

University of Portland
School of Engineering
ME 421 – Failure Analysis
Fall 2013

1) Below is a photograph of a broken bar. The failure was due to an overload, not due to fatigue. Answer the following questions:

- a) Does the failure appear to be ductile fracture or brittle fracture?
- b) How was the part loaded when it failed? Does it appear to have been predominantly torsion, predominantly bending, or predominantly axial tension/compression?
- c) What failure theory(s) would have been appropriate for the design engineer to use: maximum shear stress, distortion energy or maximum normal stress?
- d) Observe the actual specimen available outside my office. Are there signs of where the crack initiated at?

Briefly justify (explain) each of your answers.



2) Complete Phase I and II for the fan motor mounting leg failure problem. Note: very little additional information other than that provided in the letter (back side) is available from me, so you may create a list of questions, but I may or may not be able to answer them. Nonetheless, start an investigation data log and proceed with the limited background data available (data logs available on the course web page). Phase I includes many things besides asking questions of the customer. It would be appropriate to perform a literature search for resistance welding, organizing the data and information you do have, and sketching the parts available. Do not conduct any testing yet other than visual.

3) Team project: as part of your newly arranged ME421 team (from problem 7 on assignment 1), obtain up-to-date information on one of the following recent incidences. Write a short essay about the accident (half page or so) and be prepared to discuss it in class next Wednesday. Select from: Bay Bridge cracked bolts, I-5 Skagit River Bridge, Boeing 777 crash at San Francisco, or any other similar accident that has occurred within the past year.

PUMPS INC.

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Portland, Oregon 97203
(503) 943-7432

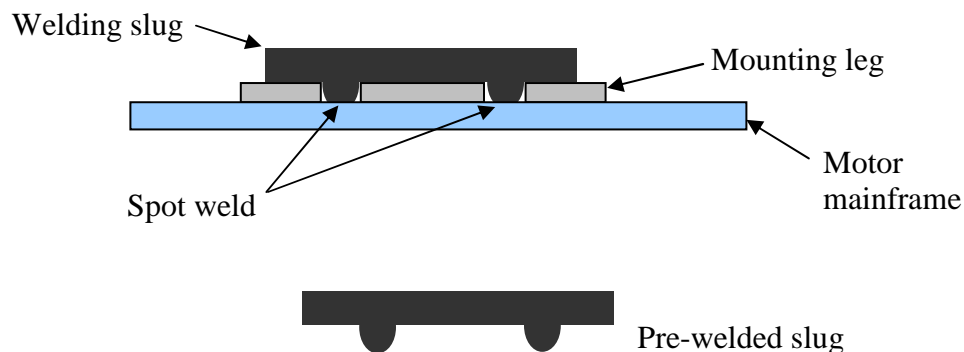
September 4, 2013

Students
UP Engineering, Inc.
5000 N. Willamette Blvd.
Portland, OR 97302

Dear Students,

My company produces motors for driving pumps and fans. We have discovered a problem with the welds that attach mounting legs on a fan motor (it is used in HVAC systems). We recently changed from a “belly band” assembly to using a resistant welding to attach the mounting legs. For economic reasons we much prefer welding rather than the belly band assembly. Therefore, I would like your assistance in determining the cause of the problem.

The motor is 5.5 inches in diameter. Three mounting legs are attached to the motor mainframe using resistance welding prior to the insertion of the stator. A three-armed fixture holds the legs in place against the mainframe while the welder cycles and welds one leg at a time. A welding slug is used, as shown in the sketch below. The slug has two “dimples” which go through pre-existing holes in the mounting legs. The actual weld is between the welding slug and the motor mainframe. The mounting leg is held in place by being sandwiched between them. The dimples in the slugs facilitate the resistive welding process.



Full production began with the resistance weld configuration in April of last year after two years of extensive testing. The welds were fatigue tested to 300,000 cycles without any problems. April and May production had no failures or problems reported by the customer or by our quality control, which checked the first assembly each hour with a static test. During the static test, the assembly was mounted into a table and a weight was dropped onto the motor. This test was primarily done to see if the welded legs could withstand normal shipping and handling loads.

In June, there were two line rejects where one of the arms came off in assembly. There were twenty in July with the same problem. Destructive testing started the first week of July, where a chisel was driven between the mainframe and the legs until something failed. If the weld itself failed (as opposed to the mainframe metal failing) it was considered to be a failure. This testing produced a 50% failure rate of welds. During August, a customer reported two weld failures.

There are photographs attached to this letter to show various parts and conditions.

We have started using the old design (belly bands) until a solution for the weld failures can be ascertained. Other than the enclosed specimens, I have no other information for you. I'm not even sure what the specifications of the metal are. Sorry. I hope you can help me in any regards. I can be reached at (503) 943-7432, lulay@up.edu.

Sincerely,

(electronic signature)

Ken Lulay

PS – please note that these parts have been sitting around my office for quite some time, and they appear to have developed some rust. That was not originally there.

Enclosed: One tested mainframe with welded legs (good weld)
One as-received (non-welded) welding slug, sectioned for microscopic examination
One non-welded leg
One section of leg and welding slug that failed the static test
One welded slug that failed static test
Photographs



Figure 1 – band with legs (leg on right has been “chisel” tested).



Figure 2 – leg that has been chisel tested.

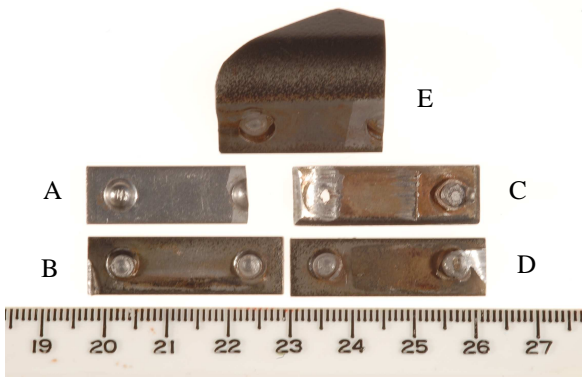


Figure 3 – various tabs that have all failed the “chisel test” except “A” – it has not been welded but was sectioned.



Figure 4 – close up of failed weld on tab “E” (see figure 3). The “rust” (red) likely developed sometime after testing.



Figure 5 – close up of cross-section through failed weld, tab Sample “E” in Figure 3.

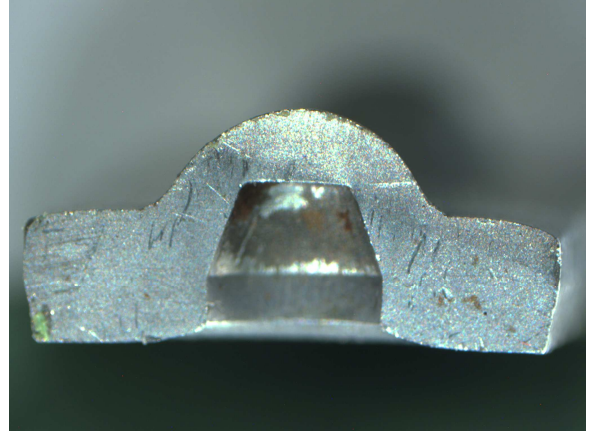


Figure 6 – cross-section through non-welded tab (sample “A” in Figure 3).

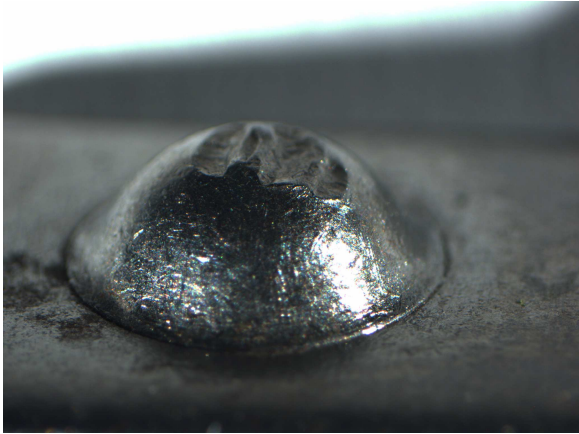


Figure 7 – non-welded tab (Sample “A” in Figure 3). Note “dents” on the tab are due to poor handling and are not typical of production parts.