University of Portland
School of Engineering
ME 421/521 – Failure Analysis
Fall 2011

Read the case study "why the Vasa Sank: 10 Lessons Learned" posted on the course web page. Please make all answers CONCISE and BRIEF (no more than a few sentences).

1) The first steps in a typical design process include identifying needs, defining the problem, setting goals and objectives, and establishing criteria. Explain how failure to follow this design process contributed to the sinking of the Vasa.

2) "Excessive innovation" is listed as Lesson-Learned numbers 5 and 6.
   a) Name two other historic failures that "pushing the envelope/excessive innovation" contributed to the failure.
   b) Explain what the excessive innovation was for the two examples you've listed in part (a).

3) "Scope creep" (also referred to as "requirements creep" or "mission creep") is a danger posed to many projects. In fact, it is so common it has a name (at least three names anyway). Engineers are prone to this problem because they always want to "do more." It can lead to failure, as it did with the Vasa and it can kill a project before it gets completed (trying to do more than initially planned requires more resources than planned or available). Explain what is meant by "scope creep" and discuss ways to prevent it.

4) "Ignoring the obvious" was listed as Lesson-Learned number 9. In the case of the Vasa, the results of the stability test were ignored. If you were the engineer in charge of the Vasa, after observing the stability test what recommendation(s) would you have made to the King? (Requesting he send you on a vacation to France is not an option). Remember, "kings" don't like it when someone suggests something won't work, especially if there is no recommendation as to how to make it work. The only thing they like even less is for someone to assure them everything is fine only to find out otherwise.

5) 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 (below) 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.

PUMPS INC.
236 UofP Drive
Portland, Oregon 97203
(503) 943-7432

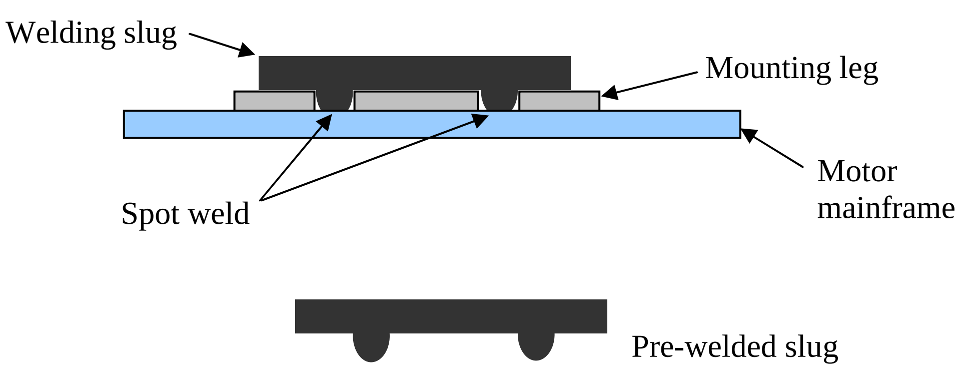
September 14, 2011

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 provided 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,

(signed)
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.

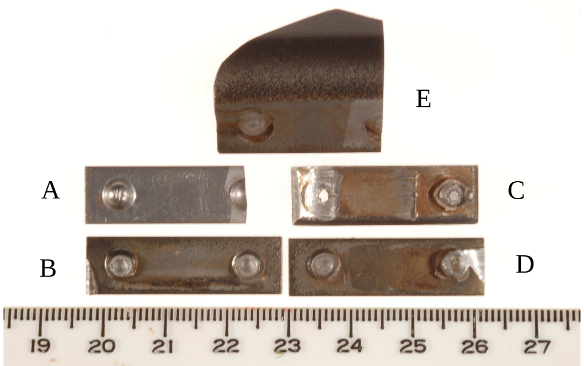


Figure 3 – various tabs that have all failed the “chisel test” except “A” – it has not been welded but was sectioned.

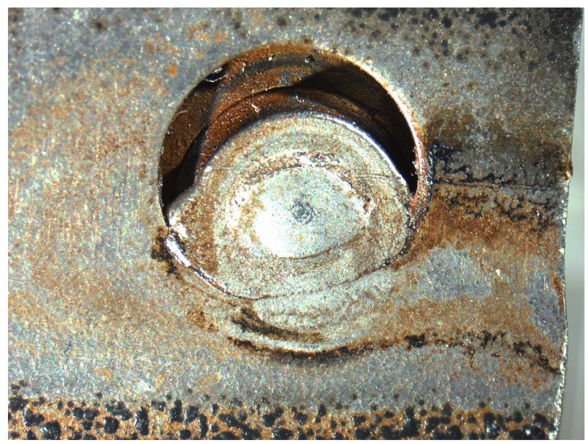


Figure 4 – close up of failed weld on tab “E” (see figure 3). The “rust” (red) developed sometime after testing.

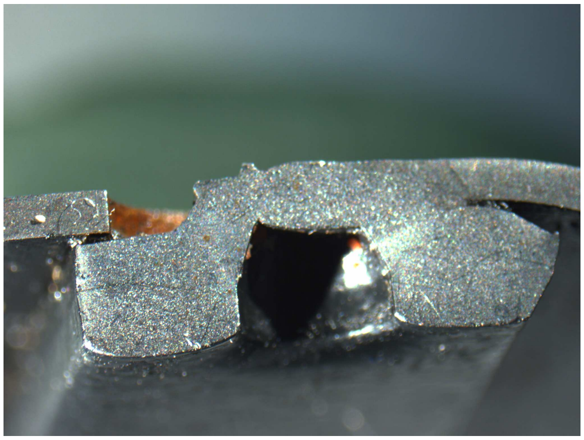


Figure 5 – close up of cross-section through failed weld, tab Sample “E” in Figure 3.

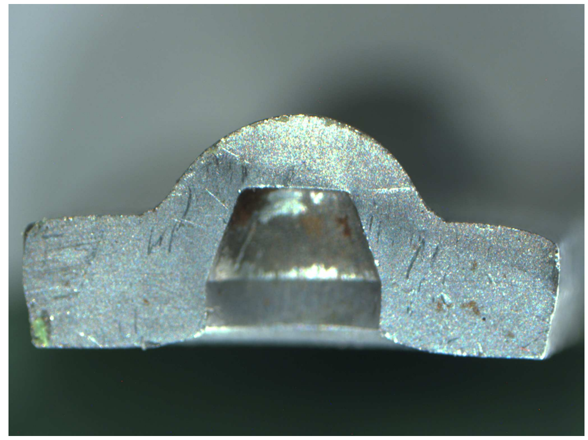


Figure 6 – cross-section through non-welded tab (sample “A” in Figure 3).

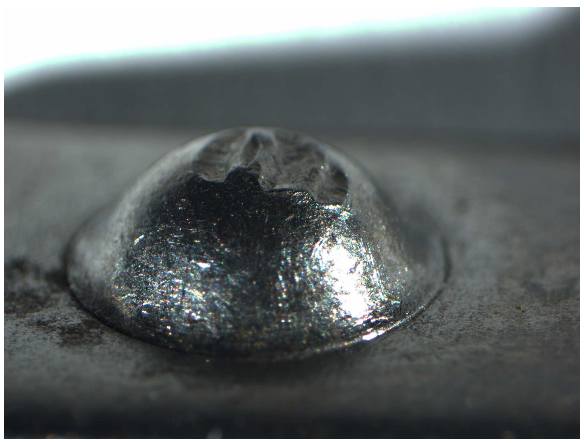


Figure 7 – non-welded tab (Sample “A” in Figure 3). Note “dents” on the tab are due to poor handling and are not typical of production parts.