# Advantages of Limiting Core Hardness During the Heat Treatment Process

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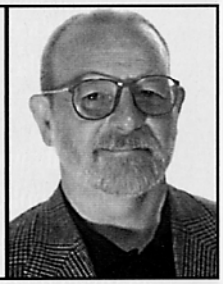

**Restricting upper core hardness to Rockwell C36 can provide screw and bolt manufacturers with added product confidence.**

It is my opinion that screw and bolt manufacturers should change their internal heat treatment specifications to limit core hardness to a maximum of Rockwell C36 wherever possible. I have formed this opinion after having been consulted many times over the past 30 years about suspected hydrogen embrittlement failures. In every investigation that I have been involved in where hydrogen embrittlement was confirmed as the root cause of a fastener's delayed failure, the core hardness was over Rockwell C 36.

This opinion has evolved over a long period of time as the result of numerous investigations and the assimilation of information gathered during a variety of conversations with industry experts. In recent years, I found a note in *SAE J933* that specifically suggests that tapping screw core hardness be held to Rockwell C 36 or less to avoid brittle failures. During the 1990s, I was heavily involved in the evolution of the Fastener Quality Act (FQA), and was party to many discussions about hydrogen embrittlement and how the FQA should deal with this potentially devastating phenomenon.

## Knowing Which Grades & Types of Parts Need to be Baked is Important

In several of these discussions, the subject of which grades and types of parts should be baked and which grades and types did not need to be baked came to the forefront. Many people were of the opinion that all Grade 8 and Property Class 10.9 and higher strength parts that are electroplated should be required to be baked and tested after plating.

On many of these occasions, several very reputable bolt manufacturers stated that they had produced Grade 8 and Property Class 10.9 bolts for 25 or more years and that they had never baked them after plating and had never had a confirmed case of hydrogen embrittlement. After probing a little further, I learned that they never allowed the core hardness of their Grade 8 or Property Class 10.9 products to exceed Rockwell C 36, instead of going to the standard's upper limit of Rockwell C 39.

Following up on these discussions, I contacted several metallurgical engineers and asked their opinion on this sub-

| Specification | Specified Core Hardness Range | Recommended Adjusted Core Hardness Range |
|---|---|---|
| SAE J78 | RC 32 – 40 | RC 32 – 36 |
| SAE J81 | RC 32 – 38 | RC 32 – 36 |
| SAE J82, Grade 120M | RC 25 – 38 | RC 25 – 36 |
| SAE J 429, Grade 5.1 | RC 25 – 40 | RC 25 – 36 |
| SAE J 429, Grade 8 | RC 33 – 39 | RC 33 – 36 |
| SAE J429, Grade 8.2 | RC 33 – 39 | RC 33 – 36 |
| SAE J933 | RC 28 – 38 | RC 28 – 36 |
| SAE J1199, Property Class 10.9 | RC 33 – 39 | RC 33 – 36 |
| SAEJ1237, Type 10 | RC 33 – 39 | RC 33 – 36 |
| ASTM A354, Grade BD, ¼-2 ½ | RC 33 – 39 | RC 33 – 36 |
| ASTM A354, Grade BD, over 2 ½ | RC 31 – 39 | RC 31 – 36 |
| ISO 898-1, Property Class 10.9 | RC 33 – 39 | RC 33 – 36 |
| ISO 2702 | RC 25 – 40 | RC 25 – 36 |

**Standards Table. Standards that have Rockwell C36 within their hardness range and the author's recommendation to manufacturers for revising their own internal working core hardness ranges.**

ject. They all agreed that the possibility of occurrences of hydrogen embrittlement in parts with a core hardness of Rockwell C 36 was substantially less than parts having a higher core hardness.

The accompanying **Standards Table** lists standards that have Rockwell C36 within their hardness range and my recommendation to manufacturers for revising their own internal working core hardness ranges. There are probably more specifications than I have listed in the Table that have Rockwell C36 within their core hardness limits. My suggestion of adjusting the upper limit down to Rockwell C36 should be considered in those standards as well.

Several of the standards in the Standards Table apply to tapping screws. Tapping screws have hardness requirements for both core hardness and case hardness. The Standards Table shown in this article pertains to the core hardness only.

All carbon steel tapping screw standards have case hardness requirements of Rockwell C45 or greater. I have not observed that case hardness has any specific impact on the occurrence of hydrogen embrittlement. The embrittlement condition in screws and bolts appears to be related closely to the core hardness and unrelated to the case hardness.

## Additional Causes of Hydrogen Embrittlement

I am not implying that the core hardness of a part is the only factor involved in the occurrence of hydrogen embrittlement. Not all screws and bolts that have a core hardness of Rockwell C37 or higher have hydrogen embrittlement.

Several things must occur during the manufacturing and finishing processes for hydrogen embrittlement to occur. But, as I stated in the beginning of this article, all of the cases of confirmed hydrogen embrittlement that I have observed did in fact have a core hardness greater than Rockwell C36.

## Conclusion

I urge manufacturers to review their internal requirements and the instructions they send to their heat treat contractors and suggest they consider the adjusted core hardness ranges as shown in the Standards Table. These simple core hardness range adjustments could provide the manufacturers with a little more confidence in the ultimate quality of the product they produce when making parts to the standards listed above.

For further discussion on this topic, contact the author or **Circle 205.** FTI