are great, including improved employability and a recognised career path for welders, and reductions in cost and risk for employers.

What is the Australian Welder Certification Register?

The AWCR is similar to the ‘Welder Passport’ systems used in Europe and North America. The software system, WeldQ, is a fully internet enabled e-commerce platform with supporting mobile app developed by the WTIA and is one of the most advanced in the world.

Welders are invited to complete a weld test, at an approved testing centre, which will qualify them to a welding procedure according to the process set out in ISO9606-1 (AS/NZS2980). The scheme is based around a number of weld procedures covering a range of processes, product, weld type, filler material, dimension, position and weld details. Once qualified, the welder is certified to that procedure and this information recorded in the National Register.

As required by ISO 9606-1 and AS/NZS2980, certification is valid for up to two years subject to six monthly confirmations by a responsible person (Supervisor or Approved Examiner). At the end of the period, certification will be re-validated by an Approved Examiner normally by the testing of two routine production welds completed in the final six months of certification.

Individuals who appear on the Register will be able to use the title ‘Registered Welder’ and entitled to the letters RW after their name. Registered Welders will be able to record details of their other verified qualifications and work history on the system. They will then have the option of making this information and their contact details available to prospective employers.

Benefits to Welders

Improved Employability
The AWCR is supported by WTIA Corporate Members who have committed to prefer Registered Welders when recruiting. In addition, welders will have the opportunity to present their work history and qualifications in a variable format to prospective employers.

Certification under ISO 9606-1 is recognised in Australian, European and North American standards, increasing the opportunity for Registered Welders to work for international companies in Australia and overseas.

Continuous Upskilling
In conjunction with the testing framework established as part of the AWCR, training providers will be offering short training courses to upskill Registered Welders to enable them to tackle more demanding weld tests.
Recognised Career Path
As a Registered Welder, you will have the opportunity to test yourself on more complex weld procedures. This will in turn lead to greater recognition by employers and more satisfying and rewarding career opportunities.

Responsibilities of Registered Welders
Registered Welders are responsible for maintaining their certification record on the system; failure to do so could lead to certification being suspended or withdrawn. To help, you will receive notification of a required action either from the system or from the AWCR staff. As a Registered Welder, you must ensure that:
• Your contact details, qualifications and work history are up to date.
• Details of every weld test you pass are accurately entered onto WeldQ by the Approved Examiner who conducted the test.
• Your supervisor or other responsible person provides evidence for your six monthly confirmation and this information is entered on your record.
• At the two year point, you promptly complete the revalidation process to prolong your certification for a further two years.

Benefits to Employers

Reduced Costs
Through the AWCR, employers can check the competence level of any Registered Welder against an internationally recognised standard. This will enable employers to minimise the number of welders required to be tested to qualify to specific weld procedures.

Minimised Risk
By having a recognised and certified competency level, the risk of a welder failing a weld procedure is significantly reduced. Furthermore, the chance of errors in employer test procedures is reduced.

Currency of Certification
As a Registered Welder must retain currency to remain on the register, employers will be able to assess welders against current (rather than past) performance. Employing Registered Welders provides independent records of qualification, simplifying record keeping for quality management systems.

Unparalleled Access to Skills Base
Through the work history portal employers will be able to identify and contact Registered Welders.

Responsibilities of Employers
• Encourage and incentivise welders to join the scheme.
• Prefer the employment of Registered Welders wherever practical.
• Regularly promote the scheme.
• Nominate an AWCR ‘Champion’ to ensure the register is kept up to date.
• Register suitably qualified staff for Approved Examiners status.
• Use the system to certify your own weld procedures.
The Changing Face of Welding Standards

There have been a number of new developments within the remit of Australian Standards over the last quarter, particularly in relation to those dealing with structural steel. Public comments have closed on DR AS/NZS5131 Structural Steelwork – Fabrication and Erection. With such a large number of comments received, the revised version of the standard will be circulated for review. In addition, two new projects have been approved, which will see the revision of AS/NZS2980 Qualification of welders for fusion welding of steels, and the amendment of AS/NZS1554.3 Structural steel welding.

Structural Steel Standards
Public comments have now closed on the proposed standard Structural Steelwork – Fabrication and Erection (DR AS/NZS5131).

The drafting committee has reviewed all comments and made their recommendations. Due to the large number of comments received by the committee, Standards Australia has announced that a revised draft will be recirculated for a combined ballot and public review process. This is standard procedure where a large number of comments have been made leading to technical changes within the document.

The WTIA encourages all members of the welding and steel sectors to access the draft and provide further comments when it is released.

Standards Australia has also approved two new projects within the structural steel sector.

These projects include:
1. A project to revise AS/NZS2980 has been approved and a launch meeting is in the process of being scheduled.
2. A project to amend AS/NZS1554.3, as proposed by the Steel Reinforcing Institute of Australia has also been accepted. The amendments will correct a number of known errors and propose a number of changes to the standard.

Join the WTIA
Help Secure the Future of Australia’s Welding Industry: Become a WTIA Member Today.

The WTIA is dedicated to providing members with a competitive advantage through access to industry, research, education, government, and the wider welding community. Our primary goal is to ensure that the Australian welding industry remains both locally and globally competitive, now and into the future.
The launch meeting for both of these projects has been delayed at the request of Standards Australia, although it is hoped that the meeting will take place towards the end of September.

**Corrections to AS/NZS1554**

Corrections are required for AS/NZS1554 parts 1, 4 and 5. The correction required in part 1 is minor. However, in parts 4 and 5, there are a number of errors that need to be corrected. These errors relate to the permissible levels of imperfections (Table 6.2) that could mislead or confuse users due to the use of conflicting symbols. It is anticipated that the corrections will be dealt with during the upcoming launch meeting (for the structural steel sector projects) mentioned above.

**Aged Standards Review**

At the request of Standards Australia, committee WD-003 is undertaking a review of key aged standards, issued by other committees that are no longer active. These standards include AS1101.3, AS1674.1, AS2812, AS3545, and the AS2205 series, among others.

Whilst it is anticipated that some of these standards may require revision, most do not and it is anticipated that all will be reconfirmed at the earliest opportunity pending the identification and revision after reconfirmation.

**Review of AS3788**

It has been apparent for some time that AS/NZS3788 Pressure equipment—In-service inspection is in serious need of revision. WTIA has submitted a project proposal to Standards Australia on two separate occasions but has been unsuccessful in having it accepted. Because of the lead time now required to achieve a full revision of the standard, an industry group representing key stakeholders has come together to consider how to best proceed.

The group proposes to draft a Pressure Equipment Repair Code and a Technical Specification with a view to forming the basis for the future revision of AS/NZS3788 by Standards Australia and Standards New Zealand.

**Expressions of Interest for AS/NZS3788 Working Group**

We would like to invite interested industry experts to participate in a drafting working group to prepare and publish these documents. It is anticipated that the working group will:

1. Review AS/NZS3788 Pressure equipment—In-service inspection
2. Draw upon the current technical literature
3. Incorporate new inspection techniques, methods and technologies not specifically given cognisance within AS/NZS3788
4. Draw upon latest national and international research

Once published, it is anticipated that the code will remain readily available for the use of industry following any subsequent revision and publication of a revised AS/NZS3788 by Standards Australia and New Zealand.

Expressions of interest should be forwarded to Bruce Cannon (WTIA Technical Publications Manager) via b.cannon@wtia.com.au.

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Standards set out specifications, procedures and guidelines. They are designed to ensure products, services and systems are safe, reliable and consistent. They are based on industrial, scientific and consumer experience and are regularly reviewed to ensure they keep pace with new technologies.
Australia's six class laser system enables the prescription of tailored safety standards. The six classes of lasers are numbered 1, 2, 3a, 3b (restricted), 3b, and 4, becoming incrementally more dangerous as the numbers progress.

As such, if exposure to the direct or indirect effects of a laser is considered not hazardous, or safe by current medical standards, the laser is stated as belonging to Class 1. In comparison, exposure to a laser belonging to Class 4 has the potential to be fatal.

**Class 1** laser technology poses no operational safety hazard. A laser with the strength to qualify for higher classes may qualify for Class 1 due to the built-in safety mechanisms of the laser technology itself. For example, if the laser is securely enclosed such that there is no possibility of human exposure.

**Class 2** lasers pose a physical (optical) danger upon direct exposure of greater than 0.25 seconds.

**Class 3A** contains laser technology of medium power that poses modest potential for injury. Under normal conditions, the danger is purely eye-related. These lasers produce higher levels of radiation than those of Class 2, but are not necessarily more dangerous to the eye. Under altered viewing conditions (when using binoculars, for example), these lasers are significantly more dangerous.
Class 3B (restricted) lasers are equal to Class 3A lasers when one faces exposure during daylight. But in dim lighting of less than 10 lux, these lasers pose the safety hazard of Class 3B.

Class 3B lasers emit both visible and invisible radiation; direct exposure is hazardous to the eye. These lasers are particularly dangerous because the human aversion mechanism of blinking is incapable of responding to the wavelengths emitted by these lasers. Class 3B lasers are strong enough to cause damage in under 0.25s, and have the potential to burn exposed skin.

Class 4 features high-power lasers that pose serious physical risk to both eyesight and skin, and has the potential to be fatal. These lasers require the highest degree of operational experience and safety equipment.

Operational Dangers of Laser Technology

Potential hazards related to the use of lasers can generally be divided into primary and secondary hazards. The laser beam itself represents the primary potential hazard, as it can affect humans or objects – in the form of raw beam, focused beam, directly reflected beam, or scattered radiation.

Secondary potential hazards are further subdivided:

- **Direct potential hazards** are caused by technical components of the laser installation (high voltage, excitation radiation, laser gases, optics)
- **Indirect potential hazards** are generated by the interaction of the laser beam with materials or the atmosphere, including the UV-radiation caused by plasma formation, hazardous substances generated during material processing, and also potential ignition of explosive materials and the danger of fire.

Laser Radiation

The primary hazard posed by laser technology is direct exposure to the beam itself, in the form of laser radiation. As a result of direct contact with lasers above the Maximum Permissible Exposure (MPE), there is a distinct risk of serious damage to the eyes and skin. There are a number of factors that influence the risk factor:

- The wavelength of laser radiation
- Tissue spectral absorption, reflection and transmission
- Irradiance levels
- The size of the irradiated area
- Exposure duration
- Pupil size

Lasers pose a threat of severe eye damage to the retina and cornea, and skin damage in the form of burns. Class 4 lasers are capable of causing deep, severe, and permanent damage. The most effective method of prevention is to ensure the encapsulation of the laser beam such that no operational exposure can occur.

Safety Measures

Eye Protection

High quality eye protection is an absolute must have when working with lasers of Class 3 and above, and highly recommended when working with Class 2. Choosing the correct eyewear can be complicated. AS/NZS1336 Recommended Practices for Occupational Eye Protection should be consulted for more comprehensive information.

You must take into account the wavelength of the laser technology to be used, the level of radiant exposure and the MPE, along with your practical user considerations. Protective eyewear is usually designed to withstand a maximum exposure of up to 10 seconds or 100 pulses. It does not allow you to purposefully gaze at a high strength laser beam unharmed. Class 4 lasers have unique requirements for protective eyewear.

Skin Protection

For certain instances of Class 3B laser usage, and for all instances of Class 4 laser usage, protective clothing must be worn to guard against the dangers of laser exposure, as well as the risk of fire.

Medical Surveillance

If your job demands that you place yourself at risk of exposure to laser radiation that exceeds the MPE, you should seek eye and skin examinations before you start, and after you leave your position. However, in many instances, it’s wise to schedule eye examinations throughout your time in the role.

Laser Safety Officer

Organisations who utilise potentially harmful laser systems ought to employ a Laser Safety Officer. It is the responsibility of the Laser Safety Office to evaluate and oversee the implementation of recommended safety practices.
About Furphy Engineering

J. Furphy & Sons is an Australian engineering icon. Established in 1864, it is still family owned (fifth generation) and operated from its base in Shepparton, Victoria. The company is renowned for its historical links to rural Australia and in particular its most famous product - the Furphy Water Cart. Today, the company is much different.

The design and manufacture of stainless steel tanks and pressure vessels is Furphy's core business, and is predominantly responsible for the company’s growth and the profile it enjoys today as one of Australia’s premier and most unique metal manufacturing companies. Its client base includes many of industries most reputable multi-national and domestic companies.

In recent times, the company has received several significant industry awards including the Australian Family Business of the Year 2000 and the WTIA Large Fabricator of the Year in 2000 and again in 2008. J. Furphy and Sons was an inaugural inductee into the Victorian Manufacturers Hall of Fame. For more information, please visit: www.furphys.com.au

Converting the bulk fuel supplier’s fuel tanks from carbon steel to stainless delivered project cost savings, increased fuel quality, and reduced maintenance costs.
Fuel Tanks Converted from Carbon to Stainless Steel

Project Overview
- **Company**: Furphy Engineering
- **Client**: Bulk Fuel Supplier
- **Location**: Townsville, Queensland
- **Project**:
  - 4 Diesel Fuel Tanks and 2 ULP Fuel Tanks
  - Fuel Storage Tanks to support mining and local industries

Project Specification Changes
Originally specified as Carbon Steel tanks, the 6 storage tanks were converted to Stainless Steel vessels. The decision was based on the benefits of increased fuel quality, lower maintenance requirements and project cost savings.

Conversion to Stainless Steel
Stainless Steel provides superior corrosion resistance, compared to Carbon Steel tanks. As a result, a corrosion allowance was not required to be built in to the thickness of each tanks’ walls. Stainless Steel also offers a higher strength to material thickness ratio, enabling a thinner gauge of steel to be specified. These attributes delivered cost savings to the client.

Storage in a Stainless Steel vessel also provides a more sterile environment. Unlike Carbon Steel a Stainless Steel surface does not require a paint system. This removes the need for repainting during the life of the tank and delivers an internal surface that will not flake or contaminate the fuel with paint particles; reducing maintenance requirements and increasing the quality of stored fuel.

Design Considerations
All elements of design considered Australian and International standards to optimise the life and performance of each tank.

Structural design considered the density of stored fuels - diesel and ULP, along with the venting requirements for petrochemicals, in accordance with AS1692. Additional components were added to each tank; these included access points for maintenance and internal floating roof systems to create vapour barriers.

Townsville’s geographic location; the local wind and earthquake loads, determined each tank’s height, depth and structural requirements.

Tank components such as nozzles, floor structures and roof installation were developed according to API650 and AS1210, with finishing welds meeting AS1554.6-2012 II (a), for structural integrity.

Build Requirements
All tanks were fabricated at Furphy Engineering’s Shepparton plant in Victoria using stainless steel sourced through Australian-based supply outlets. The project used 96 tonnes of stainless steel and required 15 weeks to complete.

NATA approved non-destructive testing (NDT) was carried out by third party providers to evaluate the properties of each tank; ensuring they passed all code requirements.

Transportation
With manufacture taking place in Shepparton and installation in Townsville, tank design needed to consider suitability for long haul transport. The tanks weighed 15 tonnes and were up to 21 metres long, requiring heavy haulage equipment and the support of pilot vehicles, for the trip.

Tank design considered the most suitable transportation method, the cost to transport and how to maintain the structural integrity of each tank throughout the delivery and installation process.

Once transported, the tanks were successfully installed at the bulk fuel suppliers operations in Townsville.
Footbridge Fast Facts

- The new bridge has a deck width of 4.7m and is 7.6m wide in total, including eaves, guttering and so on. This is more than double the width of the old footbridge.
- The new bridge has an increased traffic clearance of 5.5m.
- Two new elevators have been added to the bridge.
- An estimated 14,000 people will use the bridge daily.
- The works also included an extension of Hornsby Mall to George Street.
- The footbridge itself weighed 57.55 tonnes, with an additional 8.27 tonne canopy.
- All steel was procured locally from Bluescope, Orrcon Steel, Horan Steel, OneSteel and Southern Steel.

Project Background

The outdated footbridge over George Street in Hornsby (on the Upper North Shore of Sydney) has recently been replaced.

The new bridge extends into Hornsby Mall and is twice as wide (at 4.7m) and taller (with a traffic clearance of 5.5m) than the old bridge. The project was jointly funded by Hornsby Council ($2 million) and the NSW Government ($5 million).

The new alignment gives the 14,000 pedestrians that use the bridge each day access to Hornsby Mall without having to cross any roads, while two lifts at the Florence Street end provide disabled access to the bridge.

“The old bridge [was] well past its used by date and we’re very grateful to the State Government for their assistance in replacing it,” Hornsby Shire Council Mayor, Steve Russell said.

“This is not just about access to Hornsby Station, this bridge is instrumental in linking the two halves of Hornsby together and creating a single community,” Mayor Russell said.

According to S&L Steel’s project manager, Amit Roy, there were a number of challenges that S&L Steel overcame, “During fabrication, there were height restrictions, and we had to procure and use special mesh for the bridge’s sides, which had to be sourced from Germany.”

“The installation of the footbridge was also posed some difficulties. The new footbridge was built next to the existing one, so that the existing bridge could remain open during construction, creating the least possible interruption to pedestrian and vehicle traffic. In addition, the bridge was installed at night to minimise inconvenience.”

Installation of the Hornsby Pedestrian Bridge.
About S&L Steel

Founded in 1974, S&L Steel provides structural steel fabrication, engineering and erection services to a variety of industries across Australia.

Today, S&L Steel is one of the largest fabrication and engineering companies in New South Wales. S&L Steel holds ISO 9001 and ISO 14001 certification, RMS pre-qualification and PCCP accreditation, and certification to AS3834 (Part 2) and AS/NZS4801. S&L Steel won a number of 2016 Australian Steel Institute Awards, including the Steel Excellence Award in Engineering Projects for City Walk Bridge.

S&L have carried out work on a number of important infrastructure and commercial projects, including bridgeworks that were part of the Pacific Highway Upgrade, the New South Wales Desalination Plant, and upgrade works on a number of defence facilities.

Whether you’re building a bridge, pressure vessels, a railway station, or mining facilities, S&L Steel’s mission remains the same: to continuously provide certainty of quality, delivery, and integrity in all services. For more information, visit: www.slsteel.com.au
Welding for Outer-Space: NASA Space Launch System

NASA’s Space Launch System (SLS) is a powerful, advanced launch vehicle for a new era of human exploration beyond Earth’s orbit. With its unprecedented power and capabilities, SLS will launch crews of up to four astronauts in the agency’s Orion spacecraft on missions to explore multiple, deep-space destinations. Offering more payload mass, volume capability and energy to speed missions through space than any current launch vehicle, SLS is designed to be flexible and evolvable and will open new possibilities for payloads, including robotic scientific missions to places like Mars, Saturn and Jupiter.
In 2015, NASA completed the critical design review—a first for a NASA human-rated launch vehicle since the space shuttle almost 40 years ago. SLS continues to move forward with production of the first exploration-class launch vehicle built since the Saturn V. Engineers continue to make progress aimed toward delivering the first SLS rocket in 2018 to NASA’s Kennedy Space Center in Florida for its first launch.

The Power to Explore Beyond Earth’s Orbit

To fit NASA’s future needs for deep-space missions, SLS is designed to evolve into increasingly more powerful configurations. The first SLS vehicle, called Block 1, has a minimum 70-metric-ton (77-ton) lift capability. It will be powered by twin five-segment solid rocket boosters and four RS-25 liquid propellant engines, as well as a modified version of an existing upper stage.

The next planned evolution of the SLS, Block 1B, will use a new, more powerful Exploration Upper Stage (EUS) to enable more ambitious missions and deliver a 105-metric-ton (115-ton) lift capacity.

A later evolution, Block 2, would replace the current five-segment boosters with a pair of advanced solid or liquid propellant boosters to provide a 130-metric-ton (143-ton) lift capacity. In each configuration, SLS will continue to use the same core stage design with four RS-25 engines.

An evolvable design allows NASA to provide the nation with a rocket able to pioneer new human spaceflight missions and revolutionary scientific missions in the shortest time possible, while continuing to develop more powerful configurations. The next wave of human exploration will take explorers farther into the solar system—developing new technologies, inspiring future generations and expanding our knowledge about our place in the universe.

Welding Liquid Hydrogen Tanks for Space Exploration

In the image below, a qualification test article for the SLS’s liquid hydrogen tank is lifted off the Vertical Assembly Center after final welding at the Michoud Assembly Facility in New Orleans.

This giant tank isn’t destined for space, but it will play a critical role in ensuring the safety of future explorers. The liquid hydrogen qualification article closely replicates flight hardware and was built using identical processing procedures.

SLS will have the largest cryogenic fuel tanks ever used on a rocket. The liquid hydrogen tank—along with a liquid oxygen tank—are part of the SLS core stage. The core stage is made up of the engine section, liquid hydrogen tank, intertank, liquid oxygen tank and forward skirt. As four qualification articles of the core stage hardware are manufactured, they will be shipped on the Pegasus barge from Michoud to NASA’s Marshall Space Flight Center in Huntsville, Alabama, for structural loads testing.

Now that welding is finished, the liquid hydrogen tank hardware, standing at more than 40m tall, will be outfitted with sensors to record important data. It will be tested in a new, twin-tower test stand currently under construction for the tank at the Marshall Center. Structural loads testing ensures that these huge structures can withstand the incredible stresses of launch.

In the image opposite, welders work inside the large liquid hydrogen tank at the Michoud Assembly Facility in New Orleans, plugging holes left after the tank was assembled.

Using frictional heating and forging pressure, friction stir welding produces high-strength bonds virtually free of defects. The process transforms metals from a solid state into a ‘plastic-like’ state and uses a rotating pin tool to soften, stir and forge a bond between two metal sections to form a uniform welded joint.

At the beginning and end of each weld, holes remain where the rotating pin tool enters and exits the metal. Six 6.5m tall barrels and two domed caps were joined together to create the qualification test article, which measures an astounding 8.5m in diameter and over 40m long.

Qualification test articles, like the one shown below, closely replicate flight hardware and are built using identical processing procedures. The liquid hydrogen tank, a liquid oxygen tank, four RS-25 engines and other elements form SLS’s core stage, which also serves as the rocket’s structural backbone.
Exploring the Applications of Quenched & Tempered Steel

Following the initial discovery and refinement of steel alloys, users have continued to find ways to improve key characteristics and properties. Development of steel accelerated as a result of World War II where the requirement for higher strength and higher hardness steels came as a result of ever increasing requirements of tanks and other armoured vehicles. Through research, and trial and error, it was found that heating and cooling certain alloys of steel resulted in significant and beneficial changes in key mechanical properties including hardness, toughness, tensile strength and weldability.

Today, modern steel manufacturing processes have advanced so considerably that we now have cleaner, leaner, stronger and more workable steel than ever before. While in the past, ductility and weldability may have come at a cost to strength and toughness, quenched and tempered steel (Q&T)—a high strength and abrasion resistant steel—comes with enhanced fabrication qualities, without the compromise on mechanical properties.

Bisalloy, based in Wollongong, New South Wales, is Australia’s only manufacturer of high tensile and abrasion resistant quenched and tempered steel plate under the brand name of ‘BISALLOY®’. Bisalloy manufactures large plates, which are typically eight meters long by two and a half meters wide. The processes undertaken by Bisalloy both strengthen and harden the specially alloyed steel plate, with two key steps in the process: quenching (or quench hardening), which involves heating the material to a strictly monitored and controlled set point, and then rapidly cooling in water. The process is particular to the alloy of the plate and changes depending on the desired properties.

After the plate has been quenched to a predetermined hardened state, the second process—tempering—is used to achieve greater toughness and ductility by decreasing the hardness. Tempering is achieved by heating the plate to a critical point for a set period of time and then allowing it to cool at a particular cooling rate. Both the temperature and heating time depend on the alloying of the steel and is determined by the amount of the final hardness required and the overall mechanical properties of the steel required.

While harder steel is highly desirable in a range of applications, especially in mining situations where abrasion resistance is key, the tempering process means the steel plate is less brittle and more ductile without sacrificing all of the hardness. The toughness of Bisalloy’s range of high hardness Q&T grades means an even greater resistance to wear and abrasion. That is why quenched and tempered steel is particularly useful in machinery, plant and equipment where greater abrasion resistance combined with higher strength are necessary, such as mining, quarrying and earthmoving.

However, the benefits of BISALLOY® quenched and tempered steel reach far beyond the construction site. Equipment such as dump truck bodies, storage bins, hoppers and chutes can now be manufactured with an overall lighter weight whilst still maintaining the same strength.

The lower hardness and more ductile variants of BISALLOY® are ideally suited to structural applications, especially construction. Importantly, high strength quenched and tempered steel plate, conforming to the Australian Standard AS3597, are now included in the recently revised Australian Standard for steel structures, AS4100 (2012 amendment, Table 2.1). Bisalloy’s range of structural grades of steel enables fabrication of columns,
INSIDE THE INDUSTRY: QUENCHED & TEMPERED STEEL

beams, trusses and tubular sections that can potentially save weight and offer other design possibilities.

The increased strength of BISALLOY® structural grades, where tensile strengths range from 590 to 1100 MPa means that engineers and architects can now design and write specifications for structures. BISALLOY® makes it possible to build taller towers, span larger areas and specify smaller columns while actually reducing the amount of steel needed. Reductions in frame weight lead to savings on foundations, fabrication and construction costs.

Importantly, fabrication considerations such as cutting, drilling, and forming and rolling are not compromised. Overall, it is the combination of the two processes of quenching and tempering, combined with a specialised and highly refined alloying, that produces harder and tougher steel that remains as weldable and ductile as any ordinary carbon steel.

Bisalloy was established in 1980 and, with over 35 years of continual production in Australia, has earned an outstanding reputation for the quality of its products and significant level of technical backup. Being a specialist supplier enables Bisalloy to not only respond quickly to customers' demands and market changes anywhere in the world, it also allows the company to remain clearly focused on the important dual task of keeping plant and equipment up and running for as long as possible, while keeping costs as low as possible.

Working in collaboration with customers and key BISALLOY® Solution Partners, Bisalloy strives to take an innovative approach to BISALLOY® quenched and tempered steel solutions to meet the ever challenging requirements of customers and end users. Concepts such as ‘Lean Design’, compliance with key industry standards such as AS3597, technical knowledge and assistance with welding (including AS1554.4 and AS1554.5), and ongoing development around building and construction (as demonstrated by the update to AS4100) are supported by Bisalloy to provide a unique level of ‘Design Readiness’ for customers and users.

As the number one supplier of quenched and tempered steels to the Australian and south-east Asian regional markets, Bisalloy provides customers with a superior level of supply and availability through local BISALLOY® Manufacturing, BisExpress Warehouse Hubs and Distributors.

BISALLOY® has become the generic name for quenched and tempered steel in Australia and many countries in Asia. Bisalloy is proudly Australian, and operates from its modern headquarters at Unanderra. Bisalloy has supported Australian and other global companies servicing the mining, building, infra-structure and defence industries in the design of structural, heavy mobile equipment, fixed plant equipment and defence applications for over 35 years in order to continuously improve the performance and economic outcomes for their businesses.

By Justin Suwart, Business Development Manager New Products & Markets, Bisalloy.
For more information, visit: www.bisalloy.com.au
Advances in Metal Additive Manufacturing

There are two key types of processes used for commercial purposes in metal additive manufacturing. One is the powder bed system or selective laser melting (SLM) that uses a layered process as an initial build; the other is laser melted deposition (LMD) where metal powder is simultaneously fed and melted through a guided laser nozzle building onto an original product to create new functions or repairing worn parts. Both processes offer advantages to additive manufacturers and both are radical departures from the traditional subtractive manufacturing process, presenting challenges and requiring a paradigm shift in thinking. To embrace this new technology requires an understanding of the techniques involved.

The metal additive manufacturing process is often referred to as ‘3D printing’ as the products are first designed digitally, greatly reducing production development time and costs. The 3D model is then used to build the product ‘adding’ metal powder and guiding the laser beam. In comparison, traditional manufacturing processes rely on technologies that cut objects from large blocks or sheets of material, which are then machined or welded. The benefits of additive manufacturing include material savings, reduced wastage and reduced energy costs. Even greater benefits lie in the opportunity to produce products or enhance components that were impossible to manufacture without conventional subtractive technology.

Laser Melted Deposition

LMD also referred to as shaped metal deposition, is a process where the laser energy is transformed into thermal energy through interaction with a stream of metallic particles, or metal powder, solidifying into a dense deposit with excellent metallurgical bond.

The advantage of LMD is that, with a high brightness laser source, users have the ability to focus the laser spot down to micron range, resulting in accurate part building. The coaxial nozzle is the key to the process allowing more disciplined control over the stream of metal powder carried by inert gas and resulting in a better deposition quality than comparative processes. This deposition method results in uniform and dense metal deposits with technical qualities comparable to parts produced by forging and founding processes. Turn-key machines are available that provide 3 or 5 axis capability improving handling in a controlled atmosphere. Recent developments provide options where the deposition head moves with the work piece remaining stable, or the deposition head remains stable with the work piece moving. This facility offers real advantages for prototyping and design iterations of new parts, and for reparation of different metal structures. Several companies in Australia have already installed lasers operating on robots to repair of large parts such as mining equipment, large turbine fans, and centrifugal screen equipment.
Selective Laser Melting

Developed at the Fraunhofer Institute of Laser Technology in Germany, SLM enables the production of parts using complex geometries without the need for part-specific tools or pre-production costs.

The 3D CAD model that is to be manufactured, is broken down into layers. These layers are transferred to the SLM machine that uses the generic information to define the scanning path of the laser beam. The SLM machine deposits defined thin layers of metal onto a substrate and then passes the beam over them, melting the metal within the tightly controlled atmosphere of inert gas.

The geometric information then defines the scanning path of the laser beam in melting the powder. As one layer is completed the process is repeated until the product is finished. A complete melt provides a density of approximately 100% achieving mechanical properties that can be matched with traditionally manufactured parts.

With additive manufacturing, parts must be re-designed, not transitioned from previous processes. The 3D CAD design offers greater options not available to tooling processes, as manufacturing complex aesthetic shapes is no longer a problem. 3D CAD design parameters allow the design of very complex structures inside a part. For example the fuel nozzle for aircraft engines manufactured by GE in the USA when using traditional processes comprised 20 separate parts that had to be machined together. Now, using SLM technology there is one single part, and, it is five times stronger. Advantages of time to completion are evident, while less joining provides for a stronger end product, a major attraction where parts are used in high stress environments such as aircraft.

Metal powders required for SLM fabrication need to be very fine. Ti64 is one of the most widely used materials in the manufacture of aircraft parts due to its low density, high strength, excellent mechanical properties and corrosion resistance. As amortised metal powders are quite different from powders used for other applications, the list of available powders at the appropriate micron size for SLM is still limited. Laser system suppliers will generally provide suitable powders along with their machine and can include stainless steel, aluminum, titanium alloys, nickel-based alloys, and cobalt-based alloy, providing adequate opportunities for implementation.

Research has indicated the need for optimising geometry to satisfy the structural constraints of the piece. It requires a comprehensive understanding of the associated mechanical properties as well as any post-production requirements. In other words, all designers need to have a good understanding of the SLM building process. These are not limitations, but requirements.

Limitations are somewhat removed as SLM manufacturing enables the designer to focus on maximizing product performance, testing various wall thicknesses or deep channels, trying twisted and contorted shapes, in fact any level of complexity that allows a single functional physical product. Additionally, following part testing, the only changes required are of the CAD model making iterations easy and experimentation kept in-house.

The general convenience of additive manufacturing (AM) of metals is already evident. In some fields, fabrication is already a commercial reality. It appears AM reduces time and costs from design to manufacture and once the product is complete manufacturing can begin immediately, as there are no costly tooling delays or new production issues.

We are seeing financial gain, efficiency growth and process improvements are significant and outweigh some traditional manufacturing processes. Costs of materials and AM technologies remain high, but amortised across volume, and early market penetration, mean opportunities will overcome the challenges of start-up.
The Task
In April 2014, Wood Group PSN won a contract to provide brownfield engineering, procurement and construction service support at the Longford Gas Conditioning Plant Project for Esso Australia. Part of Wood Group PSN’s responsibilities was to establish a pair of 1,200m long pipes to bring raw gas from the offshore facilities to the gas conditioning plant.

The company’s engineers laid down two 600 nominal bore pipes with 32mm wall thickness. One pipe would carry untreated, raw gas to the plant, while treated gas would flow through the other.

The pipe sections would be welded together using a combination of gas metal arc welding and flux-cored arc welding. But each of the 76 welds would require preheating and post-weld heat treatments, to ensure the metallurgical integrity of the pipes would not be compromised by the temperature fluctuations caused by the welding work.

According to David Barry, Construction Welding Superintendent at Wood Group PSN, strict statutory codes and scientific tests govern this type of welding work. “Before we start welding, we go through all manner of welding procedure qualifications, proving all the equipment, welding methodology, proving we’ve got enough preheat so it doesn’t cool too quickly, proving that our post-weld heat treatment is correct and the results we achieve meet the requirements,” he said.

Bringing It In-House
Normally, preheat and post-weld heat treatments are considered complex specialist tasks, requiring a third party contractor with resistance-type heating equipment.

But there are both risks and costs involved in bringing in third party contractors on site. “Contractors sometimes aren’t familiar with the requirements, haven’t received the proper training, or have no experience working in a major hazard facility,” David said.

Having to work around their schedules also added to the cost, and made it difficult to manage other parts of projects.

When the team learned about the Miller Pro Heat 35 Induction Heating system from WIA, they knew that it would enable them to bring the preheating and post-weld heat treatment work in-house and still deliver the same results, but in a faster, more cost-effective and safer way.

WIA helped smooth the way by providing comprehensive training and support. “The training process started when WIA first introduced us to the equipment. We worked very closely with them programming the machines, and setting up the hardware on the pipes,” David said. “As we drew closer to commencing production welding, WIA came down for a few days to work with the engineers who would be doing the work, and ran them through some formal training.”
Wood Group PSN was able to quickly build up its in-house preheating and post-heat treatment expertise, saving around $1 million in contracting fees.

**Faster Treatment**

One big advantage that induction heating has over the traditional resistance approach is its ability to heat the material consistently and quickly. “With the induction equipment, we can achieve our 80°C preheat temperature in 10 to 15 minutes. Resistance type equipment would take 30 to 35 minutes, depending on the ambient temperature,” David explained.

In post-weld heat treatments, the rate of temperature rise is regulated. But those limits only apply once temperatures soar above 400°C. “So we can get up to 400°C as quickly as we like,” he said. “We saved a lot of time there by getting up to 400°C in 25 minutes with the induction method. Conventional equipment would require two hours.”

Multiplied across the 76 welding cycles for the project, the team saved more than 145 hours on the preheat and heat treatment operations.

**Health and Safety**

Ignition sources like open flames and hot elements, while dangerous by themselves, can be especially deadly when combined with the volatile materials and confined spaces found in the oil and gas industry. Thus, engineers undertaking welding work within the oil and gas sector must ensure compliance with a raft of safety legislations.

“Health and Safety

Ignition sources like open flames and hot elements, while dangerous by themselves, can be especially deadly when combined with the volatile materials and confined spaces found in the oil and gas industry. Thus, engineers undertaking welding work within the oil and gas sector must ensure compliance with a raft of safety legislations.

“We are working in a live plant, so most of the time we are working in habitats measuring 4m x 4m. We need to contain any sparks and ignition sources,” David said. In traditional resistance heating methods, engineers install ceramic heat pads on the surface of the pipe, wire them up, then wrap them in synthetic mineral fibre insulation (SMF).

The pads then heat up, relying on the surface contact to heat the pipes. This results in an intense heat source that not only exposes personnel around the equipment to radiant heat, but is a high-risk ignition source. Miller Pro Heat’s non-contact heating method, which works by generating heat within the material of the pipe, rather than heating up the pad, helped Wood Group PSN eliminate the issue.

“With the induction method, there’s nothing glowing, so no potential ignition source,” explained David. The high temperatures generated by the electrical wires and ceramic pads in the resistance heating method can also quickly deteriorate the SMF insulation, which break down into particulates, resulting in the added need for respiratory protection.

“The SMF ends up flying around in the air, and you get issues with people breathing it,” David said. “Whereas with the induction method, we just wrap the pad around, plug it in, and go. Because there’s no heat present on the surface against the pad, the pad doesn’t deteriorate like the SMF does.”

**Conclusion**

With easy set-up, and features like on-board temperature control, the Miller Pro Heat 35 Induction Heating system helped David and his team at Wood Group PSN take control of the preheat and post-welding heat treatment process at the Longford Gas Conditioning Plant project. This yielded faster results, lower costs, and improved safety outcomes, without compromising on the quality of work.

The key to achieving this outcome, David suggests, was to take full advantage of the training and advice from WIA.

“Invest a little at the front end, and as we proved, there are many dollars to be saved by the use of this product,” David said. “The results you achieve with it easily exceed the results from conventional equipment.”

For more information about WIA, visit: www.welding.com.au
How K-TIG Improved GE’s Productivity & Costs

The Challenge
GE’s conventional GTAW process required extensive edge preparation, a V-groove preparation as well as joint cleaning for each joint, resulting in slow setup times. GTAW’s inability to fully penetrate the 8mm 347 stainless steel material created a requirement for four to five passes, plus tacking to complete each joint. Weld inspections were also required throughout the process, resulting in long welding and processing times.

The need for a V-groove preparation and multiple passes resulted in a requirement for large quantities of filler wire and consumables, while gas consumption, power consumption and arc-on times were correspondingly high.

The Solution
K-TIG is an autogenous, full penetration, single-pass GTAW/TIG process, which is up to 100 times faster than traditional processes. In this application, GE’s welding time was reduced from more than 260 hours to 14 hours, with corresponding savings in gas, power, consumables, preparation, labour and overall cost. The quality of K-TIG welds were found to be exceptional, with the single pass welding process dramatically reducing the opportunity for porosity, inclusions, lack of fusion, rework and repairs.

The Results
The introduction of the K-TIG process provided order-of-magnitude productivity gains and cost reductions, while significantly simplifying GE’s process and increasing quality and reliability.

According to GE, “Weld quality has been excellent. We test extensively including x-ray and fluorescent penetrant inspection and we’ve had absolutely no problems. The controller makes it foolproof to run the welds in a consistent manner. Using K-TIG, we’ve experienced much lower distortion in our weldments and significantly less transverse shrinkage, which is always key.”

GE’s Results Using K-TIG on 8mm 347 Stainless Steel Fabrication

<table>
<thead>
<tr>
<th>Reduction in</th>
<th>Reduction in</th>
<th>Reduction in</th>
<th>Reduction in</th>
<th>Reduction in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Saving</td>
<td>Welding Time</td>
<td>Wire Consumption</td>
<td>Gas Consumption</td>
<td>Grinding &amp; Cleaning</td>
</tr>
<tr>
<td>93%</td>
<td>100%</td>
<td>99%</td>
<td>90%</td>
<td>84%</td>
</tr>
</tbody>
</table>

Previous Process and Setup
- All joints were prepared with a V-prep comprised of a 70 degree included angle, and a landing of between 1mm and 1.5mm
- Joints were cleaned with a stainless steel wire brush and solvents prior to the commencement of welding
- The assembly of each circumferential component was done vertically, requiring a 2G weld position
- Tack welds were performed manually every 6 inches along the weld joint
- A manual GTAW root pass was performed along the joint with localised back-side shielding using Argon
- Root penetration was verified visually and with dye penetrant testing
- If root pass inspection was passed, the balance of the V-prep was filled by performing an additional three to four passes with filler wire
- Final welds were subjected to visual inspection, dye penetrant testing and ultrasonic testing

K-TIG Process and Set Up
- Joint preparation is square butt for entire thickness, no bevel
- Horizontal assembly, welding in a 1G torch position
- The positioner and tailstock rotate the part in a slightly tilted mode to offset the conical angle of the parts
- Backside purge using Argon
- A single keyhole pass is made using 95% Argon 5% Hydrogen
About K-TIG

Developed by the Australian Government’s Commonwealth Scientific and Industrial Research Organisation (CSIRO), K-TIG is a high speed, single pass, full penetration welding technology that eliminates the need for wire or edge bevelling and produces welds up to 100 times faster than TIG welding in materials up to 16mm in thickness.

The K-TIG process involves a specially controlled high current arc which opens a full-penetration keyhole in the joint between the two surfaces to be welded.

A typical K-TIG weld is performed autogenously in a single full-penetration pass using just one welding gas. The resulting weld is 100% parent material, without multiple fusion lines, dramatically reducing the potential for inclusions, porosity and other defects typical of many welding processes.

For more information about K-TIG, please visit: www.k-tig.com.
Dr Druce Dunne, Emeritus Professor, University of Wollongong

Dr Dunne has been a member of the Faculty of Engineering for over 45 years. Dr Dunne’s research interests include: martensitic phase transformations; shape memory alloys, particularly ferrous alloys; shape memory (nitinol) thin films; thermomechanical processing of steels; structure-property relationships in welded steels; creep resistant steels for power generation equipment; structures and properties of advanced alloys; alloy design; and crystallographic and structural analysis. Dr Dunne initiated a collaborative research program on the processing of steels with the Port Kembla steel industry and introduced a major research stream on welding and joining through the first Cooperative Research Centre (CRC) of the University of Wollongong.
Boron As An Alloying Element In Steels & Its Weld Metals

By Dr Druce Dunne, Emeritus Professor, Faculty of Engineering and Information Sciences, University of Wollongong

1. Defining an Alloy Steel

In effect, all steels are alloyed. The principal elements are Fe and C, but even for plain carbon steels, Mn and Si are normally present, together with small concentrations of other elements, deliberately added or present as impurities.

Despite the multi-component nature of most steels, a distinction is made between “unalloyed” and “alloy” steels. However, categorisation into one of these two groups is not always straightforward and, in an attempt to resolve this ambiguity, ISO – the International Organisation for Standardization, developed International Standard ISO 4948/1 in 1982 to classify steels into unalloyed and alloy steels based on composition. Table 1 lists boundary values for 19 possible alloying elements (excepting C, N, P and S) for the purpose of defining an alloy steel as one containing at least one element in a concentration equal to, or in excess of, the relevant value in the table. The boundary values were proposed by the Technical Committee ISO/TC 17, “Steel”, and were circulated to member bodies for endorsement. Although twenty five countries, including Australia, approved the International Standard, disapproval on technical grounds was registered by the UK and USA. This outcome indicates that the selection of boundary values is somewhat arbitrary and, in some cases, contentious.

In 2000, the European Standard EN 10020 was prepared by the Technical Committee ECISS/TC 6 “Steels - Definition and classification”. The intention was to align the Standard “as far as possible” with ISO 4948-1 and ISO 4948-2; and with the Harmonised System Nomenclature of the World Custom Organisation (WCO). A few of the composition values defining the unalloyed/alloyed steel boundary differ from those of ISO 4948-1 (Table 1). Specifically, the Al and Si boundary values are higher, 0.3 wt% and 0.6 wt%, compared with 0.1 wt% and 0.5 wt% in ISO 4948-1. This European Standard has the status of the British Standard and has been widely accepted. Moreover, the boundary values are mostly the same as those listed in Chapter 72 (iron and steel) of Schedule 3 of the Australian Customs Tariff Act of 1995. These lists of alloy boundary values all specify that 8 ppm or more of boron qualifies steel as alloy steel.

2. Steel Microstructures and Basic Metallurgical Terms

The two primary elements of steel are iron and carbon. The versatility of steel as an engineering material stems from the polymorphic nature of iron (the capacity to exist in more than one crystal structure) and the significant strengthening effect produced by carbon. The polymorphism of iron makes steel amenable to heat treatment. At elevated temperatures the stable phase, called austenite, has a face-centred cubic (FCC) crystal structure. However, on slow cooling of steels containing less than 0.8% C, austenite initially undergoes transformation to a body-centred cubic (BCC) phase, called ferrite. A second bi-phase constituent, called pearlite, which consists of

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>0.10</td>
</tr>
<tr>
<td>Boron</td>
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</tr>
<tr>
<td>Bismuth</td>
<td>0.10</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.30</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.10</td>
</tr>
<tr>
<td>Copper</td>
<td>0.40</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.65*</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.08</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.30</td>
</tr>
<tr>
<td>Niobium</td>
<td>0.06</td>
</tr>
<tr>
<td>Lead</td>
<td>0.40</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.10</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.50</td>
</tr>
<tr>
<td>Tellurium</td>
<td>0.10</td>
</tr>
<tr>
<td>Titanium</td>
<td>0.05</td>
</tr>
<tr>
<td>Tungsten</td>
<td>0.10</td>
</tr>
<tr>
<td>Vanadium</td>
<td>0.10</td>
</tr>
<tr>
<td>Zirconium</td>
<td>0.05</td>
</tr>
<tr>
<td>Lanthanides (each)</td>
<td>0.05</td>
</tr>
<tr>
<td>Other specified elements (except S, P, C and N)</td>
<td>0.05</td>
</tr>
</tbody>
</table>

* If only a maximum is specified for the manganese content of the steel, the boundary shall be at 1.80%.
fine alternating plates or lamellae of ferrite and iron carbide, also forms from the remaining austenite. The average C content of pearlite is 0.8% and an alloy of this composition has a microstructure of 100 volume % pearlite on cooling to room temperature. For C contents < 0.8%, the microstructure is a mixture of ferrite and pearlite, with the volume fraction of pearlite decreasing with decreasing C content.

The vast majority of commercial steels have C contents much lower than 0.8% and therefore the microstructure that evolves in these steels on slow cooling, by annealing (furnace cooling) or normalising (air cooling), is a mixture of ferrite and pearlite. Ferrite is typically the dominant phase because of the trend in steel design since the 1970s to lower the carbon content in order to facilitate welding.

If low carbon steels are subjected to fast cooling, the formation of ferrite and pearlite is suppressed and different ferritic-type microstructures can form: bainite – a product composed mainly of ferrite laths and residual interlath “islands” of various C-rich constituents [1]; martensite – a phase which has a lath/plate morphology and is supersaturated with carbon; and acicular ferrite – which consists of fine multi-variant ferrite laths nucleated from small particles within the austenite grains. The last type of transformation product is common in weld metals [1].

Bainite forms over a higher temperature range than martensite and therefore cooling by rapid quenching in oil or water is usually required to produce martensite. Steels that can readily form bainite or martensite on cooling are said to have a high hardenability. Since both of these products have high strength and hardness, heat treatment by tempering at intermediate temperatures (200 – 600°C) is frequently employed to increase toughness, with controlled loss of strength.

3. Boron as an Alloying Element in Steel

The outstanding element in Table 1 is boron, which is considered to qualify steel as “alloyed” for a concentration that is at least an order of magnitude lower than the boundary concentration of any other element in the table.

This extraordinarily low boundary value arises from the potency of boron in increasing the hardenability of steel by suppressing the transformation of austenite to ferrite and pearlite on cooling from elevated temperatures (above about 850°C) and promoting the formation of bainitic or martensitic microstructures over lower temperature ranges. These latter transformation products significantly increase the strength and hardness at the expense of ductility.

In order for boron to be effective as a hardenability-promoter, it must be present at high temperature as solute atoms that can diffuse to, and segregate at, austenite grain boundaries, thereby reducing their effectiveness as nucleation sites for ferrite grain formation on cooling [2, 3]. Since boron is a reactive element, other elements are required during steelmaking to prevent the formation of nitride, oxide and carbide compounds (BN, B₂O₃ and Fe₇₅(BC)₆). The formation of these compounds reduces the B solute content and the efficacy of B as a hardenability agent [3].

Boron, in combination with Mo, can result in the formation of a bainitic microstructure on cooling of low carbon steel (0.10-0.15%C) over a wide range of rates after hot rolling [3], resulting in a yield strength higher than about 450 MPa. More typically however, boron-containing low alloy steels are designed for use in the quenched and tempered (QT) martensitic condition. Both hot rolled bainitic steels and QT martensitic steels are normally Al-killed to lower the oxygen content and Ti-treated to remove N from solid solution. Although B can increase hardenability at concentrations as low as 5 ppm, the optimum concentration range is 15-25 ppm - higher concentrations can promote the formation of Fe₇₅(BC)₆ and decrease both the effectiveness of boron as a hardenability enhancer and the toughness of the steel [2, 3]. Boron promotes hardenability most strongly in low carbon steels and its effectiveness diminishes with increasing carbon content [4].

The addition of B to low alloy steels has become more common in recent decades because of its capacity to strongly increase the hardenability per se, as well as enhancing the effectiveness of traditional hardenability-promoting elements such as C, Cr, Mo and V. Moreover, the use of boron allows reductions of the concentrations of other alloying elements, thereby reducing the alloy cost without compromising the alloy hardenability.

4. Welding of Steel

Whether the base microstructure of a structural steel is ferrite + pearlite or bainite/martensite, it is likely to be fabricated by welding in the construction of engineering components and assemblies. Since welding subjects the base steel to high temperatures adjacent to the molten weld pool (in the so-called heat affected zone, HAZ), followed by relatively rapid cooling, the austenite present in the HAZ at elevated temperatures has the potential to transform to martensite on cooling, particularly if the carbon and alloy contents of the parent plate are relatively high. This possibility
is a serious welding issue because the presence of a martensitic structure with high hardness and low toughness, together with small concentrations of H absorbed in the welding process, can result in hydrogen assisted cold cracking (HACC) of the weldment [5].

Welding researchers have proposed a number of empirical formulae for calculation of an index called the Carbon Equivalent (CE). This index is effectively a hardenability predictor based on the parent or weld metal composition. One of the most widely used formulas for CE is that proposed by the International Institute for Welding (IIW) [6]:

\[ CE\ (IIW) = C + \frac{Mn}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Cu+Ni)}{15} \]  

This formula covers a wide range of C contents and its usefulness is reflected in its incorporation into a British Standard in 1974 [7]. CE(IIW) values higher than 0.40 are considered to require welding procedures that ensure that the cooling rate is low enough to prevent excessive hardening of the HAZ. An “excessive” HAZ hardness in relation to susceptibility to HACC is generally considered to be about 350 HV [8], but both lower and higher limits have been proposed. The limiting CE and the maximum hardness are empirically based and a range of carbon equivalent formulas and maximum HAZ hardness values have been proposed in attempting to account for different steel designs.

Despite its wide use, CE is an imprecise predictor of hardenability, particularly of weld metal, as it does not take into account the variables of prior austenite grain size; type, quantity and size distribution of non-metallic inclusions; and the weld cooling rate. These factors, together with the alloy composition, determine the transformation behaviour of the austenite on cooling. Nevertheless, CE(IIW) is widely used to provide guidance in the control of the weld heat input and the preheat appropriate for a particular welding process, weld configuration and effective thickness of the plates being welded. These factors control the cooling rate and can be used to reduce hardening of the weld metal and HAZ and to avoid cracking of the weldment.

Early CE formulae did not take into account boron, but the strong effect of B on hardenability is well recognised by the welding industry and modified formulae have been proposed to overcome this shortcoming.

**5. Welding of B-Containing Steels**

The following formula for B-containing, low carbon, microalloyed steels was proposed by Ito and Bessyo [9] and was adopted by the Japanese Welding Engineering Society in 1983:

\[ P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B \]  

Compared to Equation (1), the effects of the substitutional alloying elements are downgraded relative to C and the strong contribution of B is recognised.

A more recent formula by Yurioka et al. [10] is a combined version of Equations (1) and (2) for which the carbon equivalent, CEN, approaches CE(IIW) given by Equation (1) for C levels higher than 0.18%, and is close to the values given by Pcm for C contents lower than 0.16%.

Because of its strong effect on hardenability, the presence of B in steels introduces the requirement of stricter weld procedure control to avoid cracking. This issue has been pointed out repeatedly by various steel industry bodies.

One example is a Customer Information guide from Dillinger Hutte, a major German plate steel producer, published in 2014 [11], which points out that adding 8 ppm or more of boron to normally non-alloyed S235JR and S355J2 (EN 10025) hot rolled structural steels can raise the HAZ hardness above the specified maximum of 380 HV, particularly for tack welding, oxy-cutting and welding of temporary assembly aids. The risks of HACC are therefore increased. A similar “Industry Alert” was issued recently by the Welding Technology Institute of Australia (WTIA) [12].
The European Standard EN10025 is referred to above and it should be recognised, as pointed out in Ref. [13], that steel standards (e.g. for non-alloyed structural steel plate) are likely to differ for different countries across the world. The various standards can be comparable but are rarely equivalent, because of at least small differences in steel compositions and mechanical properties. Therefore, although imported steels may be comparable (or a close match) to steel standards specified in relevant AS/NZS standards, they will not normally be equivalent.

6. Types of B-Alloyed Steels

6.1 Hot Rolled Bainitic Steels and Tempered Martensitic (QT) Steel

As discussed in Section 3, about 20 ppm of B can promote bainite formation during cooling of controlled-rolled steels. The pioneer steel design was developed in the 1950s by Irvine and Pickering [14] and the main components were 0.1-0.15% C, 1.25% Mn, 0.5% Mo and 20 ppm B. Since the design of this steel, more advanced B-alloyed designs have been developed to produce hot rolled bainitic steels with outstanding toughness, strength and weldability. To achieve these properties an ultra-low C content of 0.02-0.03% is used, together with controlled rolling and carefully adjusted concentrations of Ti and Nb [15].

Notwithstanding the attractive properties of controlled-rolled bainitic steels, the most widely used type of B-alloyed steel is a low carbon, low alloy steel designed for use in the quenched and tempered condition. Yield strengths are typically above about 700 MPa and can be 1800 MPa or higher. Restricting the carbon content to below 0.25 wt% ensures that the CE remains relatively low, facilitating fabrication by welding. BisPlate 80 is an Australian-produced tempered martensitic plate steel (Bisalloy Steels) with a 690 MPa minimum yield strength that is used in applications where a high strength to weight ratio is important, such as building frames, dumper truck bodies, bins, cranes and mining equipment. EM812 steel, which was used for construction of the hull of the Collins Class submarine, is another example of a B-alloyed martensitic steel with a minimum yield strength of 690 MPa.

Many of the traditional higher strength QT alloy steels have higher carbon contents of 0.3 to 0.5 wt% and are used to manufacture components which may not involve welding, such as highly stressed shafts and gears. An example of the American Iron and Steel Institute (AISI) designation for alloy steel of this type is AISI 4340, where the first two digits indicate the presence of Ni, Cr and Mo and the last two digits specify an average C content (0.40%). Yield strengths in the range 850 to 1850 MPa can be obtained by adjusting the tempering temperature of the as-quenched martensitic structure. In recent years boron-alloyed alternatives to these alloys have become available, including lower carbon, high strength alloys (< 0.25% C) with improved weldability.

If the first two digits of the AISI designation are 10 or 15, the Mn content is lower than 1% (10) or higher than 1% (15). For example, AISI 15B20H indicates a hardenable alloy (H) containing boron (B), an average C content of 0.20% and more than 1% Mn. The B content is typically in the range 5-30 ppm and alloys are available with a wide range of C contents to produce tensile properties in the QT condition that are similar to those for traditional B-free alloy steels.

A boron content of 30 ppm is approximately equivalent to 0.5% C or 1% Ni or 0.3% Mo in terms of hardenability effect [16]. These C-Mn-B steels can be used as replacements for more expensive steels of equivalent hardenability in applications such as drive sprockets, axle components, crankshafts, cutting and punching tools and spades [16].

The European automotive industry, in particular, has embraced these types of alloys for improved crash-worthiness and durability of vehicle components such as pillar reinforcements, roof rails, side-wall members and beams for crash management [17].

The B-alloyed steels are typically low in C and alloy content (e.g. AISI 15B20H or EN 10083 alloy 22MnB5) and can be hot stamped and quenched to produce martensite in a single operation [17]. A tensile strength of about 1500 MPa is typical and allows manufacture of thin lightweight components that result in significant vehicle weight savings. These alloys are also suitable for joining by spot welding.

6.2 Weld Filler Metals

Another area in which B alloying has been adopted is in the manufacture of welding consumables for producing higher strength weld metals designed for strength-matching with high strength plate or strip steel components. Boron-alloying of welding consumables has not, however, been universally welcome. In 2008, the Research and Standards Committee (RSC) of the Australian Pipeline Industry Association (APIA) issued a “Boron Alert” about the largely undisclosed use of boron in EXX10 cellulose electrodes designed for field girth welding of pipelines [18]. Almost universally, maximum boron levels of 5 ppm have been specified by pipeline fabricators because of past experience of serious welding
reported [5] that B in the filler is effectively transferred across the arc for GTA and GMA welding using Ar gas shielding and also for the submerged arc (SA) welding process. Using AISI 1020 and AISI 10B20 (17 ppm B) as the base steels and remelting to adjust the B content, Devletian and Heine [5] produced a series of seven 2.2 mm dia. weld filler wires with B contents in the range 0 to 240 ppm.

Welding was performed on both B-free 1020 plate and 10B20 plate. They found that for B concentrations between 10 and 30 ppm the weld metal hardness was significantly increased and the tensile strength of notched cross-weld specimens peaked at about 20 ppm, 25% higher than for B-free weld metal. However, a B content of 30 ppm or higher resulted in significant borocarbide precipitation on grain and cell boundaries, and resulted in fracture at a lower tensile stress. Degradation of strength and toughness has also reported for wrought B-steels containing more than 25 ppm of boron [2, 3]. Devletian and Heine concluded that for a B concentration of 17 ppm, the hardness of weld metal was similar to that of the B-containing parent plate, cooled at the same rate. Although the hardness values were similar, the microstructures were markedly different, implying that different transformation mechanisms occurred during cooling. Moreover, the soluble B content of the weld metal

problems for boron-alloyed steels.

These concerns apply to high hydrogen cellulosic consumables and increased susceptibility to HACC for weld metal containing more than 5 ppm B. However, other types of consumables do contain boron and have been successfully used. For example, Ti-B consumables can be used for submerged arc welding (SAW) and commercially available, B-containing flux-cored arc (FCA) consumables are used to provide increased weld metal strength with reduced levels of more expensive alloy additions such as Mn, Cr, Mo and Ni [19].

However, the effect of boron on weld metal structure and properties is more complex than for wrought steels. Research work by Devletian and Heine [20] established that weld metals produced by gas metal arc (GMA) and gas tungsten arc (GTA) welding were substantially refined in the presence of a B content as low as 6 ppm and C contents of 0.05-0.45%. Grain refinement was found to result from the formation of ferrite allotriomorphs along both cell and columnar grain boundaries that are enriched in Mn and decorated by fine precipitates of borocarbides. Refinement was maximised for Mn > 0.5%, C > 0.18% and intermediate weld cooling rates. These authors subsequently...
was only about 9 ppm compared with 17 ppm in the wrought 10B20 steel. Although 9 ppm of soluble B is likely to retard transformation of the austenite to a ferrite-pearlite microstructure, undercooling would also have been promoted by the relatively coarse as-solidified grain size. Transformation of austenite is expected to have occurred over a low temperature range, forming a high proportion of acicular ferrite nucleated by non-metallic inclusions and boron-containing particles, instead of formation of the martensitic/bainitic microstructure of the AISI 10B20 plate.

A complication arising from the use of B-containing weld consumables is that even for 100% transfer across the arc, the boron content of the weld metal will depend on the extent of dilution by the base plate, which depends in turn on the welding process and the weld heat input. The weld metal composition is not known a priori and test welds are normally recommended to qualify the welding procedure. Boron content and the form in which it is present in the weld metal will depend on type and concentrations of co-elements in both the filler metal and the base plate.

Oh et al. [20] investigated a series of commercially produced Ti-B weld metals (AWS designation E71T-1) that are designed for flux cored arc welding (FCAW). The Ti and B were included in the consumable as compounds in the flux. The aim was to maximise the % acicular ferrite which is known to provide superior low temperature toughness compared to other possible weld metal microstructures. The 25 mm thick base plate was a 0.14% C structural steel (ASTM A663Gr) and the welds were produced by 4 passes into a 12.5 mm deep vee groove using heat inputs ranging from 1.07 to 2.13 kJ/mm and CO2 shielding gas. The weld metal compositions ranged from 8-91 ppm B, 76-778 ppm Ti and 63-146 ppm N. The C, Mn, Si, Ni and O contents of the weld metals were approximately constant at 0.08%, 1.4%, 0.45%, 0.05% and 300 ppm, respectively. It was concluded that the optimum combination of B and Ti to achieve maximum acicular ferrite content and the highest toughness was 42 ppm B and 420 ppm Ti.

However, B at this concentration level and a low Ti content did not promote acicular ferrite, presumably because of formation of BN. Further, high B and Ti contents enhanced transformation to upper bainite at the expense of acicular ferrite and reduced the toughness. The optimum B content of 42 ppm is considerably higher than that normally recommended for wrought steels in order to avoid a decrease in toughness and increased susceptibility to cracking.

It is likely that only a proportion of the total B was available in the solute form necessary to retard formation of ferrite, with most of the remaining B being combined as B2O3 due to the high oxygen potential of CO2 shielding gas. Although 420 ppm of Ti would be expected to tie up N and prevent loss of solute B as BN, the formation of Fe23(BC)6 is also possible.

Special care should therefore be exercised in welding of B-containing steels and in the selection of B-alloyed filler metals to obtain the structures and properties required for the weld metal and the HAZ.

Avoidance of welding conditions that increase the susceptibility to HACC is of paramount importance.

6.3 Extra Deep Drawing Steels
The third class of steels for which B has become an accepted alloying element is highly formable sheet steels used, for example, in forming of automotive structural
components. Extra deep drawing capacity can be obtained by using “interstitial-free” (IF) steels in which C and N atoms are removed from solution as carbides and nitrides formed as a result of addition of one or more of the elements Al, Ti and Nb. Boron is also an effective scavenger for C and N and can be used instead of, or in addition to, Ti and Al [21].

However, the main role of B in IF steels is as solute atoms, which segregate to ferrite grain boundaries, thereby displacing P which can cause secondary cold work embrittlement (SCWE) [21]. About 10-15 ppm of B is used for this purpose.

6.4 High Alloy Steels
Boron has been found to be a useful alloying element in a several types of high alloy steels in cases where hardenability is not the primary consideration [16]. For example, B can be added to tool steels such as 18W-4Cr-1V high speed steel to improve cutting performance. Up to 100 ppm B can also be added to austenitic steels to enhance high temperature strength and 5-50 ppm can be used in ferritic stainless steels (14-18% Cr) to improve surface quality of strip [16].

7. Conclusions
Boron can be an extremely useful alloying addition to steels because of its potential to act either as a powerful hardenability-promoter or an effective scavenger of unwanted N, C and O from solid solution. However, the concentration of B has to be carefully limited to prevent formation of B-containing compounds that can degrade the strength and toughness of the steel. Moreover, when B is used to promote formation of martensite or bainite by heat treatment (QT) or thermomechanical controlled processing (TMCP), diligence is required during subsequent welding processes to avoid increased susceptibility to hydrogen assisted cold cracking of weldments.

Care should also be exercised in using B-containing weld filler metals designed to increase weld metal strength and toughness by promoting formation of acicular ferrite.

The distribution of boron between solute and compound forms can be variable, depending on the welding conditions, and excessive formation of boron-rich compounds can degrade strength and toughness, as well as increasing the susceptibility to hydrogen assisted cold cracking.

For normal structural steel applications, there is little need to use a hardenable alloy steel to boost the strength level. Boron in solute form in ferrite exerts no significant strengthening effect [16] and therefore the addition of B with no heat treatment, other than that locally imposed by welding, is likely to be counterproductive, especially if its presence in the steel is undeclared or is poorly quantified.

Alloying with boron is only a valid strategy if it leads to a verifiable improvement in the properties of the steel.

This is unlikely to be the case for low C structural steels of moderate strength levels (yield strengths of 250-350 MPa), which exhibit excellent ductility and weldability. Addition of boron will not increase the strength unless a QT type heat treatment is applied [16], but it is likely to increase the potential for weldment cracking by promoting the formation of martensite in the HAZ. If the dangers of B-alloying are recognised, counteractive welding procedures can be employed, but these are likely to add to manufacturing costs.

References
18. APIA Research and Standards Committee Member Alert: “Welding electrodes for pipelines - The current situation”, March.
Reinforcing Steel Coordinator Course

In recent times, a number of manufactured reinforced steel structures have failed due to poor weld quality. Industry has determined that there is a need for properly trained personnel to supervise and inspect the welding of reinforced steel structures used for construction. In response, the WTIA (in conjunction with the Steel Reinforcement Institute of Australia) has developed the Reinforced Steel Coordinator course, designed to enable graduates to perform the required supervision. Those who complete the course will be certified to supervise welding of reinforced steel only in accordance with AS/NZS1554.3, without having to complete the full Welding Supervisors training requirements as per AS2214 (Section 2).

Course Aims
- Provide training to ensure competent personnel are available for the supervision and inspection of welding of reinforcing steel used in construction in accordance with AS/NZS1554.3 (Welding of Reinforcing Steel)
- Give a working knowledge of the requirements of AS/NZS1554.3
- Train suitable candidates for the role of 'Welding Coordinator' in accordance with:
  - AS/NZS1554.3 Clause 4.12.1, specifically item (e); and
  - Requirements for welding coordination as per ISO 14731.

Knowledge and skills will be based on the requirements of relevant parts of AS 2214 Certification of welding supervisors – Structural steel welding.

Typical Job Description
A Reinforcing Steel Welding Coordinator is typically responsible for the quality, cost and productivity of all reinforcing steel welding related activities within a company specifically manufacturing reinforced concrete products, including:
- Perform, supervise and oversee company-nominated welding and welding-related activities for reinforced steel
- Have overall responsibility for the quality of these welding and welding-related activities for reinforced steel products
- Be authorised to sign on behalf of the organisation in all nominated welding quality related matters or delegate such signing, including: goods release for dispatch, inspection sign-off, accepting technical welding requirements, or verifying that the organisation has complied with all relevant quality considerations in the production of the product.

Pre-Requisites
The entry requirements for participants are as follows:
- Three years approved practical experience in the fabrication engineering industry, and successful completion of an approved course that includes:
  - Welding process technology
  - Welding metallurgy
  - Weld testing and inspection
  - Standards and specifications – Steel structures.
  OR
- Three years approved experience in the supervision or inspection of welding; or
- A qualification in either engineering, metallurgy or welding, and three years approved experience related to the practical application of welding; or
- Other qualifications or experience acceptable to the principle conforming to the requirement of ISO 14731, with specific technical knowledge and experience in the welding of reinforcing steel.

Course Content
The five day course will cover:
- Duties of a Welding Supervisor or Coordinator
- Metallurgy, Weldability and Manufacture of Reinforcing Steel
- Welding Process Technology
- Welding Equipment and Power Sources – Function, Safety and Maintenance
- Fulfilling Fabrication Requirements – Interpretation of Drawings and Welding Symbols
- Qualification of Welding Procedure Specifications
- Qualification of Welders
- Inspection and Quality Assurance
- Quality Assurance and Safety in Welded Construction

Further Information
For further information, please contact the WTIA on 02 8748 0150 or training@wtia.com.au.
Significant Changes to International Welding Engineer (IWE) Qualification

Following feedback from members in relation to access conditions for International Welding Engineer (IWE) status, the WTIA obtained clarification from the International Institute of Welding (IIW) on the inclusion of a much wider range of qualifications.

Previously, candidates had to hold a Bachelor Degree. Now, candidates with any postgraduate qualification—a Bachelor Degree or higher—from a recognised Australian university will meet the entry requirements.

Postgraduate qualifications that meet the revised IWE entry requirements include any of the following in an engineering discipline: Bachelor Degree, Bachelor Honours Degree, Graduate Certificate, Graduate Diploma, Master’s Degree, Doctoral Degree, or Higher Doctoral Degree.

For instance, candidates with a Graduate Diploma in Materials Welding Technology from RMIT, or a Master of Engineering Practice in Materials Welding and Joining from University of Wollongong, will now meet the IIW IWE entry requirements.

For further information, please contact Annette Dickerson (WTIA Qualification & Certification Manager) on a.dickerson@wtia.com.au.
An Update from:
SMART Industry Groups

About SMART Industry Groups

WTIA's SMART (Save Money and Re-engineer with Technology) Industry Groups provide a facilitated private forum where industry-specific members can discuss and analyse welding-related challenges and issues, and source potential solutions. For further information on any of the SMART Groups, please contact info@wtia.com.au.

Road and Rail SMART Group

The SMART Road and Rail Group met in Sydney in early September. This meeting saw the participation of the various state-based road authorities, including Department of Transport and Main Roads (Queensland), Roads and Maritime Services (New South Wales), VicRoads (Victoria), and the Department of Planning, Transport and Infrastructure (South Australia) together with the WTIA and the Australian Steel Institute.

The Austroad Steel Fabrication Specification project is progressing well and was one of the major topics discussed during the meeting, particularly the adoption of the fundamental concept of a risk-based fit-for-purpose categorisation (Construction Category or CC).

The launch of the WTIA's new Reinforcing Steel Welding Coordinator Course was also on the agenda at the meeting.

Recently, the WTIA was made aware that, although there is a dedicated Australian Standard, there is an underestimation about the importance of welding reinforcing bars for concrete structures.

In recent times, a number of manufactured reinforced steel structures have failed due to poor weld quality. Industry has determined that there is a need for properly trained personnel to supervise and inspect the welding of reinforced steel structures used for construction. In response, the WTIA (in conjunction with the Steel Reinforcement Institute of Australia) has developed the Reinforced Steel Coordinator course, designed to enable graduates to perform the required supervision. Those who complete the course will be certified to supervise welding of reinforced steel only in accordance with AS/NZS1554.3, without having to complete the full Welding Supervisors training requirements as per AS2214 (Section 2).

For further information about the course, please refer to page 44.

APT SMART Group

The recent meeting of the APT Group focused on members. The objective of the meeting was to discuss the key challenges currently faced by companies operating within the power generation industry, and ways that the APT Group can help overcome these challenges, thereby delivering value to members.
A number of existing and proposed projects were discussed, including REMLIFE, the Replication Project, and the PG9 project, which involves the identification and qualification of welding procedures.

Three critical welding procedures were qualified successfully in Round One of the PG9 project. One procedure was qualified for specific use on aged material, making it ideal for repair and maintenance welding.

A second procedure was developed, which has resulted in very successful trials of a new low-chromium nickel-based consumable. The third procedure, which has now been successfully completed and tested, will enable the welding of dissimilar materials (low alloy ferritic steel to Austenitic stainless steel), without PWHT. This will save a significant amount of time and money.

Gaps in the current welding procedure database have been identified as the focus for Round Two, and the logistics of qualification were discussed.

**Defence SMART Group**

The Defence SMART Group will meet in late September, in Adelaide. Expected to be the largest Defence SMART Group meeting the WTIA has ever seen, key players within the defence industry will attend, including representatives from DCNS, ASC, DMTC, TAFE SA, Defence SA, ANSTO, Rheinmetall and BAE Systems.

Key discussions will range from shipbuilding in Australia and the LAND 400 armoured vehicles project, through to how local SMEs can support these defence projects.

As part of the discussion, Geoff Crittenden (WTIA CEO) will brief attendees on the Australian Welder Certification Register (AWCR). The AWCR will help ensure a ready supply of sufficient numbers of qualified welders for a range of industrial projects, including the various upcoming defence industry projects. For further information about the AWCR, refer to page 16.

A number of new research projects will be discussed at the meeting, including robotic welding in confined spaces, additive manufacturing using welding techniques, and joining composites and steel.

It is worth noting that the WTIA is looking to expand the breadth of its technical offering to include plastic and composite joining to metal—techniques which will be used in the various shipbuilding and manufacturing projects across the nation. As such, Geoff Crittenden met with David Marino, Chief Executive Officer and Managing Director of Quickstep.

The largest manufacturer of advanced composites in Australia, Quickstep and DCNS signed a Memorandum of Understanding (MoU) as a first step of cooperation for Australia’s Future submarines project.

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Want to know more? Contact Donna South on d.south@wtia.com.au or +61 (0)2 8748 0130
Can you provide some detail on Welding Procedures, Procedure Qualification Record and Welder Qualification?

Welding Procedure Specifications (WPS) are needed to provide a well-defined basis for planning of welding operations and quality control during welding. WPS are “the detailed methods and practices involved in the production of a weldment”. Essentially, a WPS lists all the important welding parameters that need to be controlled to ensure a satisfactory weld.

The WPS begins with the actual welding process or processes to be used and then identifies the material specification and grade. Having identified the welding process and material specification, the procedure begins to get rather more specific and indicates the range of essential variables to which the procedure can be applied without the need for requalification.

In this regard, the WPS is a general document since it provides a complete range of parameters to which the procedure could be applied in accordance with the applicable code.

Development of a welding procedure consists of three stages:

- **Stage One**: Development of a pWPS (Preliminary Welding Procedure Specification)
- **Stage Two**: Witness the welding test and record all the actual welding parameters during the test.
- **Stage Three**: Final Welding Procedure, based on the limits of the essential variables of the application Standard.

The requirements for procedure qualification vary with each Standard or code. A proposed (or draft) welding procedure specification (pWPS) should be prepared by the fabricator and may require the approval of the Principal under some contract arrangements. This may be modified and amended during the procedure tests as deemed necessary. In its final version, the WPS is to include all the parameters characterising the welding process, particularly (as applicable):

- a. Type of welding process and equipment
- b. Type of joint, preparation and backing material, if any
- c. Base metal and thickness range
- d. Filler metal
- e. Welding position
- f. Minimum preheat and maximum interpass temperature
- g. Post-weld heat treatment
- h. Shielding gas
- i. Welding parameters (i.e., current, voltage, travel speed, etc.)
- j. Any other information relevant to the welding techniques.

The flow diagram opposite shows the stages involved during the development of a welding procedure.
The PQR is a document that records the actual welding parameters used during the welding of the test piece. The document indicates the name of the welder and the welding inspector who carried out the qualification weld and details specific items. The procedure qualification record is generally a two page document. The first page details actual welding parameters and the second page lists all the visual, non-destructive testing and mechanical testing that was carried out on the test weld to demonstrate compliance with the application standard. Even prequalified procedures require some form of mechanical testing as in AS/NZS1554.1.

The skill of the welder is often a major factor in determining the final weld quality. Welder qualification is separate from procedure qualification. Qualification of welding procedure and welder needs to be viewed in a different perspective. Procedure qualification is intended to justify that particular procedure will work in the service satisfying the requirement of application code. Whereas the welder qualification tests are specifically devised to determine a welder’s ability to produce sound welds.

The level of skill required to pass a welder qualification test varies significantly with the process, welding position and base metal. For example, the skill required to pass a welding test by gas tungsten arc welding on aluminium in the overhead position will require considerably more skill than shielded metal arc welding on carbon steel in the flat position. For this reason, a person is qualified in the process, material, thickness and position in which tested, as well as less difficult positions.

References
1. Modern Welding Technology, H. Cary
3. The Procedure Handbook of Arc Welding, The Lincoln Electric Company

Figure 1. Flow Diagram for Developing a Welding Procedure for the Production of a Welded Product

<table>
<thead>
<tr>
<th>Development of WPS</th>
<th>Factors to be Considered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review customer and contract requirements for specific product &amp; service</td>
<td>Scope of the contract works</td>
</tr>
<tr>
<td>Identify the Standard for the structure to meet</td>
<td>Specifications and Standards</td>
</tr>
<tr>
<td>Identify the material, thickness and welding position</td>
<td>Specific instructions</td>
</tr>
<tr>
<td>Type of joint</td>
<td>Optimum selection of Standard or Code and class</td>
</tr>
<tr>
<td>Select the most suitable welding process</td>
<td>Quality acceptance criteria</td>
</tr>
<tr>
<td>Select welding consumables to meet performance requirements</td>
<td>Testing requirements</td>
</tr>
<tr>
<td>Create pWPS - specify (for above welds):</td>
<td>Base metal (material grouping - spec, grade, etc.)</td>
</tr>
<tr>
<td>• Thickness ranges</td>
<td>• Thickness diameter, access, position, weld size</td>
</tr>
<tr>
<td>• Essential variables</td>
<td>• Shop or site</td>
</tr>
<tr>
<td>• Preheat/Postweld heat treatment</td>
<td>Butt weld - Groove design (U groove, V groove, single bevel, etc.)</td>
</tr>
<tr>
<td>• Type of production tests</td>
<td>• Backing, root gap, root face, etc.</td>
</tr>
<tr>
<td>Determine other information relevant to the welding techniques</td>
<td>Process features (eg. capabilities)</td>
</tr>
<tr>
<td>Use the pWPS to produce and document a test weld</td>
<td>Availability of equipment &amp; power sources</td>
</tr>
<tr>
<td>Perform required NDE and mechanical tests on test weld to produce the PQR</td>
<td>Availability of qualified welder or operator</td>
</tr>
<tr>
<td>Prepare a WPS based on the completed PQR</td>
<td>Consumable classification or specification</td>
</tr>
<tr>
<td>The WPS should incorporate the essential variable ranges as allowed by the welding specification appropriate to the welding conditions</td>
<td>Shielding gas classification or specification</td>
</tr>
<tr>
<td></td>
<td>Essential variables (ie. materials, consumables, heat input, current, voltage, polarity, travel speed, welding position, stringer, weave, back-gouge, cleaning, preheat, PWHT)</td>
</tr>
<tr>
<td></td>
<td>• NDT – Radiography, UT, PT, MP, etc.</td>
</tr>
<tr>
<td></td>
<td>• Mechanical – tensile, bend, hardness, etc.</td>
</tr>
<tr>
<td></td>
<td>Use of run-on and run-off tabs</td>
</tr>
<tr>
<td></td>
<td>• Run sequencing</td>
</tr>
<tr>
<td></td>
<td>• Blending of toe areas for special services (fatigue)</td>
</tr>
<tr>
<td>Follow pWPS as far as practical</td>
<td>Use welder suitable for procedure</td>
</tr>
<tr>
<td></td>
<td>• If necessary, hire equipment. Witness test weld.</td>
</tr>
<tr>
<td></td>
<td>Use tests required by Standard, customers and other standards (Cv may qualify for pressure vessel)</td>
</tr>
<tr>
<td></td>
<td>• Tests may be NDT and mechanical</td>
</tr>
</tbody>
</table>
For Your Diary

Upcoming Events

Whether you need to brush up on skills learnt years ago, want to try your hand at something new, or crave some networking opportunities, there is an industry event for you. For further information on any of the events listed below, or any WTIA events, please email events@wtia.com.au or phone +61 (0)2 8748 0100.

October 2016

51st Australian Foundry Conference and the 16th ADCA Die Casting Conference
9 to 10 October, Geelong
www.afivictoria.org.au

10th International Conference on Trends in Welding Research
11 to 14, Tokyo
www.trends2016.org

Materials and Maintenance Advancements for Mining
14 October, Kalgoorlie

2nd Pressure Equipment Workshop 2016
14 October, Auckland
www.hera.org.nz

International Congress on Applications of Lasers and Electro-Optics
16 to 20 October, San Diego
www.lia.org

American Society for Non-Destructive Testing Annual Conference
24 to 27 October, Long Beach
www.asnt.org/annual

EuroBLECH 2016
25 to 29 October, Hanover
www.euroblech.com

November 2016

FABTECH 2016
16 to 18 November, Las Vegas
www.fabtechexpo.com

December 2016

CAMS 2016 - Advancing Materials and Manufacturing
6 to 8 December, Melbourne
www.cams2016.com.au

Additive Manufacturing Americas
7 to 9 December, Pasadena
www.amshow-americas.com

Event Spotlight: Materials and Maintenance Advancements for Mining, 14 October, Kalgoorlie

In conjunction with Materials Australia, the WTIA will present this seminar in Kalgoorlie on 14 October. The seminar will cover the innovative use of materials and maintenance to support life extension on capital equipment and plant assets—a topic that is critical to the Kalgoorlie mining industry. Particular focus will be given to materials, welding, asset management and corrosion.

Keynote speakers include Erich Hofmann of Hofmann Engineering, Garly Lantzky (CEO of Callidus Welding Solutions), Johann Petrick (Metallurgical Engineer at MTS Metallurgical Testing Services) and Louise Petrick (WTIA Technology Manager).

The seminar will be followed by a KCGM plant visit. For further details, please visit: http://wtia.com.au/event-calendar
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• Mechanical Testing
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• Provision of welding specialists (IWE, IWT, IWS) for site work
• Pipelines- in-service welding, repairs, hot tapping

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• R&D – Application of technology
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• Training leading to formal International Institute of Welding (IIW) Qualification and Certification
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