

## Fault Finding Information

In order to recommend a welding repair procedure, we need to know as much as possible regarding the fault and what have caused it. If possible please attach drawing or photo to better understand the problem.

1) State name and purpose of object to be repaired: .....

2) Inform base materials chemical composition: .....

3) Thickness of base material at fault location: .....

4) Give approximate configuration of object: .....

5) Give fault position: Horizontal , Vertical , Horizontal/Vertical , Overhead , Inclined

6) Ambient temperature at the time of fault occurrence: .....

7) Inform why the break/wear occurred? /under what circumstances?

Outside force or strain?

Under normal work conditions?

Under unanticipated work conditions?

8) Inform if fault is:

A) Crack / fracture in base metal  B) Crack/ fracture in weld  C) Wear problem

9) If B) Crack/fracture in weld:

A) Crack/ fracture orientation longitudinal in the weld?

B) Crack/fracture orientation longitudinal on side of the weld? (In the heat-affected zone)

C) Crack/ fracture orientation transversal to the weld?

10) If wear problem, inform type of wear: (Often the wear is a combination of one or more forms. If so inform the forms)

Cavitation (fluid flow environment)

Abrasion

Corrosion

Impact

Heat (inform temperature)

Adhesive wear (referred to as metal-to-metal wear)

Weld repair—Analyze the failure before attempting the repair

*When something breaks, you acknowledge the shock, scratch your head, take stock of the situation, and look for the fastest way to repair the item and put it back into operation. The pressure to repair quickly is understandable, but common sense suggests stopping for a moment and trying to understand what caused the break before attempting the repair.*

#### Failure Analysis

Almost anything can fracture. The science investigating the origins of fractures is called *failure analysis*, and it is used to establish responsibilities for fractures and to determine preventive measures for avoiding future occurrences. An introductory, interesting book on this subject was written by Donald J. Wulpi and is titled *Understanding How Components Fail*. 1

#### Service Failures

This article discusses only in-service weldment breakage, also described as service failures. Weldments are assemblies with parts joined by welding. Failures occurring during or immediately following welding are easier to deal with, because all conditions are known.

So if the item was welded originally, it should be weldable again for repair, right?

Yes, but only if you know the materials and their conditions and whether they still are exactly as they were at fabrication time—no heat treatment or other surface conditioning has been introduced. You also must know the precise process and welding procedure that were used in the first place, which usually isn't the case.

#### What Caused the Break?

Before attempting any repair, you must determine why the break occurred. If you restore the item exactly to its original condition, chances are another breakage will occur. (At that time it may well be none of your concern, but you must operate professionally at all times).

While a fully implemented professional investigation by an experienced metallurgist would be the best recourse, this usually is justifiable only in selected cases—for example, for presenting claims to the manufacturer or to the insurance company. It is mandatory, however, if injury to persons or property loss was or could have been involved.

Left to involved people, the human urge to clear oneself and to find fault in someone else's actions or inactions can interfere with an investigation.

The main reasons that weldments fail is:

- Inadequate material or properties.
- Poor design.
- Poor workmanship.
- Excessive unanticipated service conditions.

#### The Investigation Process

Even if the person in charge is not specifically trained as a failure analyst, a few investigative steps should always be taken:

1. First take care that nothing be moved, manipulated, reassembled, or fixed.
2. Document the condition of the weldment when the breakage was found.
3. Write down all that is known, and question all who were present.
4. Note the ambient temperature at the time of occurrence.

5. Take pictures, both general and close-ups.
6. Protect the place from rain and other environmental disturbing factors

Firmly resist the pressing urge (your own and of those around you) to supply a theory for the breakage, especially before having assembled all the information.

A description of the weld profile as visible under low-power magnification should include such details as dimensions and fit-up as much as they can be determined visually. If possible, these details should be compared with design requirements.

When the structure operates normally at elevated temperature, it is probably under some code legislation that may request an official investigation.

A weld breakage usually is a crack or a fracture. Much information can be drawn from an exact description of the failure. A crack should be characterized by its dimensions, by its orientation (longitudinal, along the weld bead, or transversal), and by its position relative to the weld itself (on the weld bead or on its sides, in the heat-affected zone, or in the base metal).

If the fracture is open, do not reassemble the mating parts. Doing so can obliterate important clues. Inspect the fractured surfaces with a low-power lens or microscope that can show internal defects like gas holes or pores, nonmetallic inclusions, or indications of fatigue failure in the form of concentric *beach marks*.

The presence of macroscopic deformations and the fibrous or glassy aspect of the surfaces should be assessed to reveal if the failure was ductile (with deformation) or brittle (without deformation).

Specific colors on the surfaces should be remarked; they might be clues about local heating and oxidation. The extent of corrosion, if present, has to be determined and documented.

The presence of arc strikes on the surface, improper starting conditions, or accidental contact may be at the origin of considerable damage.

Hardness testing is a very informative, simple, nondestructive test. However, selecting the proper locations, especially if the weldment must be sectioned for testing, may be beyond what can be expected from a technician not specifically trained for this kind of investigation.

The materials involved should be known and their properties checked for conformance to specifications. No weld repair should be attempted without this essential knowledge. Having this information allows you to select the proper repair procedures and filler metal.

If materials are not known, an effort should be made to provide at least qualitative information. This information can be obtained by X-ray fluorescence, a nondestructive test readily available from many metal-related services.

#### What Next?

Having assembled and organized all the facts, you now should be able to formulate an educated guess as to the possible causes of the failure.

Was faulty workmanship the culprit? A professional investigation service uses metallographic examinations of weld sections to look for weld defects in the original weldment. Obviously, faulty welds should have been detected by inspection after manufacturing, but nobody is perfect. If the original weld was faulty, a repair weld performed with utmost care should improve the future in-service performance of the repaired item.

A design change is not normally applicable for repair. However, if it is clear a faulty design caused the failure, an improvement might be introduced. But you should be aware that adding stiffness may

make the matter worse, by increasing internal stresses and paving the way for the next fatigue fracture.

If the breakdown was sudden but caused by a progressively deteriorating condition of certain components (as in the case of fatigue fractures or corrosion), a corrective action program should be initiated. The plan has to incorporate periodic examination of the parts involved, after the structure is repaired, to detect dangerously spreading cracks before much damage occurs again.

Cracks must be removed completely by careful grinding before rewelding. If the base metal is in acceptable condition, weld repair may be attempted with suitable ductile filler metal or low-hydrogen electrodes.

The process selected should introduce minimum heat and residual stresses, and possibly should be followed by light hammer peening. Preheat and/or postheat, if necessary.

If separation has occurred, then a proper joint has to be designed and prepared, possibly by introducing a transition element to make up for the volume of metal to be discarded.

Experience and common sense always are important, and even more so when dealing with weld repairs.