Sample Removal and Shipping…
What NOT to Do

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(from the *Conduit*, Vol 17, No 2)

When sending a sample to the laboratory for failure analysis, it is important that parts are removed and packaged in a way to preserve the failure and protect it during shipping. Occasionally, we receive samples that are not ideal for conducting a failure analysis. Our intent with publishing this article is to inform our clients of best practices, to ensure the most accurate analysis possible. We acknowledge that sometimes a failed part is removed purely for replacement purposes to get equipment back up and running quickly, and failure analysis is an afterthought. In other cases, it is difficult to remove a sample without partially destroying it (e.g., boiler tubes where they are rolled into the mud drum, Figure 1). But if you know ahead of time that you want to look at a failure more closely to determine the mechanism or root cause, it is important to minimize the damage to the failed area during removal and shipping. Preserving the sample as close as possible to its post-failure condition is imperative to an accurate and successful failure analysis.

In this article, we have collected some examples of parts that we have received that illustrate what not to do and the importance of this first step in a failure analysis.

Sample Removal

It is tempting to think that since the part has already failed, that there is little you can do to cause more damage. However, there are several actions during sample removal that can further damage the part or remove "information" from the sample. In most cases, we are able to work with the sample condition as it is received, but it is optimal to avoid these practices to get the best sample possible for analysis. This can also help avoid a misdiagnosis of the problem. The following figures show examples of things to avoid during sample removal.

For the first example, this tube was received with a saw cut through the middle of the rupture (Figure 2). It appeared that this was done in order to fit the tube into a shorter box. In this case, we were still able to determine the failure mechanism (short-term overheating), but cutting through the failure area runs the risk of removing or damaging an artifact of the failure that would indicate the mechanism or more importantly in some cases, the initiation site. Sometimes we want to look at the middle of the failure, but might also want to look at the edges of the failure or adjacent to the failure to gain more information.

While saw cuts will remove a thin section of the part, they are much preferred to torch cuts. In addition to producing more metal loss, torch cutting causes significant heat damage to the part several inches around the cut (as shown earlier in Figure 1). This can obscure whether the part was overheated prior to or as a result of the failure. If torching is used, it is best to cut 12 to 18 inches away from either side of the area of interest to avoid damaging the microstructure in that area.

There have also been instances when a sample was cleaned before it was sent in. Some samples are required to be decontaminated before shipping, which is appropriate and appreciated. But, if a sample is washed or cleaned just to make it "nicer" for shipping, it can remove valuable information. We will often analyze deposits to determine what corrodents are present that led to corrosion damage. We can also examine deposits/oxides to ensure that they have a normal composition or if the makeup indicates an issue with water treatment, for example. It is best to avoid cleaning off deposit unless the part is hazardous without doing so.

Another cleaning method that can cause even more damage is grit blasting. Figure 3 shows a sample we received that had been grit blasted, including the fracture surface, to remove deposits. At first, it just appeared that the fracture was very smooth and flat. Examination at high magnification showed particles imbedded in the fracture from cleaning and dulled fracture features. This made it difficult to confirm the failure mechanism. Any grit or bead blasting of or around the fracture should be avoided to keep the damage morphology intact. Fracture surfaces should be carefully masked from any exposure to grit/bead blasting. Chemical cleaning methods can also cause similar damage if the part is exposed to the chemical for too long or without corrosion inhibitors.

Figure 4 shows a failed shaft that was received for analysis. The customer indicated that they machined around the circumference of the part to smooth the sharp edges for safety purposes. While this was considerate, it also removed the likely origin of the fracture, as these tend to be along the surface of the shaft. It is best to avoid any machining, smoothing, or beveling of parts.

Shipping

Once a sample is successfully removed, it must be packaged for shipping to the lab. Many of the parts we receive are too large or heavy to fit in cardboard boxes. In this case, a wooden box can be built (or reused) or the parts can be strapped to a pallet to accommodate the heavier part. Regardless of the container used, the parts should be carefully packed, protected, and secured so that they survive the rigors of shipping. Relying on the carefulness of the shipping company can be a risky business.

When shipping samples in a cardboard box, they should be packed in an appropriately sized box with cushioning packing material inside. Some clients use old rags or newspaper – it doesn't have to be brand new bubble wrap. When no packing material is used, the parts bang around in the box during shipping, which can shake loose deposits or cause additional damage (Figure 5). This makes it difficult to discern whether the damage was due to the failure or shipping. We have also seen a loose tube go through the side of a box and get lost because it was able to move around too much in a large container.

On the opposite end of the spectrum, going overboard with packing material can also affect the sample. Several years ago we received multiple boiler tubes from a customer that filled them with packing peanuts. This is undesirable for two reasons. First, pushing material into a tube or pipe can remove and/or contaminate deposits that are present that help determine the failure mechanism. Second, packing peanuts will do little to protect a metal tube or pipe on the inside – the material is much stronger than the peanuts, and if it does get crushed, then you have bigger problems on your hands (like someone ran over the package). For tubes or pipe sections, it is best to simply tape the ends closed to avoid anything going in or out.

In addition to padding the samples inside the box, the failure itself should be well protected (Figure 6). Wrapping the failure can also prevent damage during shipping, even if loose packing material is used around it. For example, if a fatigue fracture is impacted, it can damage the fracture and make it difficult or impossible to find the crack origin, or determine if it was high cycle or low cycle fatigue. This can easily happen post-failure, before the part is even removed from the equipment, so it is crucial to protect a "good" fracture surface that survived the failure to tell its story.

One item specific to fracture surfaces is to **not** put the mating fracture surfaces in contact. It is natural to want to fit the mating halves back together to see how well they match. However, even lightly fitting the halves back together can cause rubbing damage to the fine fracture features, particularly in the origin area. Avoid the natural tendency to put the pieces back together. We recently received a fractured shaft that was placed in a nice, custom-made wooden box for shipping (Figure 7). Everything was well protected and packed, except that the mating fracture surfaces were secured into the box touching each other. This means that they impacted against each other during the entire shipping process, over 1000 miles, until we removed them from the box. If it is necessary to secure a fracture surface for shipping, place the fracture against a wooden support. The fracture halves shown in Figure 7 could have been successfully shipped if a wooden piece (2x4, piece of plywood, or even a stack of popsicle sticks) had been placed between the two fracture surfaces to prevent them from contacting one another during shipment.

Sometimes parts are welded together for removal or shipping. In some cases, this is good because it maintains a space between the mating fracture surfaces (Figure 8) to avoid the situation described above. In other cases, a handle might be welded onto the part that happens to be welded onto the failure area. When welding on failed components to aid in sample removal or shipping, be mindful of keeping space between the fractures and avoiding welding too close to the failure and causing unwanted heat damage.

While we will accept samples in almost any condition, we appreciate when care is taken to remove and pack samples in a way that preserves the failure features. This way we can provide you with the most meaningful and accurate failure analysis possible.

Conveniently, we have a sample removal guideline for handy reference which is included on the following page. If you aren't sure about something specific when removing or packing a sample, please do not hesitate to contact us. We will be glad to answer any questions.

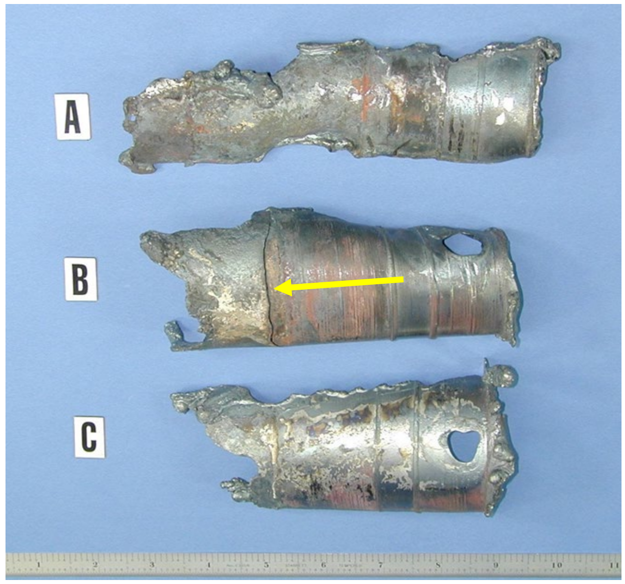

Figure 1. Sections of a boiler tube that were received for analysis. The tube was torch cut for removal from the mud drum, but a section of the crack was still preserved (arrow).

Figure 2. A boiler tube that was cut through the middle of the rupture prior to shipping.

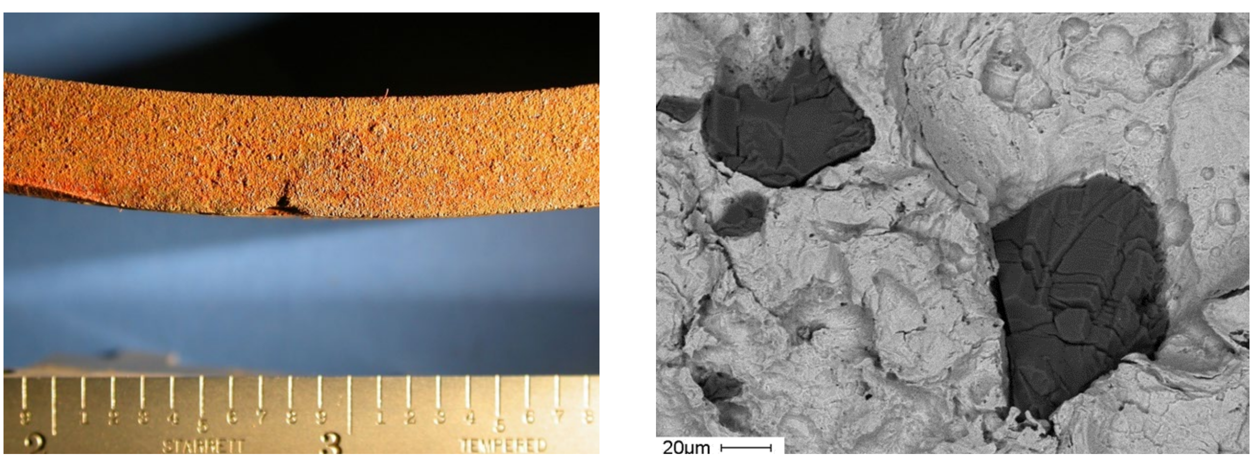

Figure 3. Sample that was grit blasted to clean it prior to shipping. Sand particles (black areas in lower right image) were found imbedded in the fracture from cleaning.

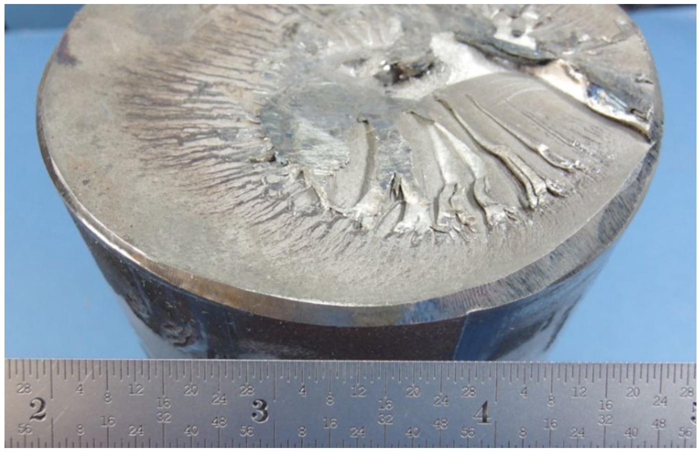

Figure 4. Shaft where the circumference was machined to bevel the edge.

Figure 5. Box with four boiler tube sections and no packing material. Deposit can be seen that fell off of the tubes in the bottom of the box.

Figure 6. Examples of well protected samples.

Figure 7. Fractured shaft that was packaged with the mating fracture surfaces touching (arrow).

Figure 8. Fractured forklift boom, where a plate was tack welded (arrows) to maintain a space between the fracture surfaces.