"The bolt pays dearly for its coat – like a fox to its fur"

The aphorism in the title can be considered a metaphor, which is intended to emphasize the importance of the designer's decision when choosing the right size and system for securing bolted joints. If he does not make the right decision, he is responsible for the possible collapse of the structure. So what is really the responsibility of the designer?

Prevent Repairs: Maintain Equipment Early

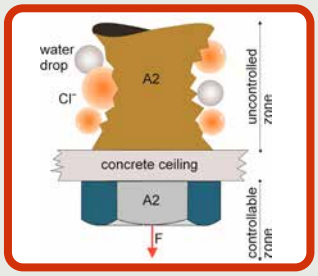
Division of Responsibility

First, a few examples: While driving on the highway, a bolt came loose from the wheel of a truck and at full speed it smashed through the window of a passenger car, seriously injuring the passenger. Who was responsible? Most people would probably answer that the truck driver was, because the rule is that it is mandatory to check the technical condition of the car before driving.

▼ Fig. 1. Deformed wheel screws

▼ Fig. 2. Insufficient material strength

▼ Fig. 3. Bolt corrosion due to Cl-



▼ Fig. 4. Swimming pool roof damage (Wikipedia)

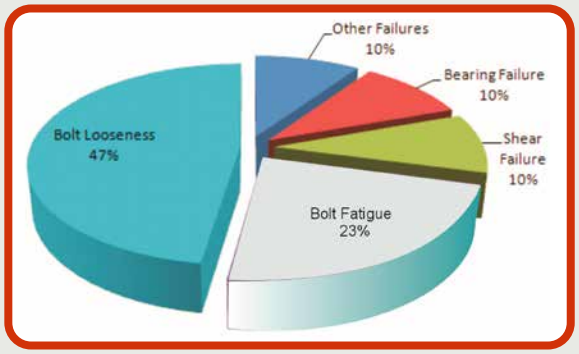
However, the case had an interesting outcome. The truck driver submitted an invoice stating that the service had changed his tires just before the trip. However, there was a note on the invoice stating that he should come for an inspection after driving 50 to 100 km. And he did not do that. Despite this, the arbitrator did not accept this note and claimed that they should have drawn up a separate document about it and had the driver sign it. According to legal regulations, the service was at fault.

A clearer case is vehicle overloading because it can be proven exactly (***Fig. 1***). Apart from the specific case in ***Fig. 1***, this often happens, for example, consciously or when transporting sand during rain. In such cases, the regulation requires the use of a tarpaulin. In both cases, the driver is responsible. The case in ***Fig. 2*** is clear. The dent is a result of the low strength of the material.

Unfortunately, the fatal mistake of the designer of the indoor swimming pool (***Fig. 3***), who hung the heavy concrete ceiling on stainless steel screws of the austenitic type (A2), had tragic consequences. He did not take into account the penetration of aggressive Cl- cations into the inaccessible space above the ceiling. As is known, A2 stainless steel is defenseless against the attack of Cl-. Ironically, when viewed from the pool area, everything seemed OK because the screw heads were untouched by corrosion. The arbitrator's decision in this case was uncompromising. Unfortunately, this is not an isolated case (***Fig. 4***)

▼ Fig. 5. Plagiarism

▼ Fig. 6. Failure frequency



▼ Fig. 7. Pipeline at height

▼ Fig. 8. Gas explosion (Wikipedia)

It is more difficult to determine the guilt in the case of unknowingly applying plagiarism. ***Fig. 5*** shows a bolt that has come loose from the wheel of a truck while driving. At first glance, it is clear that this is plagiarism. According to ISO 898-1, each structural bolt must be provided with information about the strength class and the manufacturer's mark. In this case, the declared strength of 10.9 was not confirmed and the manufacturer's mark was missing. In most cases, the suppliers of plagiarism are anonymous. So who is responsible in such a case? The decision is up to the arbitrator.

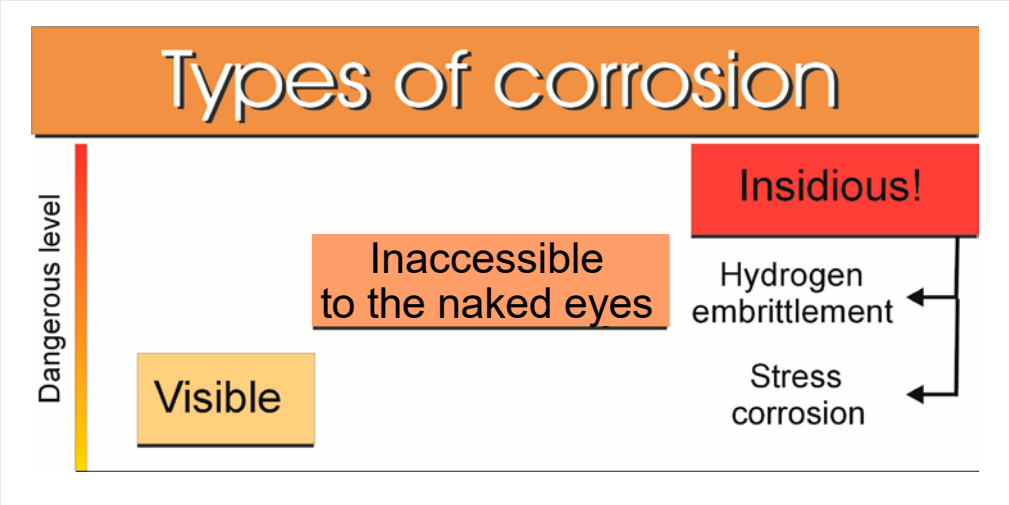
There are many cases of collapse of entire structural units due to failure of bolted joints. The reasons are various. As SKF's experience shows, the most common are bolt or nut loosening and material fatigue (***Fig.6***). In such complex cases, the arbitrator has expert opinions prepared by several independent expert institutions. Unfortunately, these expert opinions often differ from each other or do not contain clear-cut opinions, because usually none of the academics has mastered the theory of the behavior of bolted joints during assembly and operation. They will examine material changes with the help of REM microscope in vain if no one notices that in a given case the contact surfaces were not parallel (***Fig. 11***).

Cases of loss of tightness of flange joints in hard-to-reach places (***Fig. 7***) are also complicated. A leak in a flange connection can have fatal consequences. An explosion of the leaking gas demolished the surrounding residential buildings (***Fig. 8***). Corrosion is also dangerous, especially for pipes. There are several types, which are regulated by the ISO 8044 standard - Corrosion of metals and alloys. For the purposes of this publication, a specific breakdown of corrosion types is shown in ***Fig. 9***. The least dangerous is surface corrosion visible to the naked eyes. The most dangerous type is what can be called insidious because it cannot be identified. The best known are hydrogen embrittlement (***Fig. 10***) and stress corrosion (***Fig. 11***). This image shows that the cause of the crack under the screw head was the non-parallel contact surfaces.

Conclusion

As has been shown, the care of bolted joints does not end with assembly. Neglecting regular inspection of bolted joints can have a cruel revenge. This is doubly true for hard-to-reach places where no one knows what is going on there. It is precisely such cases that future research and development should focus on. ■

▼ Fig. 9. Types of corrosion



▼ Fig. 10. Hydrogen embrittlement

▼ Fig. 11. Stress corrosion