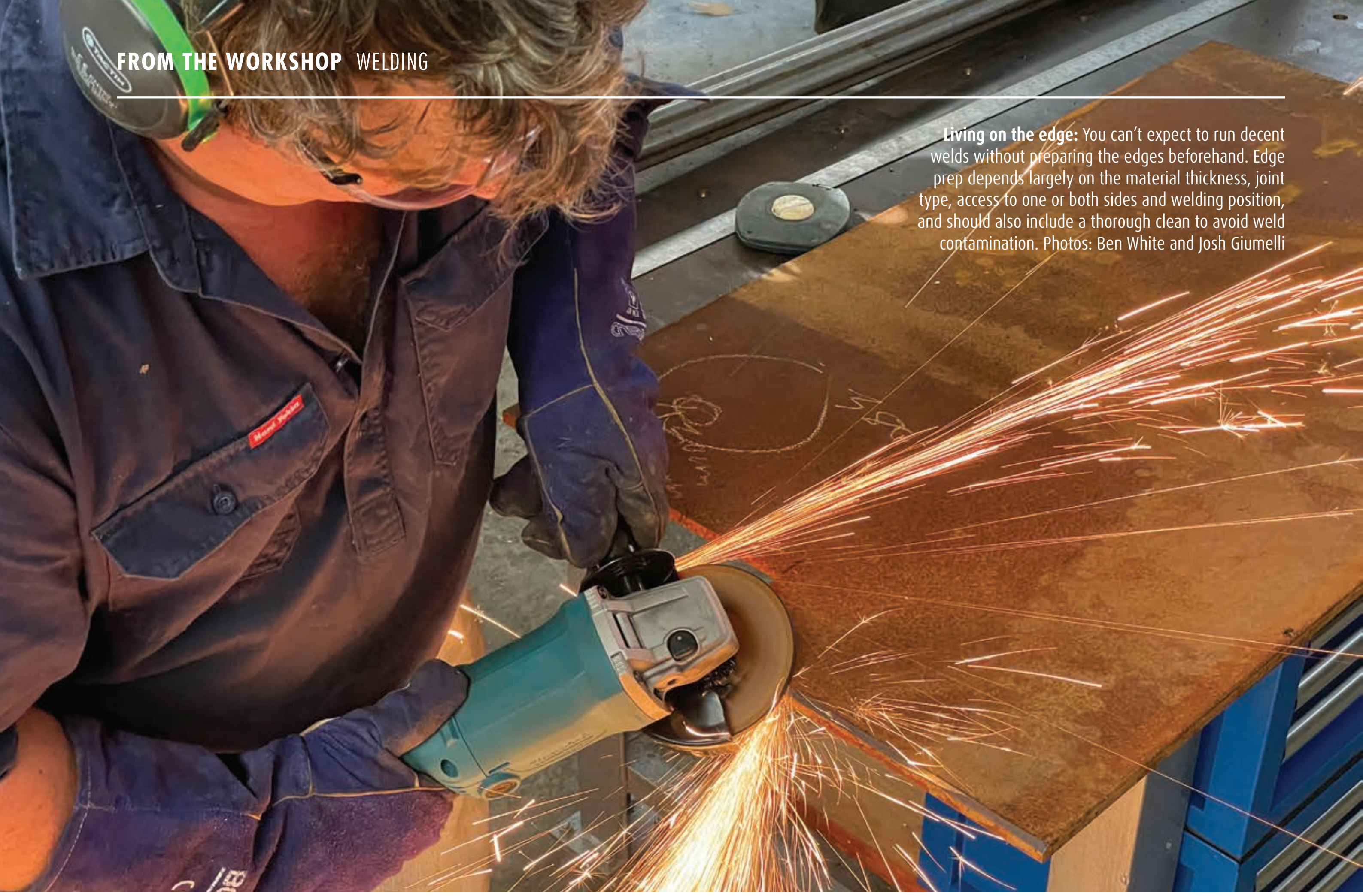


Living on the edge: You can't expect to run decent welds without preparing the edges beforehand. Edge prep depends largely on the material thickness, joint type, access to one or both sides and welding position, and should also include a thorough clean to avoid weld contamination. Photos: Ben White and Josh Giumelli

Good preparation prevents poor weld penetration

The success or otherwise failure of any weld can depend as much on the preparation done before an arc is struck, as in the welding itself. By **Josh Giumelli**

Welding preparation is crucial to achieve full penetration of the weld without distortion and also to prevent impurities in the weld.

While the preparation of thicker steel sections before welding can be quite involved, other times all that is required is a quick clean of the joint faces.

Successful welding preparation depends largely on knowing how to treat each joint, which will depend on the joint itself (for example fillet or butt welds, see figure 1 and 2), the thickness of the steel, access to one or both sides, and the joint position itself. In many cases it is simply not possible to weld from both sides of a joint, such as a butt join between two sections of tube.

CLEAN STEEL MAKES GOOD WELDS

It goes without saying that joint cleanliness is crucial to achieving strong, impurity-free welds. If you are repairing machinery, it is likely the joint is contaminated with paint, rust, oil or dirt. Even galvanised coatings need removal before welding and new steel needs attention as well.

The bluish coating of mill scale found on hot-rolled steel products will make quality welds impossible and must be removed from the adjacent area. Any contaminant on the surface will end up as inclusions in the weld, or gas bubbles if it vapourises under welding temperatures.

HIGH-TECH ABRASIVES FOR QUICKER CUTS

In the process of compiling the Workshop articles over the last two months, Kondinin Group engineers tested a range of ceramic abrasives which are becoming more popular for bulk metal removal. Suffice to say the performance of these products was impressive.

Traditional bonded abrasive discs use aluminium oxide particles glued together, or onto a backing disc in the case of fibre discs. Often a reinforcing matrix is added to increase the strength of the disc and resist shattering.

Ceramic discs use a ceramic grit which tends to shatter as it wears, leaving a sharp edge. This tends to make the abrasive self-sharpening to a certain degree. See page 32 for a review of ceramic abrasives.

Figure 1. Butt welds

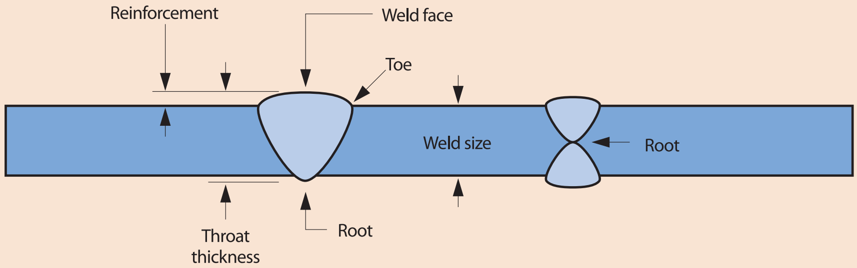
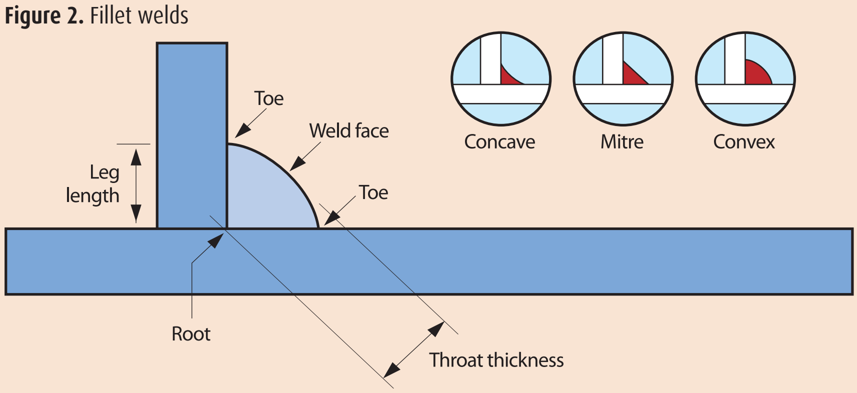


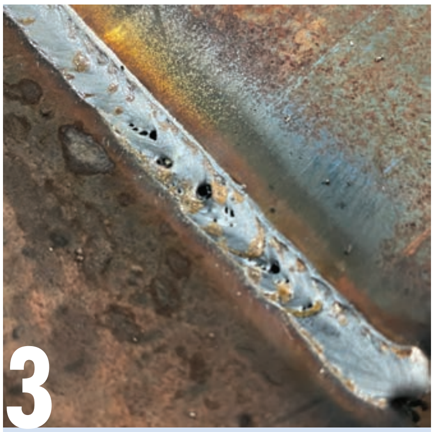
Figure 2. Fillet welds



CLEANING SURFACES

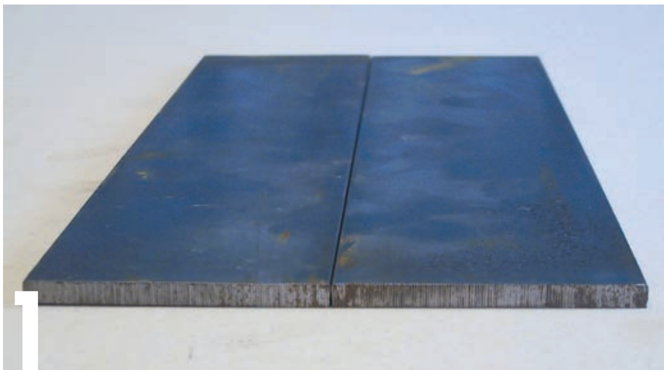
While there are may abrasive tools that can be used to clean rust and paint from steel, a wire cup brush fitted to an angle grinder is probably the quickest and most convenient tool to use. However, heavily rusted or pitted surfaces will still require the use of abrasive grinding discs.

Even mill scale should be cleaned off steel surfaces for best results. While wire wheel cup brushes on an angle grinder are good for removing rust and paint, they are probably not aggressive enough the remove mill scale. For that use an abrasive flap disc, fibre disk or grinding wheel.



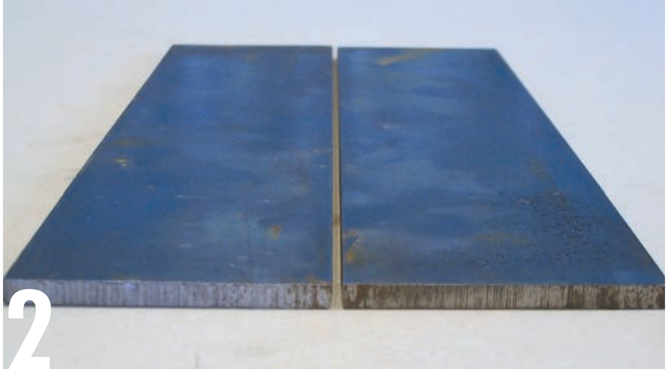
A small amount of contamination can have disastrous affects on weld quality. Here one edge of the joint was not ground back well enough, leading to gas bubbles in the weld. Certain welding processes are more prone to surface contamination, such as TIG and solid-wire MIG welding. Other welding processes such as stick electrode and gasless MIG (flux core wire) are far more forgiving of surface contaminants.

BUTT WELDS



1

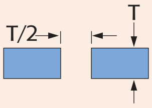
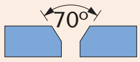
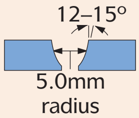
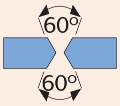
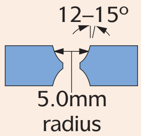
For any steel thinner than 3mm a simple closed butt can be used where both edges are touching. Note the mill scale is yet to be removed.



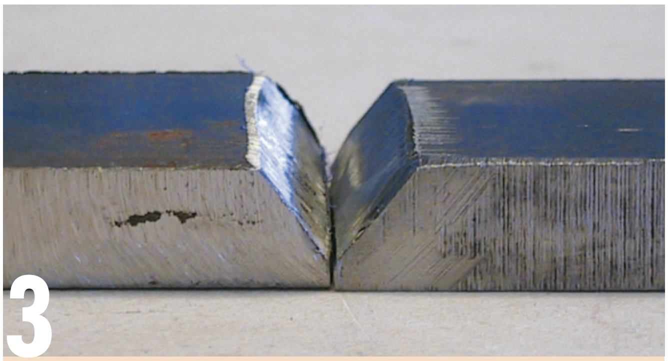
2

For thicker butt joins over 3mm but less than 5mm, use an open butt arrangement. The gap should equal half the plate thickness. Note that the welding process will also influence joint preparation. The more welding current available, the easier it is to achieve penetration. If you are welding with limited current on a small machine, err on the side of more preparation than less.

Table 1. Edge preparation

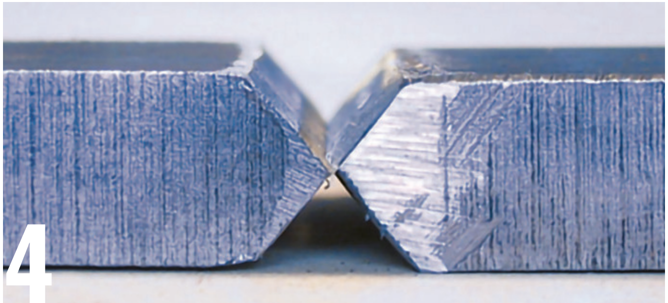
Thickness (mm)	Edge preparation	Notes
Up to 3		Square butt joint – no gap
3.0–5.0		Square butt joint – gap equal to half thickness
5.0–13.0		Single V-preparation – 1.5mm landing, 1.5mm gap
13.0–20.0		Single U-preparation – 1.5mm maximum landing, 1.5mm gap
More than 20		Double V-preparation – 3mm landing, 1.5–3mm gap
		Double U-preparation – 3mm landing, 1.5–3mm gap

Source: Cigweld



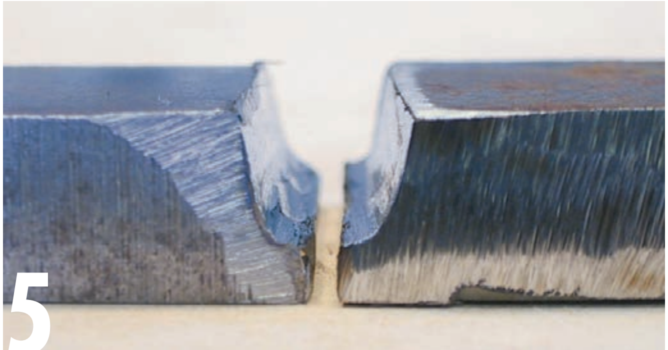
3

For single-sided joins, and for plate thickness 5-13mm, use a single V-preparation with an included angle of about 60 degrees.



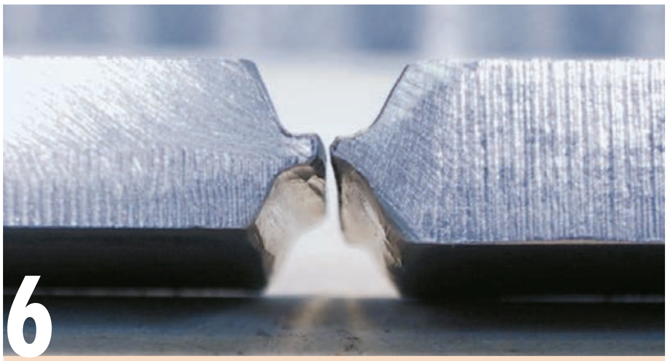
4

Use a double-V preparation for thicker sections (for example 20mm) and when welding is possible from both sides. Joint distortion control will always be easier when welding from both sides and balancing runs. Once again, an included angle of about 60 degrees should be used.



5

An alternative edge preparation to the V-shape prep is to use a U-shape preparation. For single sided welds up to 20mm use a preparation as shown.



6

For thicker sections more than 20mm, a double U-shape preparation is appropriate for butt joints where both sides are accessible.

7

Sometimes joint design requires little additional edge preparation other than grinding off mill scale and rust. The thick-wall RHS section above has a natural radius providing sufficient preparation when the square edge of another section is butted up against it. This is known as a bevel flare groove. For a thicker square edge, a V-prep may be necessary to achieve full penetration (flare-V preparation).

8

The same applies with two sections of RHS placed side-by-side where the corner radius forms a sufficient preparation for welding, provided it has been cleaned up. This is known as a V-grove flare joint.

9

Another benefit of using the correct weld preparation is that sufficient joint strength can be achieved without excessive reinforcement, or convex weld bead. This creates a neater joint and requires little dressing with a grinder to achieve a clean surface.

FILLET WELDS

1

Fillet welds generally need little preparation (top), and any "veeing" of the joint can actually cause more difficulties when welding than simply cleaning the surface, although in certain situations it is required. Not all fillet welds are in a straight line! (Bottom).

2

A T-fillet joint is where the layout permits welding from both sides and is an advantage as welding runs can be balanced, with less chance of distortion pulling things out of square. Once again, little preparation is needed other than a surface clean.

3

An external corner fillet is where the two sections meet at the corner forming a 90-degree edge prep. This leaves a rounded, neat corner requiring little to no dressing with the grinder. Additional beads can be run on the inside for increased joint strength.

4

It is not always possible to form a corner fillet as shown previously. Here 75mm flat bar is being used to cap 75x125mm RHS, so it would be tedious to grind the edge of the bar down so a corner fillet could be welded. Better to form an outside corner V-groove, which leaves a neat joint with little clean-up required. If the sections were simply butted together, any welding would leave an overly rounded bead needing extensive grinding to clean up, also risking removing much of the weld in the process.

5

A lap fillet can sometimes be used in place of a simple butt join, providing the design allows for the misalignment. The benefit of the lap fillet over the butt joint is it requires little preparation and can be welded on both exposed edges, giving greater strength.

CERAMIC ABRASIVES

Edge preparation usually involves metal removal, especially on thicker steel sections. While there are some nifty gouging nozzles available for the oxy-acetylene torch, most of us will reach for the grinder when bevelling the edge of a steel plate.

Kondinin Group engineers have trialled ceramic abrasives for a couple of months now and results have been reasonably impressive. These high-tech abrasives use triangular-shaped ceramic abrasive grains, as opposed to the rougher, random grain shape of aluminium oxide found in more traditional abrasives.

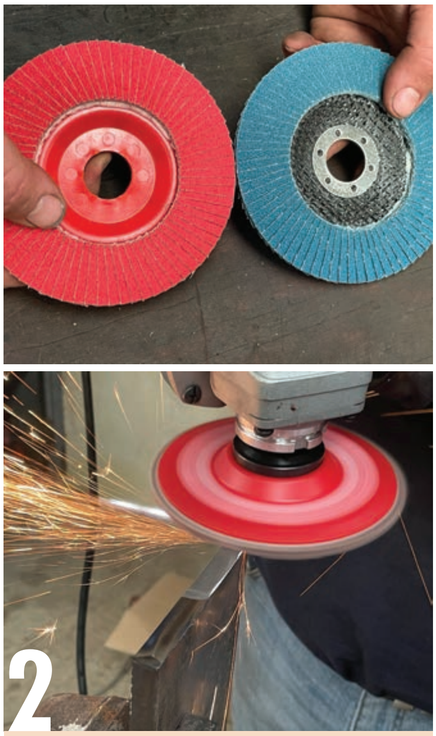
Manufacturers claim that as the ceramic grain wears, it continuously fractures, exposing a new sharp edge, rather than dulling down as with other abrasives. This is aimed to increase cutting speed as well as prolong the life of the abrasive media.

Some quick tests have highlighted the performance advantages of these abrasives, although they seem to seem to excel more in certain styles of abrasives than other styles. For example, the metal removal rates of ceramic fibre discs was far more impressive than ceramic 7mm depressed centre grinding discs when compared against normal abrasives.

Ultimately, a ceramic disc can cut faster and last longer, but will invariably cost more. If the time saving is significant due to faster metal removal, it may be worth the extra money.

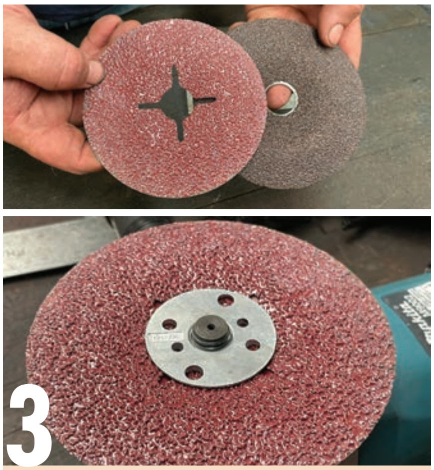
1

Depressed-centre grinding discs have long been the go-to abrasive disc for metal removal and weld prep, but these days there are a few other alternatives which offer either a faster cut rate or better surface finish. To kick off our comparison we put a 3M Cubitron ceramic grinding disc up against a Flexovit disc. Both discs were 125 x 7mm size. Metal removal was slightly faster with the 3M product, although wear rates were difficult to assess compared with the Flexovit. Given that the 3M disc costs almost $10 compared to $2.20 for the Flexovit product, we think the traditional disc is still the best choice in this instance.



2

Next we put a ceramic flap disc up against an aluminium oxide disc. We were unable to obtain a 3M Cubitron flap disc, but were able to get hold of a Josco ceramic product ($16) versus a standard abrasive disc from the same manufacturer ($8). Both were 80 grit. Metal removal was faster with the ceramic disc, and while it appeared to last longer, it does seem hard to justify the double cost over the standard disc



3

It was testing the fibre abrasive discs where things started to get really interesting. We put a 3M Cubitron ceramic disc up against a Flexovit fibre disc, both rated at 36 grit. Initial tests indicated the 3M product was a lot more aggressive than the Flexovit disc, and visually the 3M disc looks far more abrasive (top). So we repeated the tests with the same 36 grit Cubitron disc and a 24 grit Flexovit disc. In a timed test grinding down flat bar, the Cubitron disc removed three times more metal than the Flexovit product. If you have been using flap discs or standard fibre discs for weld preparation and general grinding, it is well worth trying this 3M product.

4

Due to the aggressive nature of the Cubitron discs, one of the issues in use is to control the amount of metal removal, as they can bog in and remove too much very quickly. The surface finish (top) looks almost like it has been milled rather than grinded, although a finer grit will produce a smoother result. The steel is noticeably cooler, despite the larger amount of material removed, and rather than producing dust-like debris from the grinding process, the ground metal is swarf-like and easily picked up with a magnet (bottom). In terms of cost, we paid $3.15 a disc for the Flexovit, and $3.70 each for the Cubitron. We think the use of the ceramic disc in this case is a no-brainer.

5

Lastly, we put five 125mm x 1.0mm cut-off discs head-to-head (top). The time taken for each disc to take five slices through a 5mm flat bar was recorded, and disc diameter was measured before and after the test. In order of decreasing cutting speed (bottom) was the 3M Cubitron at 12.5 seconds, the 3M standard abrasive at 14.0s, the Pferd at 15.7s, the Flexovit Advanced Ultra Fast Cut at 16.4s and the XTorque rounding it out at 16.9s. Wear rates were similar in all cases. The 3M Cubitron was the only ceramic abrasive disc tested, and while certainly fastest, it is questionable whether it is worth it at an extra dollar per disc.

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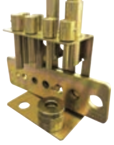

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