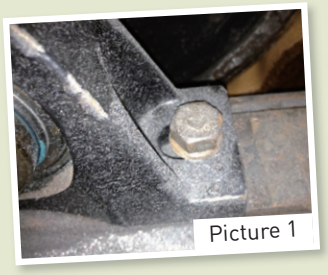
Identifying Fastener Failures

Washers

by Guy Avellon

As we've often mentioned in previous articles, it is very rare that a fastener fails due to quality matters, though it does happen. Most often it is due to installation error, using the incorrect part or trying to make something fit that doesn't belong. Take, for example, the next series of photographs where the customer was complaining of loose fasteners.

One company uses a set of cast pillow blocks with a bearing in the center that supports 6,000 pounds (2.72 Metric Tons). The block castings are made with a slot for a fastener to hold it to its mounting surface. The mounting hole is slotted for adjustment. They were also having to replace these bearing blocks because the bearings would wear out prematurely.


Picture 1

The customer had several sizes of blocks. When measured with actual fasteners, one size accepted a 5/8" bolt, the other a 3/4" bolt. However, out in the shop area, we found the following examples of assembly (picture 1).

This connection was using an SAE style flat washer on a bolt that both looked to be too small for the mounting hole (picture 2).


Picture 2

With vibration and normal movement, this washer and bolt assembly were being drawn into the mounting hole, which was becoming larger. One block assembly had already cracked.

Upon further examination of mounting blocks in the store room, we discovered these parts would not accept a 3/4" fastener. Instead, the block that should have accepted the 3/4" bolt would only accept a 5/8" bolt. Likewise, the block that should have accepted a 5/8" bolt, would only accept a 1/2" bolt. The resulting assembly looked like the picture 3.


Picture 3

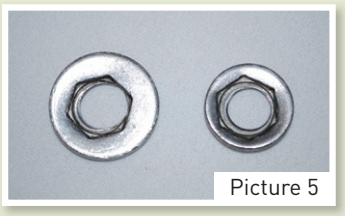
In their attempt to make a smaller fastener fit, they used a USS flat washer first, then an SAE flat washer to compensate for the larger inside diameter of the USS washer (Picture 3).


Picture 4

Picture 4 shows that in another unit they used only a single hardened USS flat washer against the connection. With the larger slotted opening and the larger inside diameter of the USS flat washer, the stresses built on the edge caused the hardened washer to crack. This will cause loss of clamp load and movement of the bearing support. Once this support moves, it will cause the main shaft to become out of alignment and the bearings will wear and fail.

Basically, picture 5 below depicts the differences in the ability between the USS flat washer (left) and the SAE flat washer (right) to support the entire load of a bolt. Only the SAE washer gives full support under the bolt head. The larger inside diameter caused part of the washer to be drawn into its mounting hole.

The fact that there are impressions into the washers is also significant because these washers are both common, wrought steel washers. These impressions were made when the fastener was tightened normally. Further embedment is also made during service loading. These depressions mean the bolt relaxed this amount and lost its preload. According to Hooke's law, for every 0.001" of bolt relaxation, per inch of loaded length, the joint loses 30,000 psi of clamp load. This can mean the loss of one bolt strength grade.


Picture 5

By studying these flat washers, it also becomes apparent that using a larger diameter flat washer does not provide an increased surface area of support beyond the hex head of the bolt. This is true for harder materials, such as steel

joints. However, the larger diameters flat washer will provide better loading for thin sheet metal, aluminum, wood and other softer materials. The only product that will provide load support over a wider area than the bolt head is a flanged head bolt. This is because the washer is basically part of the hex head.

To solve this customer's problems, they enlarged the mounting hole slots on the blocks that were smaller and standardized to flanged head bolts and flanged nuts so the maintenance personnel would know these flanged products were only to be used on this application.

Washer hardnesses has been relaxed since the early 1990's. Washer hardness specifications were common between 42-46 Rc, some were made even harder. This made for a very brittle washer in some applications since the common steel was an AISI/SAE 1065. If care was not taken when the parts were electroplated, the washers became embrittled with hydrogen absorption. Picture 6 below is of one such washer. The opposite side was stamped with the manufacturer's logo and the washer's size. The stamping created stress points which further added to the embrittlement failure. As can be noted by the circular impression one-third away from the inside diameter, this was the size of the hole the washer was placed over. The hole was a little too large and drew some of the flat washer into the hole as it was being tightened or in service.


Picture 6

Today, the hardness of flat washers that are heat treated is lowered, especially for the ASTM F436 hardened structural flat washers; they have a hardness range of 38-45 Rc. This hardness range is not as susceptible to hydrogen embrittlement as before, but still care must be taken when cleaning and electroplating these hardened steel products.

To help eliminate any such problems of embrittlement while maintaining corrosion resistance, many manufacturers and distributors have specified mechanical zinc plating or even organic coatings.