BEWARE WEDGELOCK RESISTANCE

Wedgelocks (often generalised as card guide retainers) are an essential tool for modular rugged electronics equipment, offering secure fastening, high repeatability and simple extraction for technicians.

Due to their location within a rugged chassis assembly, a factor which is regularly championed by vendors is the competitive thermal characteristics of each design, often stating a surprisingly effective thermal performance given the complex contact resistances and geometry in the joint. Typically, this factor is referred to as “wedgelock thermal resistance”, and is a loosely derived term for total item performance that can be very misleading unless truly understood. This article will examine, at a high level, the accuracy of given figures and where thermal engineers may be misinformed when developing detailed models.

WHAT ARE WEDGELOCKS?

Wedgelocks are a format of expandable tool that allows rigid securing to tenon wall. By imparting a torque to a drive screw at the front of the wedge, the axial load on the screw is then translated by friction into a perpendicular clamping load.

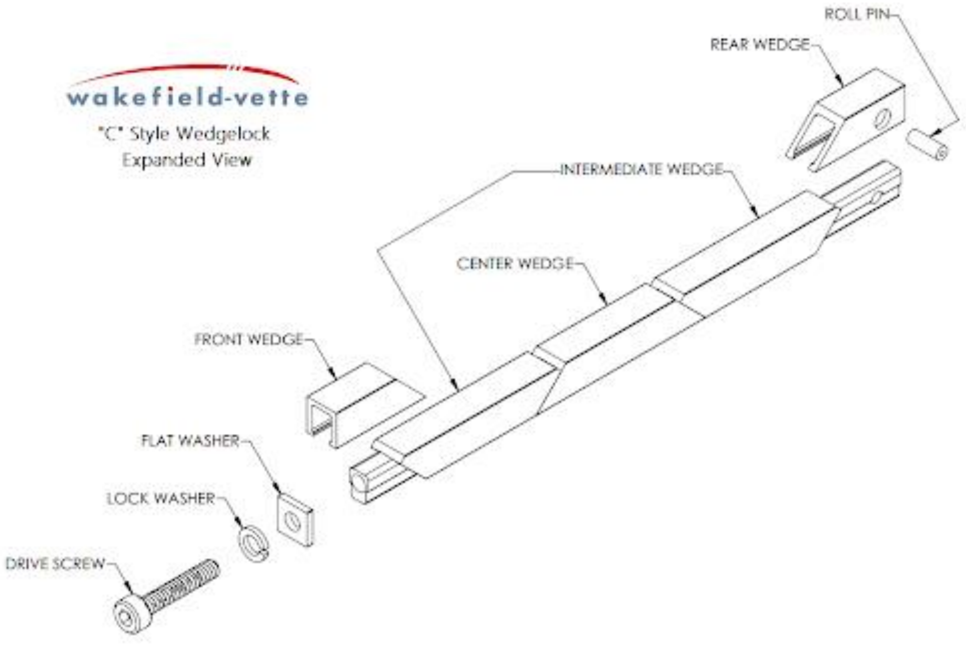

FIGURE 1 - EXPANDED VIEW OF A TYPICAL 5 WEDGE WEDGELOCK [1]

Their primary function is to secure the card within its slot during lifetime operation, ensuring stiffness and therefore transmissibility is high during vibration loading, and maintaining position between the card and backplane connectors.

Within legacy VME specifications, these were constrained to be fixed to the primary surface of the PCB (for example through IEEE 1101.2) though later VITA48.2 allowed for attachment on both the primary and secondary side, see Figure 2, which allowed for numerous further thermal development opportunities.

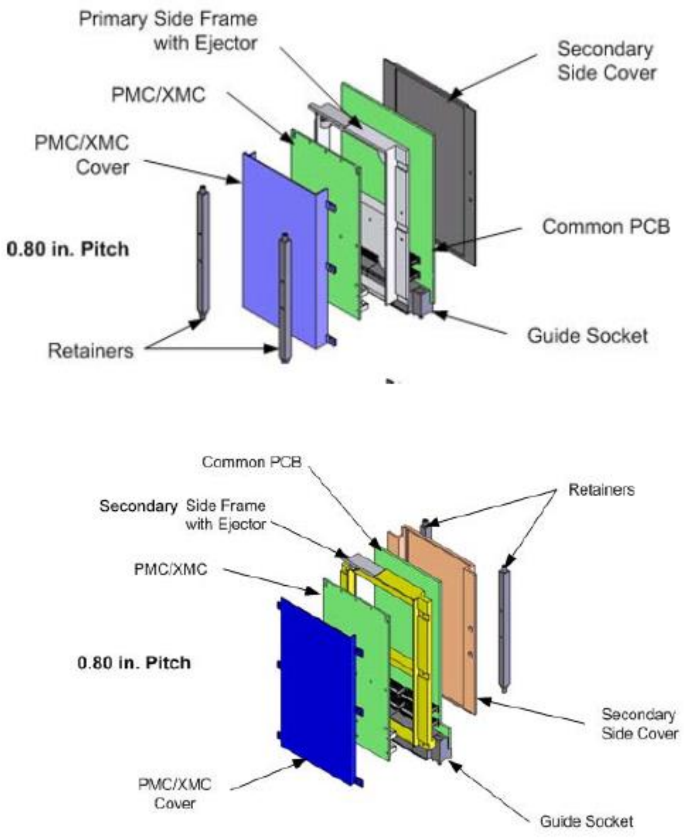

FIGURE 2 - PLUG IN UNITS SHOWING PRIMARY AND SECONADRY SIDE RETAINERS [2]

DATASHEET VALUES

How these "wedgelock thermal resistance" values are tested is not always made clear, however consistent documents from nVent, Birtcher and Wavetherm [3] all show a comparable test set up identifying temperature drop across the joint. The schematic diagram in Figure 3 shows two temperature regions being measured (on the heat frame and on the cold wall) allowing a resistance to be calculated. This diagram also indicates an estimated split for heat flow direction, with 30% of the heat flow travelling through the retainer and 70% through the heat frame. Similar values are supported in various sources, 70-30 split [3] [4] or 80-20 [5], however this is an incredibly simplistic approach to wedgelock cooling as these figures are inflexible to the joint stack up.

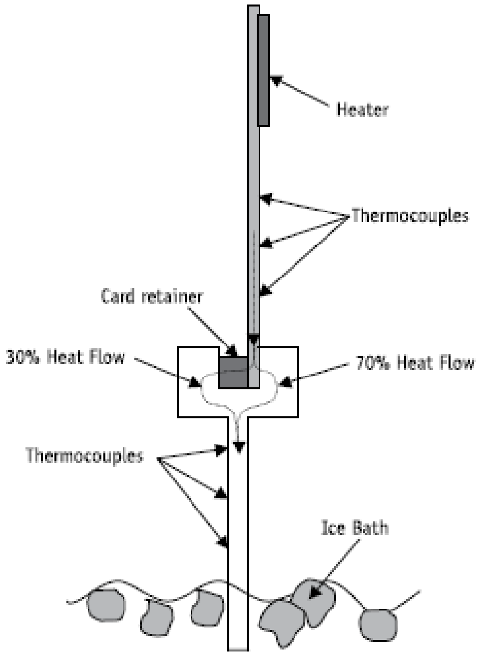

FIGURE 3 - THERMAL TEST APPARATUS SCHEMATIC DIAGRAM [6]

THERMAL RESISTANCES

With the position the wedgelocks take local to a chassis cold wall, they impact the thermal path that the heat flux takes from the devices out to the surrounding enclosure. The size and geometry of the wedgelock will impact the available cross-sectional area of the heat frame, while there will remain numerous contact resistances between mating surfaces of the items.

As wedgelocks are typically purchased as a self-contained item a simple thermal resistance network can be created for the overall joint isolating their performance, see Figure 4. $R_{thermal\_interface}$ represents the heat transfer path from an area immediately inside from the wedgelock to the cold wall of the enclosure.

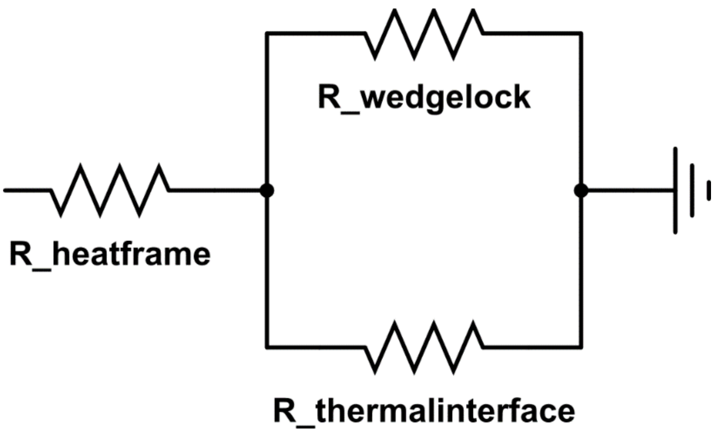

FIGURE 4 - THERMAL RESISTANCE NETWORK OF WEDGELOCK JOINT

The total resistance across this joint could be written as:

$$\frac{1}{R_{th}} = \frac{1}{R_{wedgelock}} + \frac{1}{R_{thermal\_interface}}$$

Considering the fundamental conduction transfer equation,

$$Q = kA\frac{\Delta T}{\Delta x} \qquad (1)$$

a singular value for joint resistance therefore would be impossible to determine without knowledge of the heat frame itself – such as geometry, material properties, surface treatment and pressure applied through the wedges. Figure 5 for example shows four possible wedgelock joint configurations, showing different combinations of cover, PCB and heat frame contacts.

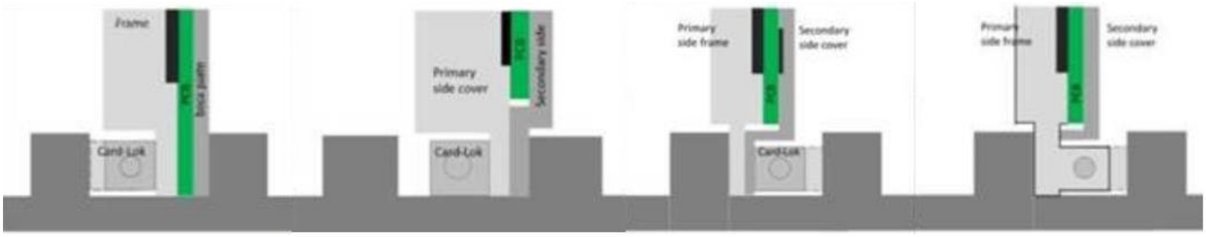

FIGURE 5 - POSSIBLE WEDGELOCK AND PCB JOINT CONFIGURATIONS

Clearly each of these will have a significant impact on $R_{thermal\_interface}$ while $R_{wedgelock}$ would remain consistent for a common item. Using a single assumed joint resistance, and therefore predicting a typical thermal split, is entirely infeasible.

It is important therefore that any thermal designer ignore any resistance values based on these figures in their entirety, and instead consider the value of the wedgelock resistance alone as this is specific to each component and can be determined by the manufacturer.

Fortunately, some wedgelock developers have recognised this inaccuracy and the limitation this can provide to simulation and calculation data. Both ACT and nVent offer resistance values across the wedgelock themselves, allowing these to be correctly assembled into a resistance model. This data is collected by test and removes the board stack in the set up entirely. The image below is an example of an nVent test setup which allows the entire thermal load to pass through the wedgelock to a cold wall.

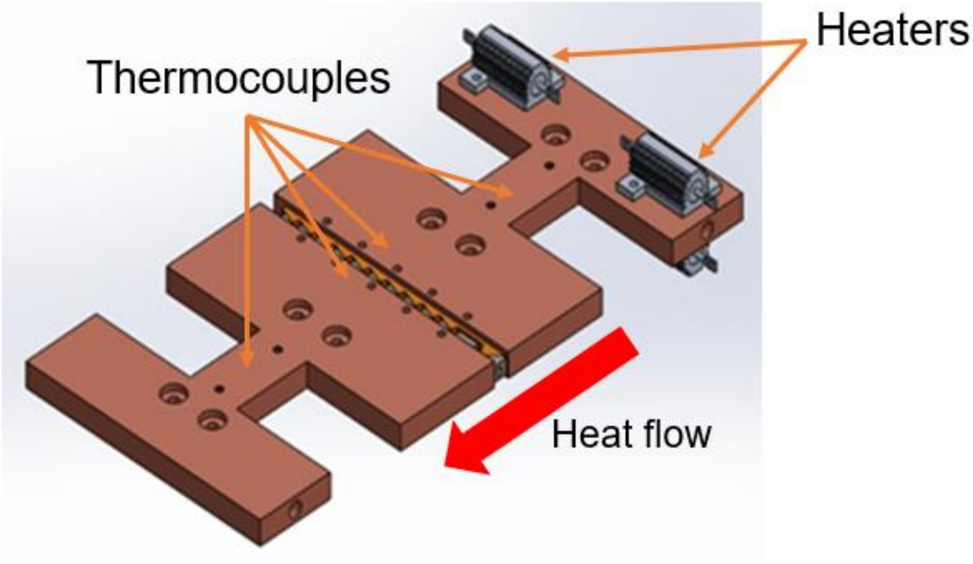

FIGURE 6 - CORRECT TEST SET-UP TO DETERMINE THE THERMAL RESISTANCE OF A WEDGELOCK

JOINT RESISTANCE V THERMAL RESISTANCE

Figure 7 below shows a comparison between the advertised thermal performance of leading wedgelock manufacturers [7] [6] [8] [9] [10], and the true resistance across a wedgelock (shown in blue). Each product will vary slightly due to construction, length and purpose, however Entropy have attempted to collate similar products for this study. For the purposes of this document it is less important to note the relative values of each manufacturer – as these may vary slightly depending on interpretation of data – and rather the magnitude of the joint resistance values against the singular retainer value.

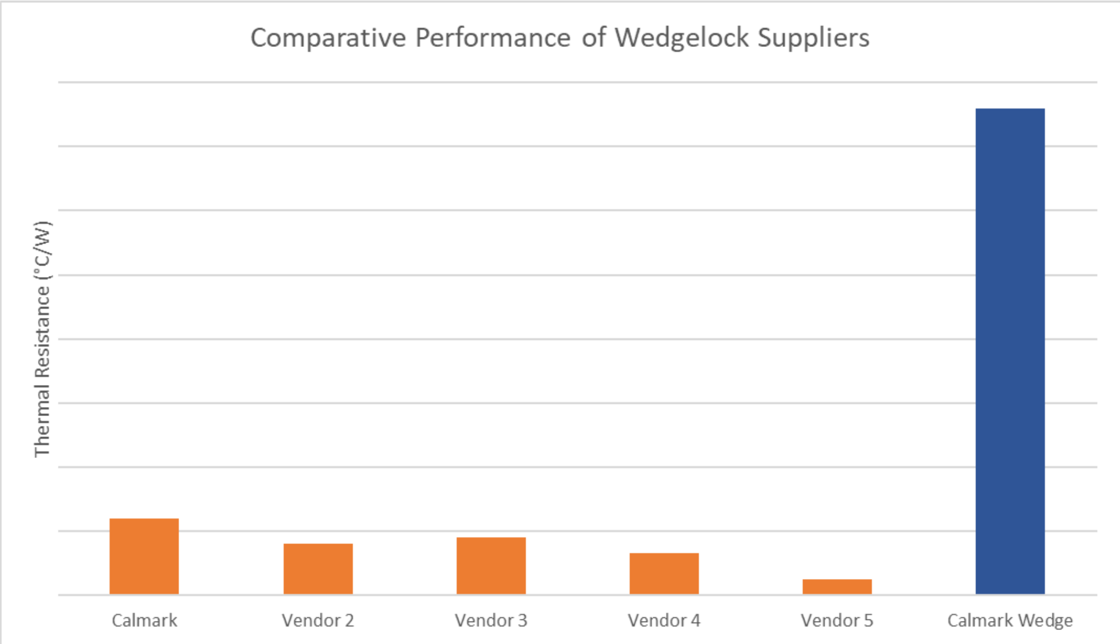

FIGURE 7 - COMPARATIVE PERFORMANCE OF WEDGELOCK SUPPLIERS

The significant difference between “tested joint resistance” and “wedgelock resistance” in this graph shows the critical importance of understanding the difference between the two values, and obtaining the correct resistance value for further modelling work.

In simulation modelling, utilising an accurate geometry with the material conductivity of the wedgelock leaves too many unknown variables – such as contact area between engaged wedges and surface resistance between interfaces. Reliable test data showing the thermal resistance per product will give a robust enough solution to allow further investigation.

Please note that Entropy are not using this information to recommend or popularise one single vendor, all decisions should be taken individually. These figures have been estimated using a black anodised surface treatment, 4.8” long with 5 individual wedges.

IN SUMMARY

Datasheet given resistance values are a positive tool for a comparison only. In reality, these figures are a misnomer and give typically highly ineffective feedback for joint cooling as the large majority of thermal power runs through the heat frame. In practise, improved wedgelock resistance does not therefore translate linearly to a reduction in component temperature, where systems are benefitted by at most a 1-2°C improvement (certainly invaluable in solutions with an already low thermal margin) and not the rather higher values that are proclaimed in vendor documentation.

Thermal engineers should always ensure that the correct resistance is applied in a detailed simulation model (or better yet in test), and the true effectiveness evaluated before making critical product decisions.