

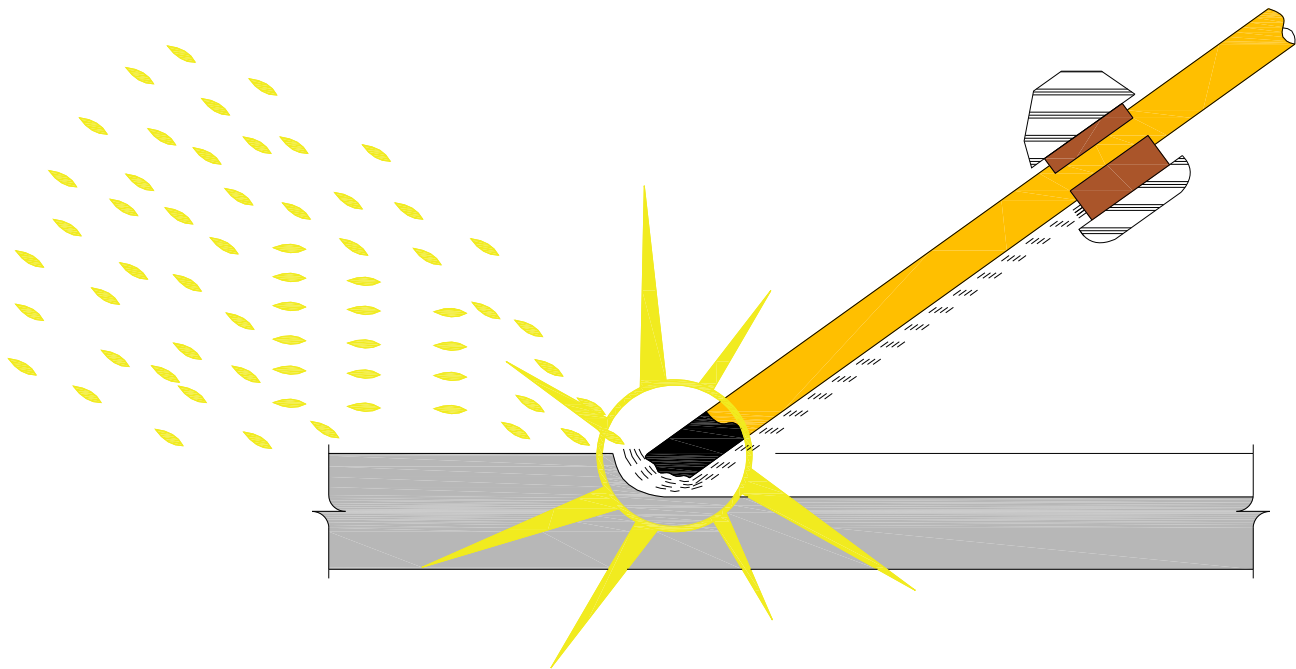
Suggestions for Air Carbon Arc Gouging

Second edition

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SAFETY

- 1.1 Fire: you will have sparks and molten metal flying everywhere, protect yourself and others. Remove combustibles from work area and / or provide a fire watch. Never use a cylinder of oxygen instead of compressed air.
- 1.2 Noise: noise from air carbon arc gouging will damage your hearing. Hearing protection must be worn by the operator and surrounding personnel.
- 1.3 Fumes: air carbon arc gouging produces a large amount of smoke, fumes and gases, do not breathe these fumes. Ventilation must be provided to keep these fumes from the operator and others in the area.
- 1.4 Use a power source with enough capacity for the job. If you don't have enough capacity and are thinking of connecting (paralleling) 2 power sources together, be careful. Consult your power source manufacturer for recommendations and safety precautions.
- 1.5 Use this guide at your own risk.
- 1.6 This Guide shall be used in conjunction with:
 - a) All welding codes and standards.
 - b) All Safety codes and standards.
 - c) CWB / AWS approved WPS or WPDS.
 - d) Company policies and safe practices.

2 EQUIPMENT

- 2.1 Power Sources: Use a power source with enough capacity for the job. The amperage range will depend on the size of carbon arc air rod to be used. Power sources should be either DC constant current, DC constant voltage or an AC/DC transformer with 100% duty cycle.
- 2.2 Newer power sources may have a gouge setting, be sure to know the output (CC or CV) you are using when gouging. Some use CC and some use CV. When using CC the amperage setting is more critical.
- 2.3 When CC gouging, the amperage is controlled by the amperage control on the machine. The operator will set the machine for the best cut for each size of electrode. This make the CC process a more sensitive, if the amperage is not within the operating range of the electrode, the gouging process will not work properly. See table 2.2 for recommended current range for electrode diameters.
- 2.4 When CV gouging, the machine will provide as much current as the electrode needs. Simply use the electrode that is needed. See table 2.2 for recommended current range for electrode diameters. I prefer CV over CC for gouging.
- 2.5 Gouging Torch: Use a gouging torch with enough capacity for the job. For example Arc Air Angle-Arc[®] torches:
 - a) K2000TM: 450 amps max. capacity.
 - b) K3000TM: 600 amps max. capacity.
 - c) K4000TM: 1000 amps max. capacity.
 - d) K5000TM: 1250 amps max. capacity.



Fig. 2.1 Arc Air: K4000, notice the model number on the handle.

2.6 Welding cables: see table 2.1 below for recommended size of cables for various currents and lengths.

Table 2.1
Recommended number and size of welding leads for various currents and lengths

| Amps | 25 Ft (7 m) | | 50 Ft (15 m) | | 100 Ft (30 m) | | 150 Ft (46 m) | |
|------|-------------|------|--------------|------|---------------|------|---------------|------|
| | # of cables | Size | # of cables | Size | # of cables | Size | # of cables | Size |
| 100 | 1 | 4 | 1 | 3 | 1 | 2 | 1 | 1/0 |
| 200 | 1 | 3 | 1 | 2 | 1 | 1/0 | 1 | 3/0 |
| 300 | 1 | 2 | 1 | 2 | 1 | 3/0 | 2 | 2/0 |
| 400 | 1 | 2 | 1 | 1/0 | 1 | 4/0 | 2 | 4/0 |
| 500 | 1 | 1 | 1 | 2/0 | 2 | 2/0 | 2 | 4/0 |
| 600 | 1 | 1 | 1 | 3/0 | 2 | 3/0 | 2 | 4/0 |
| 800 | 1 | 1/0 | 2 | 2/0 | 2 | 4/0 | 4 | 4/0 |
| 1000 | 1 | 2/0 | 1 | 4/0 | 3 | 3/0 | 5 | 4/0 |
| 1200 | 1 | 3/0 | 2 | 4/0 | 3 | 4/0 | N/A | N/A |

Notes:

- 1) Recommendations are based on 4V, DC drop 100ft.
- 2) For AC, use next heavier size.
- 3) The length given is one half the sum of the electrode and ground leads.
- 4) Inadequate grounding causes cable overheating; at least 1 in.² (645mm²) of contact per 1000 amps.
- 5) If your cables get hot, they are too small.
- 6) Reproduced from table 3, Arc Air[®] Air Carbon-Arc Guide.

2.7 Air carbon arc gouging rods: keep carbon electrodes dry. If electrodes become damp, bake them for 10 hours at 300° F. See Table 2.2 for current ranges and electrode size. Welding power source, air carbon arc torch, and welding cables are depended on rod size.

3 types of electrodes are listed below:

- a) DC copper coated electrodes: are mostly used because of their long life.
- b) DC plain electrodes: diameters of less than 3/8" (10mm), they consume more rapidly.
- c) AC coated electrodes: rare earth materials are added to ensure arc stabilization when using alternating current.

Table 2.2
Suggested current ranges (Amps) for commonly used electrodes and sizes

| Electrode Diameter | DC Electrode DCEP | AC Electrode AC | AC Electrode DCEN |
|---------------------------|--------------------------|------------------------|--------------------------|
| in (mm) | Min - Max | Min - Max | Min - Max |
| 5/32 (4) | 90 - 150 | N/A | N/A |
| 3/16 (5) | 200 - 250 | 200 - 250 | 150 - 180 |
| 1/4 (6) | 300 - 400 | 300 - 400 | 200 - 250 |
| 5/16 (8) | 350 - 450 | N/A | N/A |
| 3/8 (10) | 450 - 600 | 350 - 450 | 300 - 400 |
| 1/2 (12) | 800 - 1000 | N/A | N/A |
| 5/8 (16) | 1000 - 1250 | N/A | N/A |

Note:

1) Reproduced from table 2, Arc Air[®] Air Carbon-Arc Guide.

- 2.8 Air compressor: for general or multi-purpose use, an air compressor with a minimum of 80 psi (550 kPa) is required while the torch is in operation. Minimum air consumption is 25 cfm (708 L/min) to 33 cfm (934 L/min.). Never use a cylinder of oxygen instead of compressed air. Your air compressor should be equipped with an air dryer to remove water vapor from the compressed air.
- 2.9 Ground Clamp: A key to quality welding starts with a good quality circuit, and a key component of that circuit is the condition and the placement of the ground clamp. Poor placement of the ground on the work can lead to an overheated connection and poor welding performance. Grounding through tacks builds up resistance. Using a flat bar to extend your reach builds up resistance. Since the conductivity of copper is 7 times that of steel, the steel flat bar would have to be 7 times larger to replace a 1/2" dia. copper work lead / cable. See figure 2.2 below, all current passes through the ground clamp, if your clamp is loose or overheated it affects weld quality. Inadequate grounding causes cable overheating; at least 1 in.² (645mm²) of contact area per 1000 amps should be used. In figure 2.3 below, we have 5 places where a ground connection could fail. I would suggest using 1 or 2 large cable lug as in figure 2.2 and clamp to your work or make a lug from a piece of copper with a min. of 1 in.² (645mm²) of surface area and clamped to the work surface. See figure 2.4 below for conductivity rating of several metals. If your cables get hot, your welding cables are too small or your ground connection is not good enough.

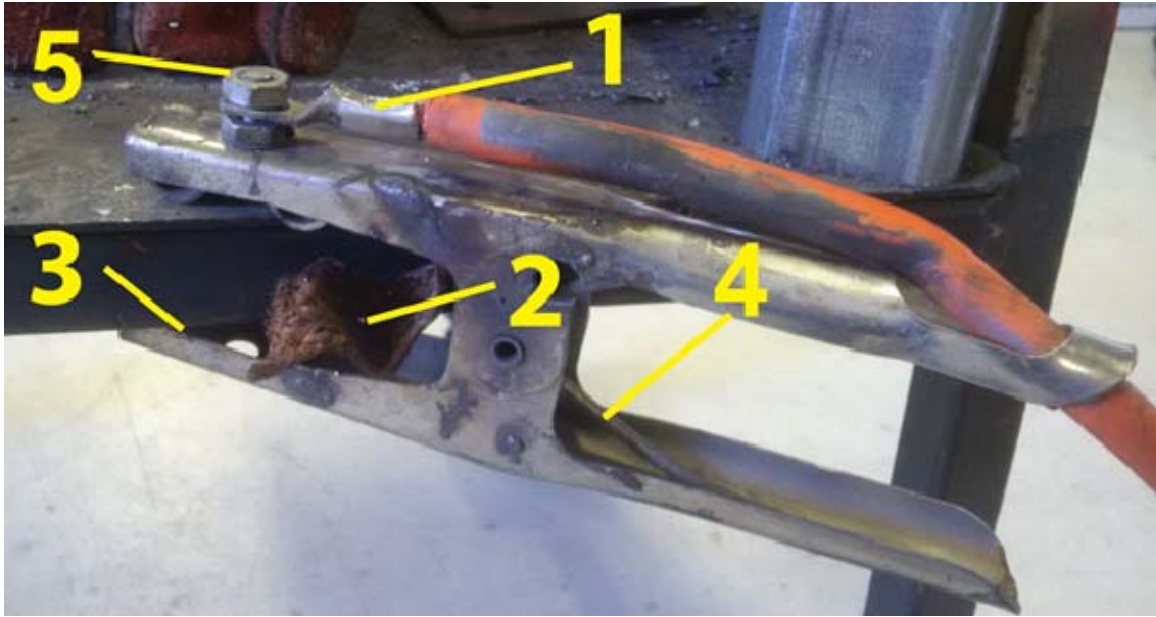


Figure 2.2: Possible ground clamp failure locations.



Figure 2.3: Copper lug on work lead / cable.

Which metal conducts electricity the best?

Material IACS (International Annealed Copper Standard)

| Ranking | Metal | % Conductivity* |
|---------|----------------------------|-----------------|
| 1 | Silver (Pure) | 105% |
| 2 | Copper | 100% |
| 3 | Gold (Pure) | 70% |
| 4 | Aluminum | 61% |
| 5 | Brass | 28% |
| 6 | Zinc | 27% |
| 7 | Nickel | 22% |
| 8 | Iron (Pure) | 17% |
| 9 | Tin | 15% |
| 10 | Phosphor Bronze | 15% |
| 11 | Steel (Stainless included) | 3-15% |
| 12 | Lead (Pure) | 7% |
| 13 | Nickel Aluminum Bronze | 7% |

* Conductivity ratings are expressed as a relative measurement to copper.

Figure 2.4: Conductivity rating for various metals.

Note: Reference from Metal supermarkets

- 2.10 Conductivity rating of metals: as you can see from figure 2.4 above, using brass or bronze cable connectors or ground clamps can cause resistance in your welding circuit. Each connection adds resistance.

3 GOUGING TECHNIQUE

3.1 Like arc welding, arc carbon air gouging uses an intense arc to create a molten pool on the work piece. The process requires a welding power source, air compressor, carbon electrode, and gouging torch, see figure 3.1 below.

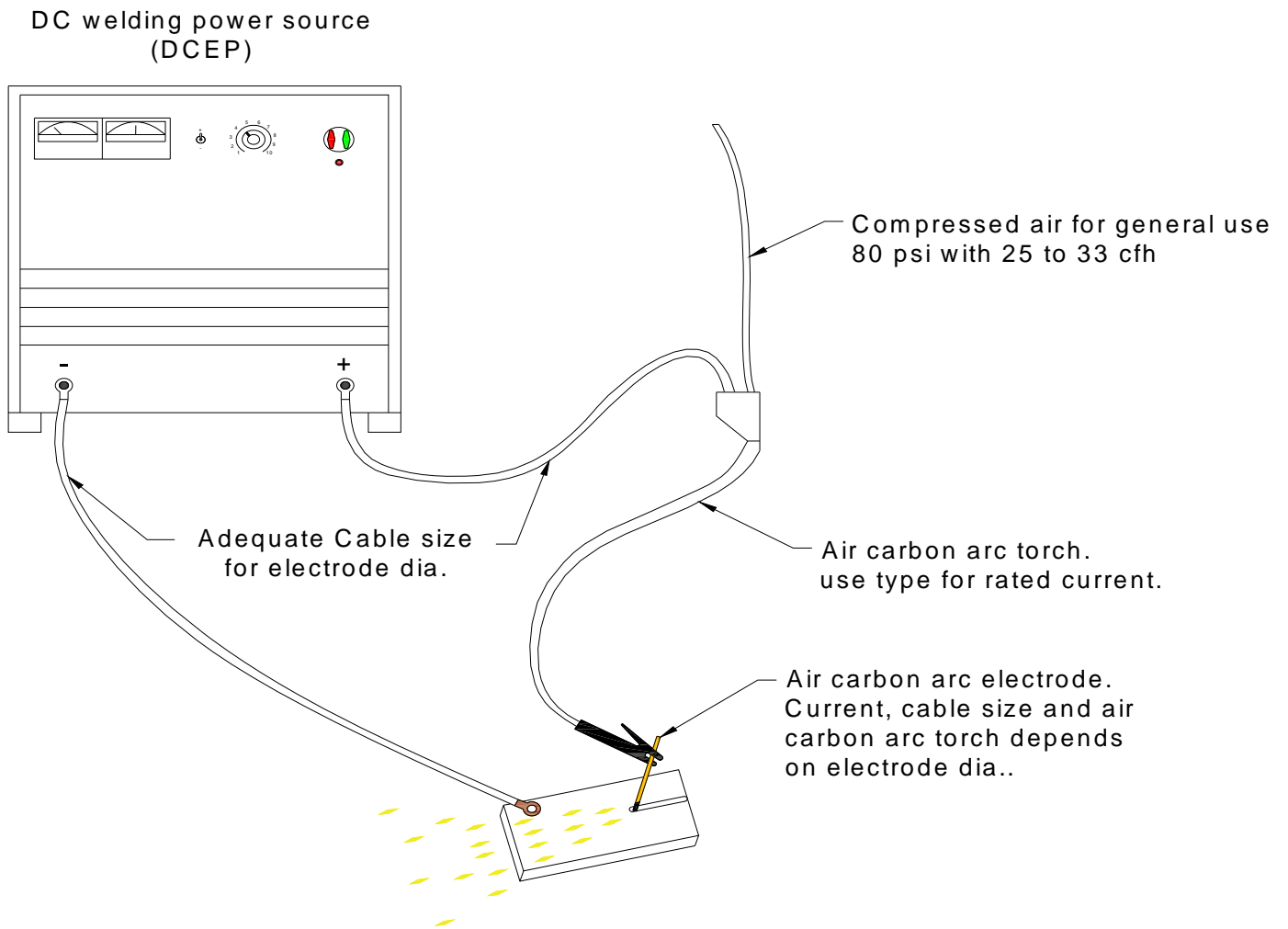


Figure 3.1 Air carbon arc setup for general use with DCEP

- 3.2 Generally for steel, DCEP is used. The maximum stick out for steel is 7" and the minimum is 2". Any less than 2" will damage the torch parts. For general use, 80 psi and 25 to 33 cfm are required. The air stream must be between the electrode and work piece, see figure 3.2 below. Amperage range is based on electrode diameter, see table 2.2.

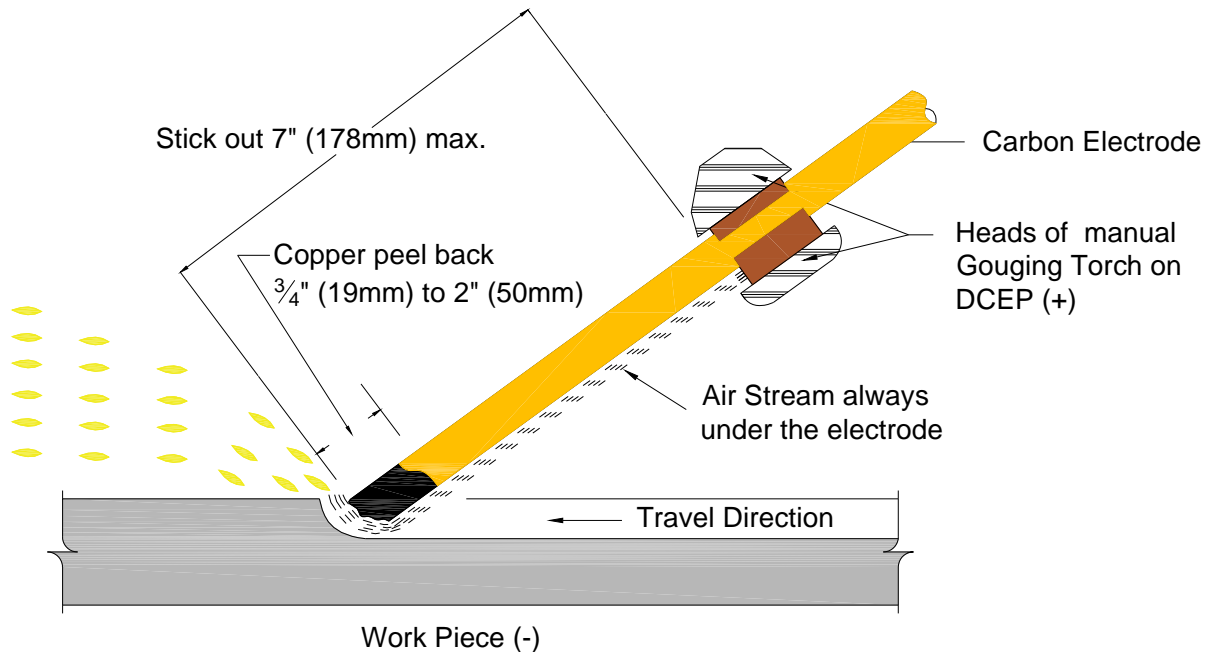


Figure 3.2 Air carbon arc with air stream location

- 3.3 For manual gouging, set up equipment as per figure 3.1, start the welding power source, turn on air before striking the plate. The arc will ignite by lightly touching the electrode to the work.
- 3.4 Use a fore hand or push travel angle. The angle should be about 35° from the work surface for most applications, see figure 3.2 above.
- 3.5 A steady position, holding the torch with both hands, ensures a smooth gouged surface. See welder positions A and B in figure 3.3 below. At position B, the welder will see the line or weld fault disappear. At Welder position A, you will not see anything disappear but may help to start a straighter groove. A grinder can hide a line or crack.
- 3.6 Travel speed depends on the size of electrode, base metal, amperage and air pressure. Proper travel speed will produce a smooth hissing sound and result in a good gouge. The groove will be about 1/8" (3mm) wider than the diameter of the electrode. Grinding the gouged surface to shiny metal is recommended.

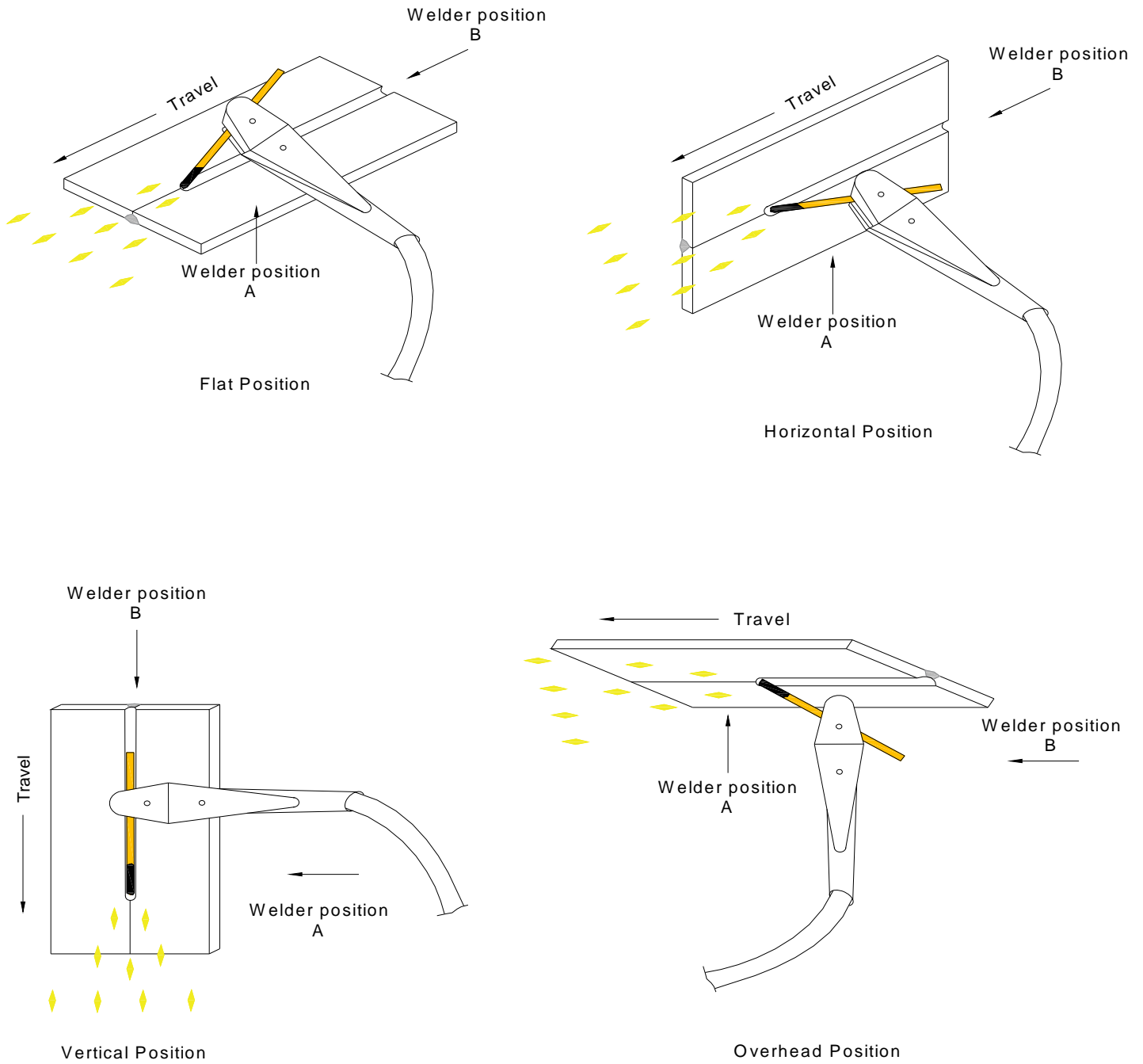


Figure 3.3 Gouging and Welder positions

4 CUTTING TECHNIQUE

- 4.1 The cutting technique is the same for gouging, but done at a steeper angle. The push travel angle is 10° to 20° from vertical.
- 4.2 1-1/2 times the electrode diameter is the maximum that can be cut in one pass. Always favor the side with air stream. Keep 1/16" (2mm) min. stick out on bottom of the plate.
- 4.3 On thick plate, the arc may be moved up and down through the plate with a sawing motion.

1 1/2 times the dia. of electrode is the max. thickness that can be cut in one pass

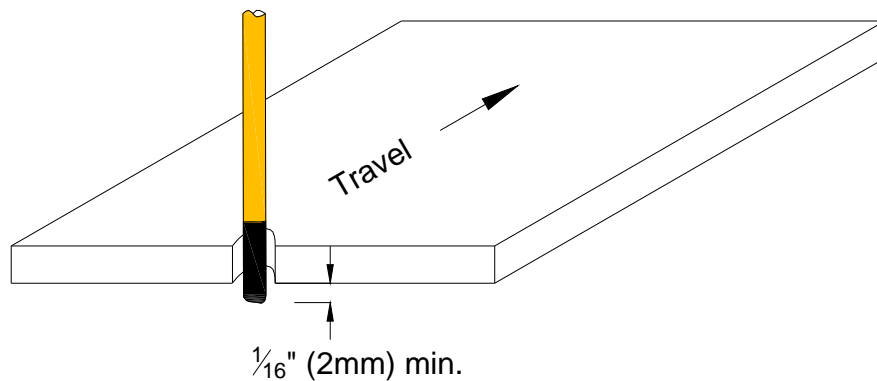


Figure 4.1 Cutting technique

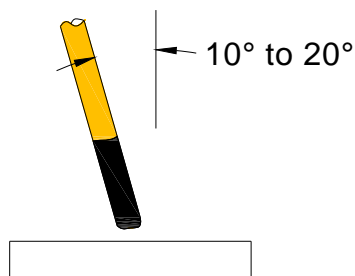


Figure 4.2 Cutting travel angle

5 PREHEAT

- 5.1 I would recommend using preheat for gouging whenever preheat is required for welding. In a repair situation I always use about 50° F (10° C) higher than the required welding preheat.
- 5.2 Preheat is intended to extend through the entire thickness of the material.
- 5.3 Two types of preheat:
 - a) Local preheat: is when the material surrounding the joint, approx. 3" (76mm), over the length of the weld, is heated to a specific temperature.
 - b) Uniform preheat: is when the entire assembly is heated to the specific temperature, such as in a furnace.
- 5.4 When preheating with a torch, the side the torch is applied to, heats up first. In order to ensure a reasonable uniform preheat temperature through the thickness of the material the measurement should be taken opposite to the side heated. Be careful of the flame distance so not to overheat the material in spots. If access to the second side is not feasible, a general rule of thumb would be to remove the heat source and wait approximately 1 minute for each 1" (25mm) of thickness before taking a reading. Try a test piece in your shop, preheat from one side only, remove torch, wait a minimum of 1 minute, then check the opposite side to see if the minimum preheat temperature has reached the back side. Equipment varies from shop to shop, adjust time to thickness as needed in your shop.
- 5.5 See my preheating guide second edition, for more information on preheating.

6 BASE METAL RECOMENDATIONS

6.1 Recommended polarity for various base metals below:

- a) Carbon and low alloy steel: use DC electrodes with DCEP. AC electrodes can be used with an AC transformer, but for this application AC is only 50% as efficient as DC.

Note: recommendations reproduced from AWS C5.3

7 SUMMARY

- 7.1 Safety first.
- 7.2 The groove will be about 1/8" (3mm) wider than the electrode diameter. Size of electrode will determine the size of equipment needed.
- 7.3 Use adequate air flow. Restricting the flow anywhere in your system by using small hoses or fittings will make your compressor underperform or make it work harder. The air hose supplying air to the torch body should have an inside diameter of at least 3/8" (10mm).
- 7.4 Have the air stream between the electrode and work.
- 7.5 Use dry compressed air.
- 7.6 Use dry electrodes.
- 7.7 More amperage is not better. Use the recommended amperages ranges.
- 7.8 The process should have a smooth hissing sound, not a series of short burst. Irregular travel speeds can cause ripples and trap carburized metal.
- 7.9 Improper travel angle will create more clean up time.
- 7.10 An inexperienced operator can create extra work.
- 7.11 Know the material you're working on and follow all codes or standards. Preheat before gouging, if preheat is required for welding.
- 7.12 Grind the groove to remove any carburized metal.
- 7.13 Remove any copper from copper coated electrodes that may have transferred to the cut surface.

8 QUESTIONS

- 8.1 Questions or tech. support? email: raycormier@rogers.com