Repair Welding -- Uh-oh . . .
The Questions Management Should Ask

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Components critical to plant operations normally get repaired by welding successfully, but occasionally those repairs don't work, or, even more exasperatingly, a part gets repaired over and over and over! This article will provide plant operations and maintenance supervisors with key questions to ask those who will make the repair to determine whether they have researched what they are about to do sufficiently to get it right the first time.

Question 1: *Can it be welded?-- and, if so, how?* If the component was made by welding, that's a good indicator that it can be repaired by welding. However, it may be that special techniques, welding processes or electrodes were used in the original construction, or that the part was heat treated after welding to obtain the required properties. Supervisors should know what the material is before welding on it. This can be done by at construction drawings, at maintenance handbook, by contacting the manufacturer or by looking for an ASTM, AISI, SAE, or other material specification and grade identifying the material on the part itself. Any other information that can be obtained about how the part was made should also be gathered. As a last resort, you may have to cut a small wedge from the part and have it analyzed

Armed with this information, contact a reputable resource such as a welding consumables manufacturer (Lincoln, Hobart, ESAB, etc.) or a welding engineering consultant for guidance. Go beyond your regular welding supply salesmen unless you know they have technically competent consulting staffs. At a minimum, the following should be established during this step:

- The appropriate welding process or processes to be used.
- Welding electrodes or filler metals to be used,
- Preheating and postweld heat treating requirements,
- Any special requirements (such as cleaning, heat input control, peening, etc.) unique to the material that may improve its weldability.
- How defects will be removed, and a requirement to verify that they have been removed before starting to weld when appropriate.
- In-process inspection points such as verification that the correct materials are being used, the tack welding and fit-up are correct, the root pass is good, that the welder properly cleaned and contoured the weld beads between passes, etc.
- Final inspections and nondestructive examination (e.g., x-ray or ultrasonic) where appropriate.

Question 2: *Is it safe?* Once your staff has figured out how to weld the component, make sure the component is safe to weld on and that the environment is safe. Parts that may have contained combustible materials need to be thoroughly cleaned and vented; any connections that may supply combustible gas or liquid to the component during welding should be disconnected where possible, or a combustible gas meter used to monitor the vent exhaust gas. Special precautions must be taken when organic dust can reach explosive concentrations.

Obviously, if a welder has to enter a confined space to make a repair, the suitability of the air in that space should be verified, and appropriate confined-space entry procedures must be followed.

The welding environment should be free of combustible materials. Generally, any combustibles within 35 feet of where the work is to be done should be removed or covered with fire-resistant fabric to prevent ignition. This includes floors both above and below the work area where sparks may fly through gratings or manways or under partitions. Fire watches are always a good idea when welding in a plant.

Parts to be welded should be clean and free of paint, grease, oil, rust, moisture, and other contaminants. Lead-containing paint was banned in 1977, so any paint that was applied before then should be sampled to see if it contains lead and, when it is removed in preparation for welding, appropriate precautions taken to avoid contamination of the workforce. Galvanized surfaces should be power wire brushed to remove heavy galvanizing; however, workers can protect themselves from the zinc oxide that is developed by torch cutting or welding galvanized steel and other particulate by wearing an N95-type particulate filter mask such as that shown in Figure 1. For further guidance on welding safety, ANSI Z49.1 *Safety in Cutting, Welding and Allied Processes* should be consulted. It is available for free download at the American Welding Society web site, www.aws.org.

External loads are usually removed from components before welding by disassembly, depressurization or other means; however, building steel presents a special situation since loads typically cannot be removed, so consult with a competent structural engineer before welding on building steel. Guidance on welding on existing building steel can be found in AWS D1.7, *Guide for Strengthening and Repairing Existing Structures*.

Question 3: *Are there any Codes or jurisdictional rules that have to be followed?* While a formal welding procedure is not required for a lot of repair work, formal welding procedures are usually required by the AWS D1.1, *Structural Welding Code – Steel,* when welding on buildings or structures and by the ASME *Boiler and Pressure Vessel Code* or the ASME B31 *Code for Pressure Piping* when welding on pressure parts (piping, pumps, boilers, vessels, etc.). Of special concern are boilers, tanks, and piping where the nameplate has “ASME” stamped on it; in most jurisdictions, only contractors who have an “R” Stamp issued by the National Board of Boiler and Pressure Vessel Inspectors may weld on these components. Where formal welding procedures are not required, guidance obtained from the welding electrode or filler metal manufacturer should be put into concise form for the welder to follow when making the repair.

When formal welding procedures are required, formal qualification of the welder is also required. For other repair work, a welder with a past history of successful welding in your facility with the welding process and filler metal type to be used for the repair should be sufficiently skilled. For a welder of unknown skill, or if the materials are new to him, he can demonstrate his skill at minimal cost to you by fillet welding together two plates of a material similar to that to be repaired, to form a “T” as shown in Figure 2. This “T” can be bent (as shown in Figure 1) and the resulting fracture evaluated. The test piece should be welded in whatever position the welder will have to work to make the repair.

Question 4: *Is preheating or postweld heat treatment necessary?* Recommended practices from the welding consumables suppliers should address preheating with regard to the base metal that will be welded. For common structural steels like A-36, A-500, and the like, preheating the parts above ambient is not normally required, provided low-hydrogen processes like GTAW (aka: TIG, Heliarc) or GMAW (aka: MIG) or low-hydrogen electrodes like E7018, E8018, etc., are used. When welding these materials and the component thickness exceeds ¾ inch, preheating steel to 200°F is good practice. Other materials such as 4130 and similar low-alloy steels used for shafts, gears, etc., commonly require preheating, and the recommendations of the welding consumable manufacturer should be followed. Some materials require postweld heat treatment to restore ductility and toughness, so competent technical assistance gets more important as materials being welded become more sophisticated.

Question 5: *Have we fixed this before?* One of my favorite statements is: "Oh, we repair that every couple of months …" When something requires repair more than a few times, it's time to call in the big guns and perform a failure analysis. This can be as simple as having a competent engineer look at what is going on and identify the root cause, or as complex as examining fracture surfaces in a scanning electron microscope and performing other metallurgical examinations and tests on the components.

Figure 3 shows a "weld repair" on a hydraulic piping system that provided 3,000-psi hydraulic fluid to a big shear in a scrap yard. While the repair weld was effective temporarily, it would crack again every few weeks, spraying (fortunately nonflammable) hydraulic fluid over the equipment. In a much more sophisticated facility with a similar problem, the owner had put a trench around the equipment to capture the fluid, resigned to the fact that it leaked and that's simply the way it was.

In both cases, the rapid opening and closing of valves resulted in pressure waves in the pipe. In both cases, it was noted that the pipe shook when valves opened; the shake was absorbed where the pipe was attached to firmly anchored components, resulting in high bending stress at the welds closest to the components as shown in Figure 3.

This stress led to cracking and leaking of the welds. While part of the solution was to replace the piping and radiographically examine all the welds to assure that the welds were of top quality, the piping was also anchored directly to the equipment and the foundation using rigid pipe supports, so that the "shake" would be absorbed by the supports rather than the piping welds. Since the equipment warmed considerably when in use, locating the anchors properly was important since anchors limit thermal expansion and, if thermal growth is excessively restrained, high cyclic stresses arise at other locations in the piping system leading to failure at those locations instead of at the equipment connections.

Failures that are obviously mechanical in nature can, in many cases, be repaired by welding, following the above guidance; however, it is important to be sure that the defect is removed adequately before welding. The welds in Figure 3 were simply added to those already in place--an expeditious way to get the equipment back in service, perhaps, but welding over a crack should always be recognized as a short-term fix.

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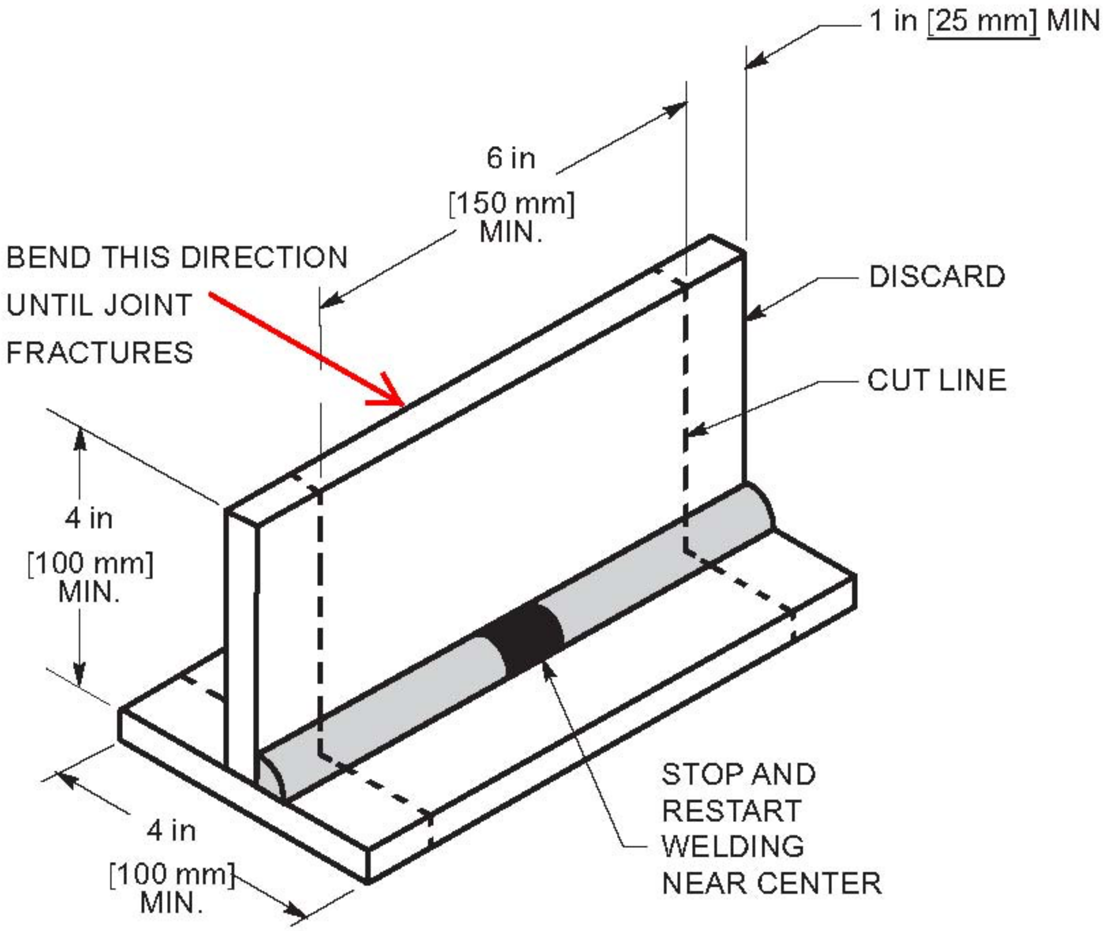
Figure 1

An inexpensive welding fume mask

The photograph shows an “N-95” type welding fume particulate mask. Use of a fume mask is not a substitute for proper ventilation of the welding area.

Figure 2
An inexpensive welder test assembly

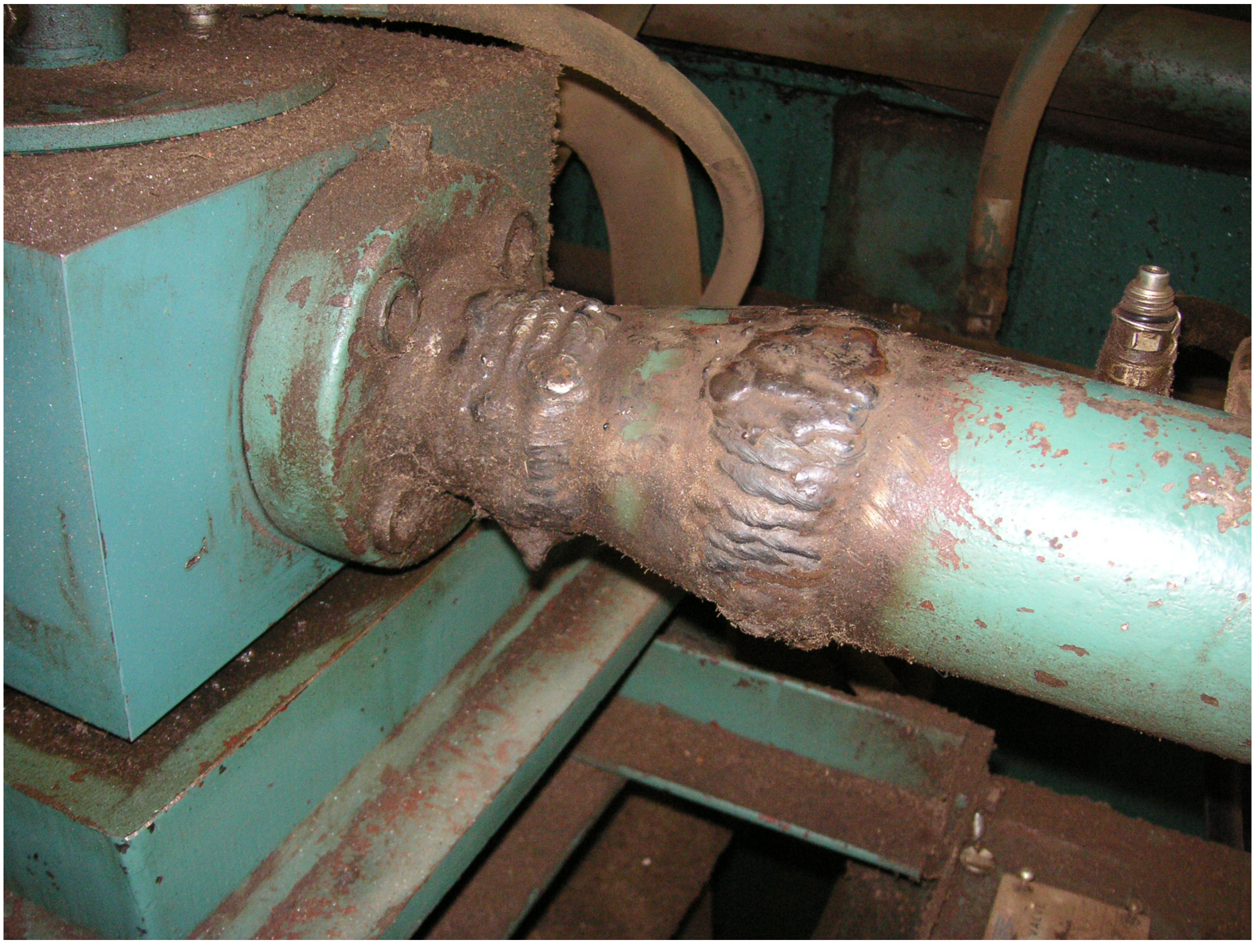


The welder makes a weld in the location shown. The portions designated as "discard" are saw-cut off, and the remaining portion is bent so that the root of the weld is put in tension. If the plate bends on itself, the weld is good; if the weld fractures, the fracture surface is examined for excessive defects.

Based on AWS B2.1:2000, Figure 3.8 reproduced with permission of the American Welding Society (AWS), Miami, Florida.

Figure 3

A “repair” weld on a high-pressure hydraulic piping system



The weld on this pipe has been repaired several times. While adding weld metal may stop the leak temporarily, it is not an effective or long-term repair.