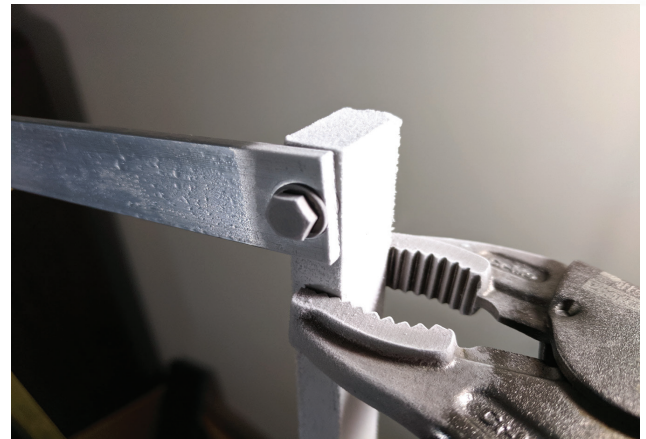




Constant Force-Load Washers

Negative CTE, Positive Results.

Drastic temperature changes and thermal cycling can cause brutal wear and tear on critical fastened assemblies. These drastic temperature changes drive tight preload margins creating nearly unobtainable design requirements. Negative thermal expansion alloys can help solve tough fastening issues with constant clamping force washers that ensure safe and reliable joints that do not tighten or loosen with temperature fluctuations.



Advantages of constant force-load washers:

- Enable smaller, lower profile, and lighter structures by eliminating the need for long compliant bolts and felxures.
- Reduce assembly time and weight by reducing the number of bolted joints required to distribute load in an assembly.
- Increase structure longevity by reducing thermal cycling fatigue.

Potential Applications:

- Cryogenics
- Aerospace
- Precision Machining
- Scientific Instrumentation
- Precision Mounting
- Optics

About Negative CTE

Allvar Alloys are the only metals in the world with a negative coefficient of thermal expansion (CTE), a property that causes metals to shrink when heated and expand when cooled. Commercially available ALLVAR Alloy 30 exhibits an axial $-30\text{ppm}/^{\circ}\text{C}$ CTE at room temperature. Attributes include:

- Positive CTE in the radial direction (similar in magnitude to Aluminium).
- Can stabilize the mechanical force on other components in a fastened assembly, the NTE can compensate for the expansion or contraction mismatch between the bolt and structural components.
- Exhibits mechanical and material properties like other Titanium alloys.
- Can be machined like many other metals, tolerances of ± 0.001 " are easily achievable for the most critical applications.
- Is manufactured into standard size washers and custom thickness spacers.

THERMAL MISMATCH AND PRELOADS IN BOLTED JOINTS:

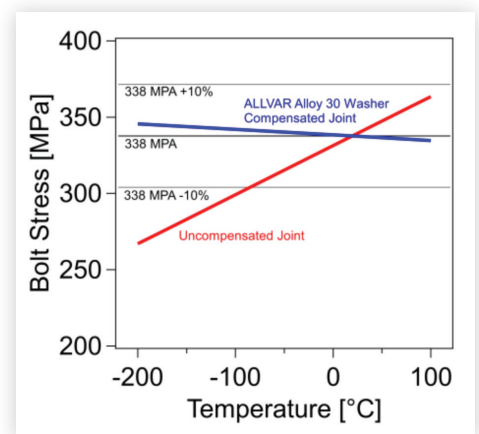
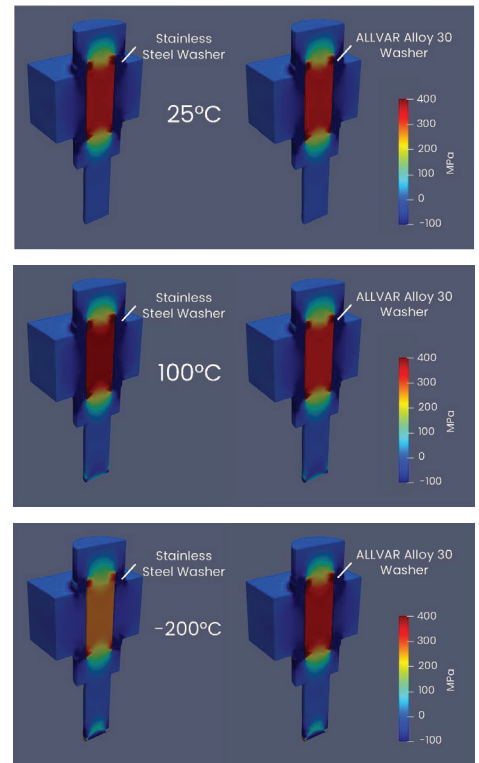


When designing bolted joints, an appropriate preload is commonly specified using torque requirements. Not only do bolts have to be torqued to the correct preload, but preload must be maintained within a certain margin of safety through the bolt's operational life. If the preload drifts beyond that margin, there is a risk that the bolt will loosen or over tighten and subsequently fail leading to degradation of a structure's performance or complete loss of integrity. Thus, specifying a torque requirement becomes more difficult when thermal mismatch can easily push a joint out of its clamping force specification. Thermal mismatch occurs when the Coefficient of Thermal Expansion on (CTE) of the bolt and clamped elements is different. The result can be joint failure from a loss of preload or overloading from temperature changes.

In the images to the right, the left bolted joint is held with a stainless-steel washer and pre-loaded to 338 MPa at 25°C. The color change to darker red indicates the bolt stress rise towards 365 MPa as the temperature increases from 25°C to 100°C. When cooling to cryogenic temperatures, the color change from red to orange represents a 22% drop in bolt stress from 338 MPa at 25°C to 263 MPa at -200°C.

Swapping out the top M5 washer in the bolted joint for an ALLVAR Alloy 30 washer greatly diminishes the fluctuations in bolt stress. The similarity in the red color of the FEA analysis images between -200°C, 25°C, and 100°C indicate there is very little fluctuation in bolt stress and thus clamping force. This is due to ALLVAR Alloy 30's negative thermal expansion property (-30 ppm/°C at 25°C), which is compensating for the difference in expansion between the aluminum plates (23.6 ppm/°C) and stainless-steel bolt (16.3ppm/°C).

With ALLVAR Alloy 30 constant clamping force washers, bolt stress is nearly constant across temperature changes. Constant clamping force washers improve reliability by limiting clamping force variation that leads to fatigue, loosening, and degradation of the joint.



ABOUT ALLVAR

ALLVAR, founded in College Station, TX in 2014, manufactures revolutionary alloys with unique negative thermal expansion properties. These alloys help compensate and eliminate the detrimental effects thermal expansion causes in a variety of extreme environment applications that require high-performance. Negative thermal expansion alloys can be used to athermalize optic designs, reduce thermal stress in assemblies, maintain a constant force load, and maintain stability with thermal changes. ALLVAR's mission is to realize long term societal benefits by rapidly transforming the scientific novelty of tailored thermal expansion alloys into useful athermalization technology.

PARTNER WITH US

To advance the Technology Readiness Level (TRL) of ALLVAR Alloys in optics applications, the ALLVAR team is looking to collaborate with prime government contractors and system integrators to design, build, and test ALLVAR Alloy athermalized optic prototypes in programs of record.

Interested in smaller, lighter, and better performing fixed focus optics? Contact us to join the athermal optic revolution!