

Zinc Plating Socket Head Cap Screws is Risky Business

By Joe Greenslade

We have received many calls from fastener suppliers over the past few years who were having problems with a customer who was complaining about the heads breaking off of zinc plated socket head cap screws they had supplied. In most of the cases it was concluded that the parts were failing due to hydrogen embrittlement. The potential liability and the severe headaches associated with these occurrences is tremendous.

Hydrogen embrittlement in electroplated screws is still, to a great extent, a mystery. It seems to only occur sporadically, making it hard to detect and prevent. One fact seems to be agreed upon by most experts. The potential for hydrogen embrittlement in electroplated screws and bolts increases in direct proportion to the amount of carbon in the steel and the hardness of the parts.

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It is generally agreed that electroplated Grades 2 screws and bolts have virtually no tendency toward hydrogen embrittlement because they are made of low carbon steel and are not hardened at all. Electroplated Grade 5 screws and bolts are very unlikely to have hydrogen embrittlement problems. They are made of medium carbon steel and are hardened to a maximum hardness of Rockwell C 34. Personally, I

have never heard of a confirmed case of hydrogen embrittlement in this Grade 5 fasteners.

Zinc electroplated Grade 8 screws and bolts are prone to hydrogen embrittlement. They are made from medium carbon alloy steel and are hardened up to Rockwell C 39.

Socket head cap screws, like Grade 8, are also made of medium carbon alloy steel, but they are hardened up to Rockwell C 45. Out of all of the types of standard screws and bolts, socket head cap screws have the highest possibility of hydrogen embrittlement failures when they are electroplated.

There continues to be a lot of confusion over what is and what is not a hydrogen embrittlement failure. It is simply this:

If a screw breaks between one and 48 hours after installation and the break is at the head to shank juncture or the thread run out it is probably a hydrogen embrittlement failure.

If, however, the parts break while they are being installed the problem is almost certainly something other than hydrogen embrittlement.

A hydrogen embrittlement failure is the worst kind of problem a fastener supplier can have because they are *delayed failures*. The product the screws or bolts are used in is at least partially assembled before the problem starts to appear. Customers frequently demand that the supplier pay for replacement fasteners plus the labor to repair assemblies already completed. In the worst cases the assembled products may have to be scrapped because the cost of rework would exceed the cost of the product. In these cases the fastener supplier is expected to pay for all scrapped assemblies.

The secondary problem associated with

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zinc plating socket head cap screws is that the standard threads are made to a class 3A fit which does not allow for plating build up. When socket head cap screws are plated their pitch diameter usually becomes oversized making the parts subject to rejection on the basis of thread size.

My suggestion is that zinc electroplated socket head cap screws should not be offered for sale to customers. In most cases the value of the sale is not worth the hassle of plating a small lot in the first place. The potential problems far out weigh the likelihood of a significant profit gain.

Most customers ask for zinc plating to improve the corrosion resistance of the

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socket head cap screws in their application. The standard finish on socket head cap screws is black oxide which provides virtually no salt spray corrosion resistance. The objective of better corrosion resistance can be met by having the socket head cap screws zinc phosphated and oiled instead of zinc electroplated. In most cases the thin zinc plating added to socket head cap screws will only provide about 12 to 24 hours of salt spray corrosion resistance. A good phosphate and oil coating will provide a minimum of 72 hours of salt spray resistance. Phosphate and oil has been a favorite finish in the automotive industry for many years because of its low cost, relative to its good corrosion resistant.

These performance differences are documented in the General Motors finish specifications. GM 4342 M, Code 20K24 requires a minimum salt spray resistance of 24 hours for .0002" zinc and clear chromate, where as, GM 4435 M requires 72 hours of salt spray resistance for zinc

phosphate and oil.

Phosphate and oil is what is known as a conversion finish and not a plating. The surface of the steel is made porous and penetrated by the phosphate which holds the oil very tenaciously. Because it is not a plating it can not seal hydrogen in the steel. Therefore, phosphate and oiled socket head cap screws do not suffer from hydrogen embrittlement failures.

Unlike electroplated zinc plating, phosphate and oil does not build up in the threads of screws and bolts. Therefore, zinc phosphate and oil does not cause thread fit and size problems.

Electroplated zinc is less slippery than black oxide and phosphate and oil. This means that it requires more torque to properly tighten a zinc plated socket head cap screw than it does the same screw with a black oxide or phosphate and oil finish. In more technical terms it can be stated that the coefficient of friction of black oxide and phosphate and oil is significantly lower than that of electroplated zinc. Where consistent bolt tightening (bolt tension) is critical, phosphate and oil

is superior to electroplated zinc.

Zinc phosphate and oil has a black color instead of the silver color of electroplated zinc. If a customer is specifying electroplated zinc strictly for the appearance, suggest that they go to stainless steel socket head cap screws or zinc plated machine screws instead. These are much safer solutions.

Zinc electroplating of socket head cap screws is risky business at best. I suggest you do not do it. The potential for problems with hydrogen embrittlement, thread fit, and inconsistent tightening is very likely. Obviously, as a fastener supplier you want to meet your customers needs. Keep in mind that customers who ask for zinc plated socket head caps screws usually mean that they want screws with greater corrosion resistance than is provided by the standard black oxide finish. You will serve your customer and yourself better by persuading them to specify the phosphate and oil finish instead of the electroplated zinc finish. □

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