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Outspoken About Wedge Locking Washers and Junker Test

Loosened nuts and bolts during operation have been a problem since their invention. ***Wedge Locking Washers are currently considered in professional circles to be one of the most reliable locking system for bolted joints.*** *In this sense, they are presented not only by manufacturers, but also by distributors.* ***They gained their popularity mainly after the spread of the so-called Junker vibration test,*** *which is used to check the reliability of locking systems. This vibration test, according to DIN 65151, is considered the most severe vibration test for bolted connections.* ***To testify to the complete properties of this locking method and to help designers is the task of this contribution.*** *It is important to note that the article is of a strictly technical nature and has no ambition to interfere with the distribution network.*

Wedge Locking Washer Design and Properties

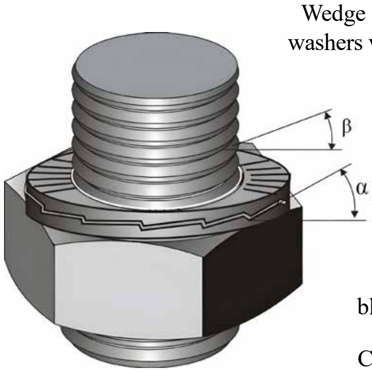


Fig. 1. α > ß, (ß - thread pitch angle)

Wedge locking washers (WLW) are two in a pair together glued washers with external ribbing and internal wedge surfaces (***Fig. 1***). The wedge-locking method is based on tension instead of friction. A typical bolted joint assembly with WLW application is shown in ***Fig. 2***. According to the manufacturer's recommendation, a pair of wedge washers should be in the case of nut connections installed under the bolt head as well as under the nut. The pair of washers use cam-geometry. Any attempt from the bolt/nut to rotate loose should be blocked by the wedge effect of the cams.

Considering that WLWs belong to the group of locking elements whose locking effect depends on the preload of the bolted joint pA → f(FM) (***Fig. 3***), the existence of up to 7 interfaces (***Fig. 2***) is unpleasant. ***Fig. 2*** also shows that by installing two pairs of WLW, the clamping length of the joint increases by 2x h.

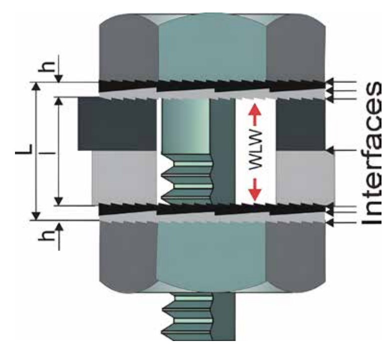


Fig. 2. Bolted joint assembly with WLW application

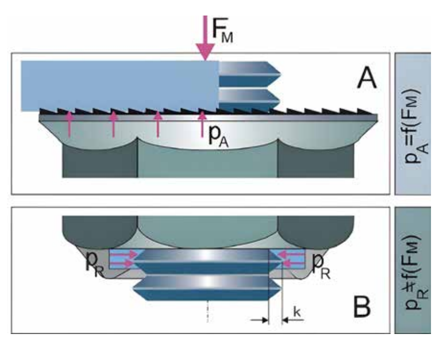
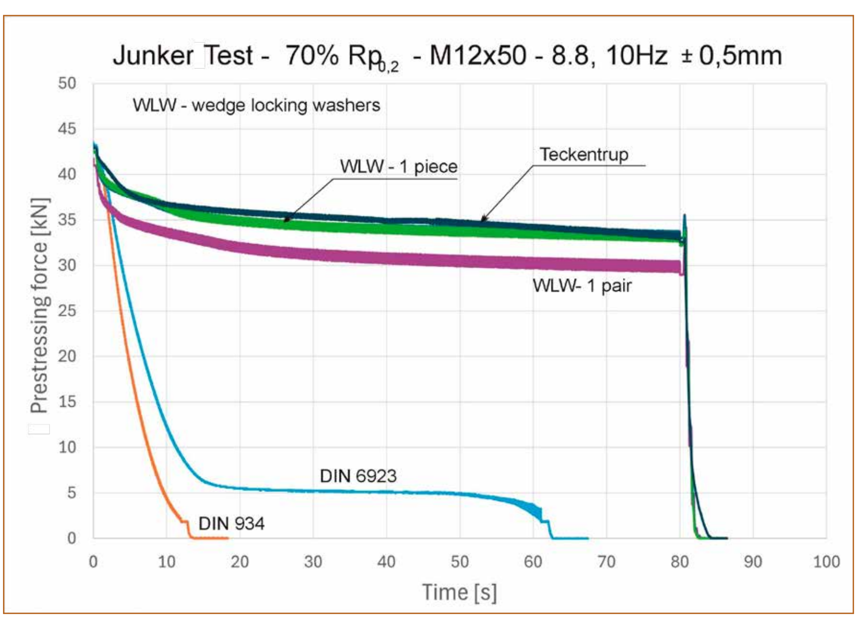


Fig. 3. Various locking parts

Fig. 4. Junker test



Depending on the roughness of the surface and the hardness of the steel, each interface manifests itself in material settling. The rougher the surface of the material and the greater the number of interfaces, the more significant the resulting settlement value and the decrease in preload. It is also proven by the Junker test in ***Fig. 4***. From this figure it is clear that only one washer, i.e. not a pair, causes a lower settling value while still showing the same locking effect. However, this fact needs to be examined more closely, as it may also depend on the strength of the material of the parts being joined.

Stress Analysis of Bolting Joints

It was already stated at the beginning that wedge locking washers are considered in professional circles to be one of the most reliable locking system for bolted joints. This is also proven by *Fig. 4*. But is it true in every case? The answer to this question requires a more detailed analysis. First, the known shortened quote from C.O. Bauer:

For each type of bolting stress, another locking "dress"!

This bolting axiom is based on the principle that during operation, screw joints are exposed to mainly two various mechanical effects (***Fig. 5, 6 and 7***). This serious fact cannot be disputed, but is fully respected. This also applies to the choice of the relevant locking of screw joints and their vibration testing methods.

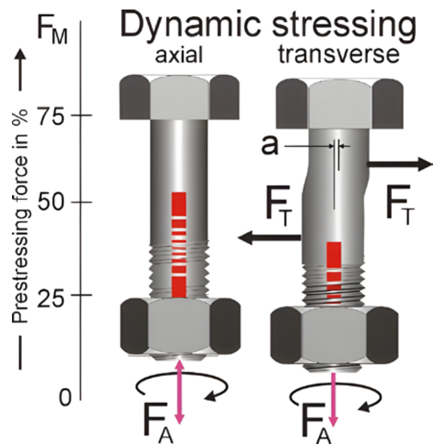


Fig. 5. Dynamic stressing

Fig. 6 Axial dynamic loading

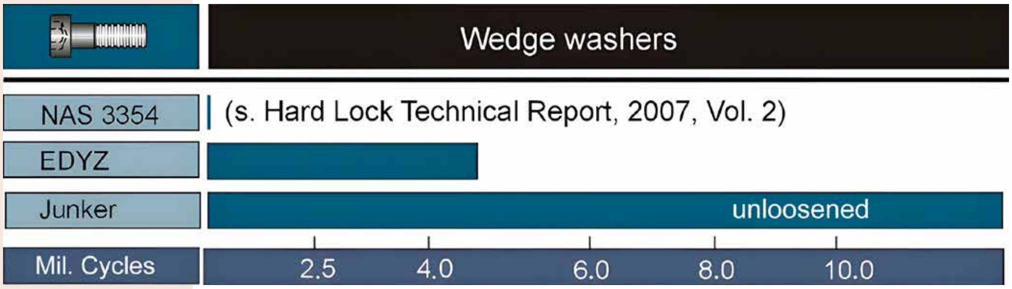
Fig. 7 Transverse dynamic stressing

Vibrations Testing

The different locking effect of WLW at different stresses is clearly documented in ***Fig. 8a*** with an associated ***Fig. 8b***.

These pictures show that wedge locking washers were the best at resisting transverse vibrations, moderately resistant to axial vibrations loading, and according to Hard Lock Technical Report, 2007, vol. 2, completely failed when NAS 3354 was applied.

Fig. 8a. Locking effect of WLW



The Junker vibrations test (*Fig. 9*) itself gradually gained such popularity that the DIN 65151 standard was assigned to it. This has earned it the credit of a generally valid standard for any type of stress. However, such a function belongs to it wrongly, because it does not respect the different stress conditions of bolted joints (s. Dominik, J.: *Polemic About Junker Test Standard*, Hardware & Fastener Components No. 62, May 2024). For that reason, there should be a revision of the standard in the sense that only transverse dynamic load applies.

Fig. 8b. Various methods

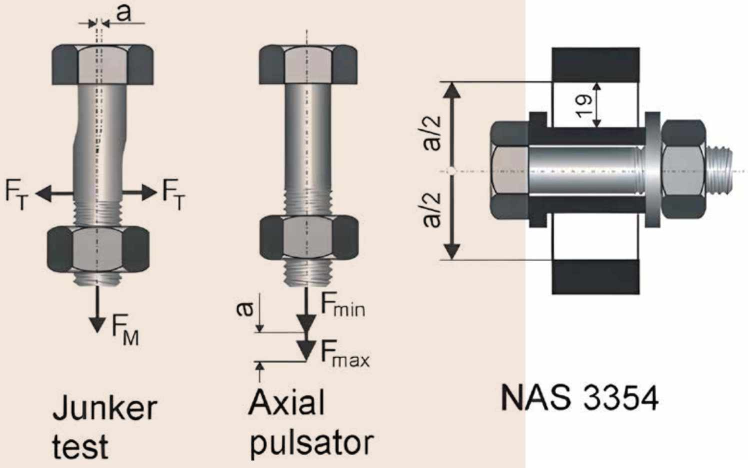
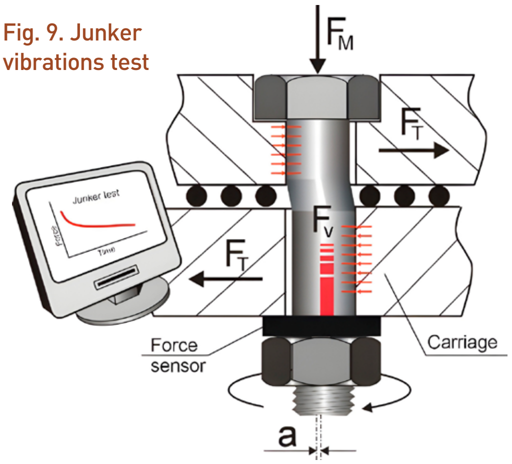


Fig. 9. Junker vibrations test



It is obvious that the hook on the wagon (***Fig. 10***) is subjected to tensile cyclic stress and an axial pulsator must be used to test the strength bolts that secure it (***Fig. 11***). The Junker test would not be objective.

Fig. 10. Hook on a wagon

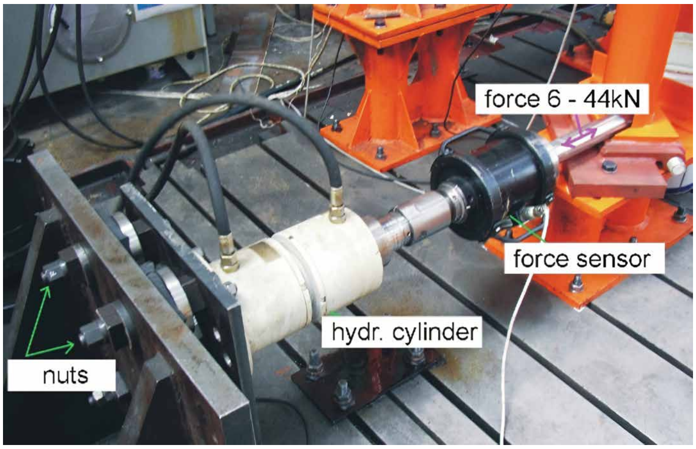


Fig. 11. Strength bolt test

Alternative Solutions

It must be objectively admitted that for the given type of stress, WLW is a good option. However, the locking effect is not the only criterion for its selection. Here are the next:

Price, Logistic (number of parts), Assembly difficulty, Repeatability, Number of interfaces, Ability to seal, Damage of contact surface

Therefore, it does not hurt to remember some other options for securing screw joints. The current market offers a wide choice of external locking elements. Among the many options, at least flange nuts with ribs (***Fig. 12***) should be mentioned (there are also similar head screws with an integrated ribbed flange). The benefits would be at hand: fewer interfaces, simpler logistics, easy assembly, safe for use in food machinery from a health point of view.

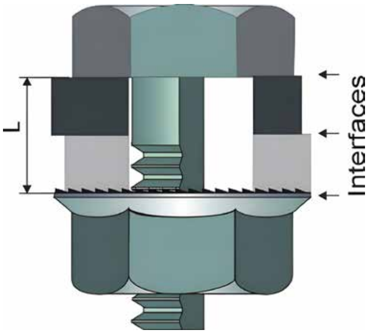


Fig. 12. Flange nut with ribs

Conclusion

The article uncompromisingly confirmed the truth of C. O. Bauer that **there is no universal type of bolting that would be equally effective for all types of stress. It should be added that there is also no universal method of testing the resistance of threaded bolting to vibration**. For designers, this is a clear signal for the individual choice of method for securing bolted joints against spontaneous loosening. Of course, this only applies to cases that require external securing. The basic prerequisite for this is a thorough knowledge of the conditions (type of stress, aggressiveness of the environment, etc.) under which the future construction will operate. ■