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Pin Fatigue Case Study: 10 inch Accu-Shear Device

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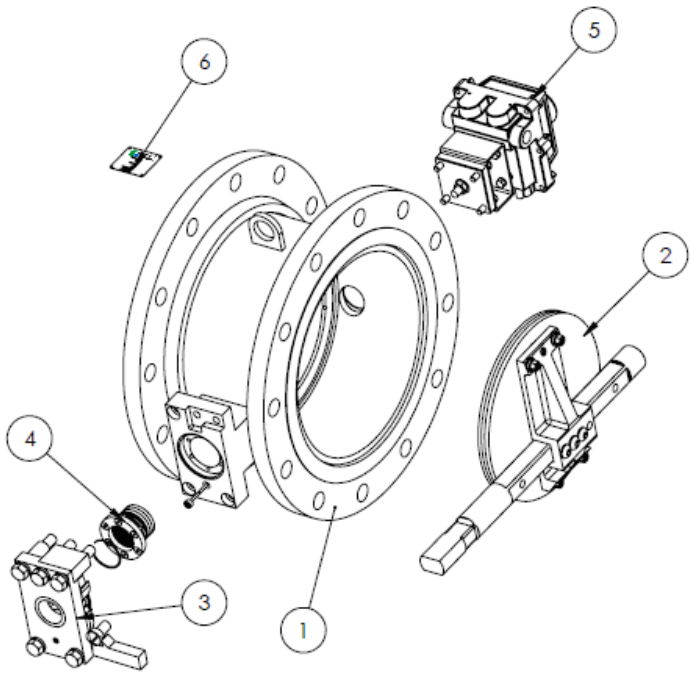
BACKGROUND OF SHEAR PIN AND FAILING COMPONENT PRESSURE RELIEF DEVICES

Fatigue failure is caused by repetitive loading well below the material strength, a well known issue with component failing pressure relief devices; rupture discs being the most popular of this type of device. As a calibrated failure component is loaded and unloaded significant reductions in set pressure are experienced. This is why much of the guidance concerning these types of devices advise operating pressure as low as 50% of set pressure.[i]

To address this fatigue issue some in the industry have turned to buckling pin devices. A buckling pin device opens when the pin buckles versus completely fails. When designed correctly the buckling force can be set below the fracture limit of the material. Although the pin still experiences the cyclic loading and associated fatigue effects from the normal operating conditions, any drift in the force required to fracture does not affect the set pressure until the fracture force drifts below the buckling force and causes an early failure.

ACCU-SHEAR SOLUTION

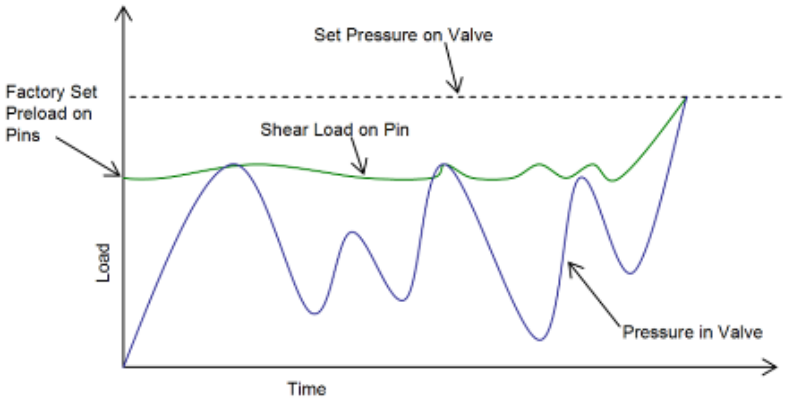
The Accu-Shear solution was made by re-evaluating the problem and determining that rather than avoiding some of the effects of fatigue on the set pressure we could stop them with a pre-load system. Much like bolts are pre-loaded to dramatically extend fatigue life our shear pin is preloaded as well. The pre-load also serves other purposes such as maintaining the required seal and retaining the pin while ensuring simple and quick pin replacements.



The motivation for this design change is to allow for simple inline pressure relief devices modeled after a triple offset butterfly valve rather than requiring a 90 degree device or a complicated mechanism to translate the linear buckling motion to a rotary shaft motion. The Accu-Shear device only contains one moving assembly (item 2 below) whose rotation is stopped by the presence of a shear pin. Once the pin shears at a calibrated force assembly 2 rotates to the open position and pressure is relieved.

HOW A PRELOAD WORKS

Fatigue is the result of constant loading and unloading. This cyclic loading slowly expands the microscopic cracks already present in the surface of the material until it reaches a critical failure point below the ultimate strength. In essence it is the *"death by a 1000 cuts"* of the metal. By adding a preload to our device we have essentially insulated the pin from the typical cyclic loading the device will experience. The graph below is meant to serve as an illustration of this point showing the loading that our preloaded pin may experience compared to operational pressure that the pressure relief device experiences.

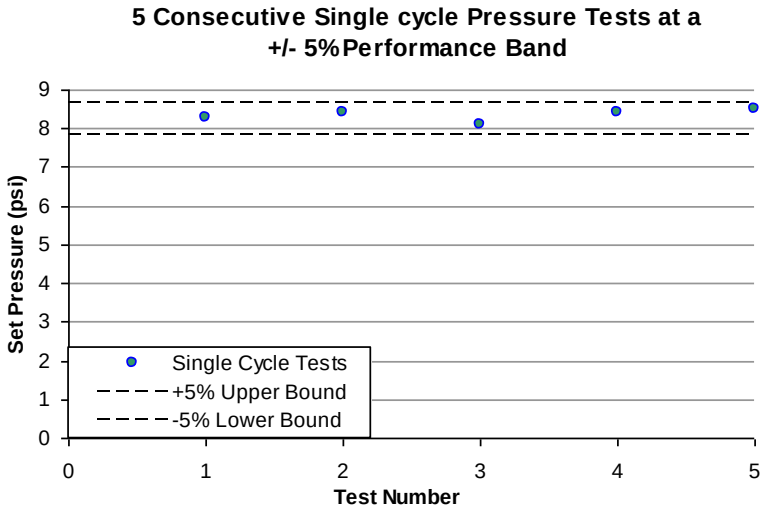


As shown above the insulating nature of the preload keeps the pin loaded at a more constant load above most operational pressure induced loads. This keeps the microscopic surface imperfections on the pin surface from 'fatigueing' into larger cracks that would cause our set pressure to drift as for rupture discs but without the added complexity and cost of a buckling pin device.

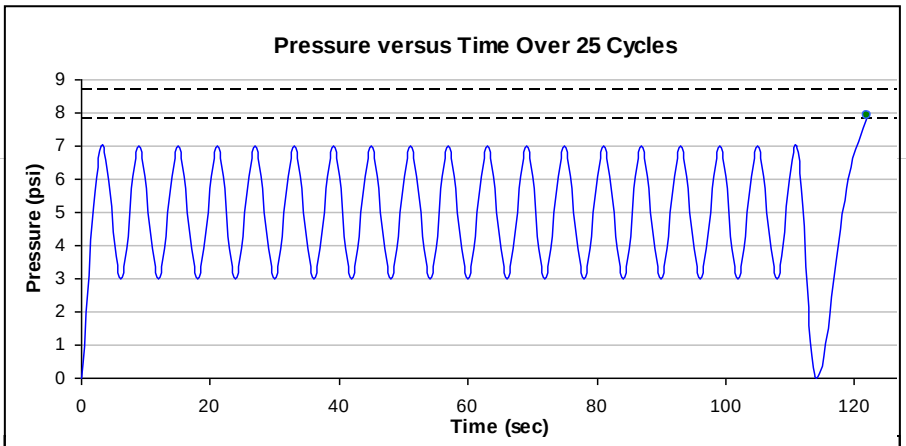
CASE STUDY OF A 10" ACCU-SHEAR DEVICE

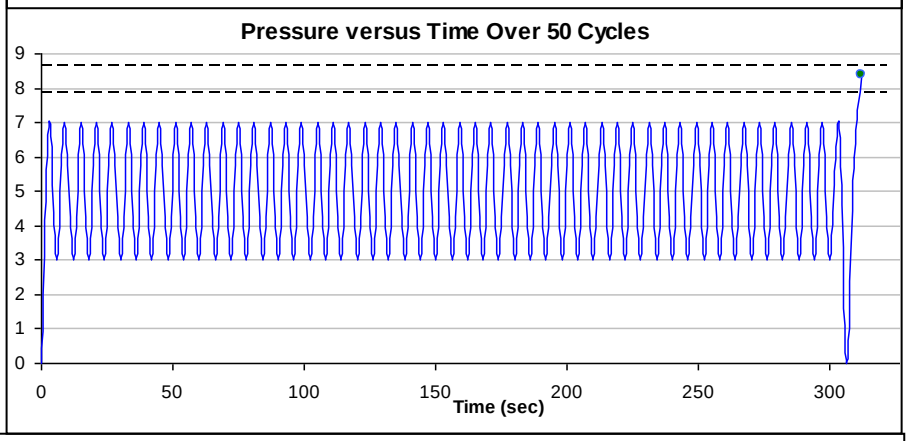
A 10 inch Accu-Shear Device is set to an opening pressure 8.25 psi and tested 5 consecutive times to establish a baseline for fatigue tests. The chart at the right shows the results of these five single cycle tests all fall within the typical set pressure tolerance of +/- 5%.

This same device was then subjected to a series of 25, 50 and 100 cycle tests between 7 psi and 3 psi, 89% and 38% of the minimum acceptable set pressure, respectively. After the completion of the cycle test the device was then pressured down to zero and a single cycle pressure test was performed. For all three cases the set pressure fell within the 8.25 psi +/- 5% performance band. Illustrative graphs of the three trials are shown below.



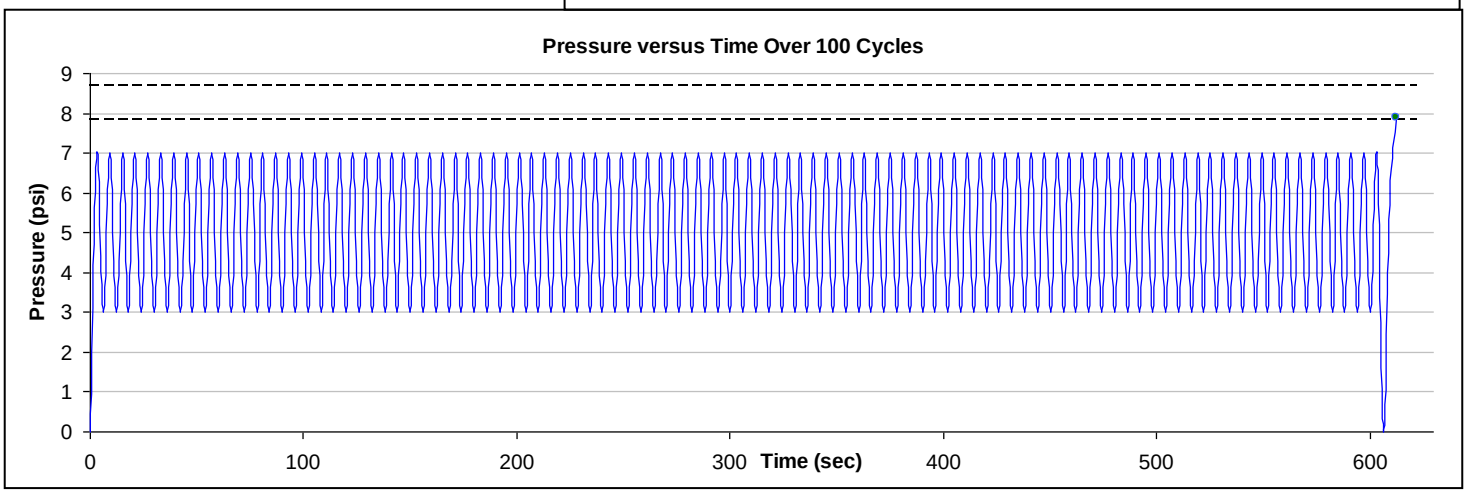
As can be seen in all three of these tests the number of cycles the Accu-Shear device undergoes has no discernable effects on the opening pressure as all three cycle tests resulted in a final set pressure within the +/- 5% tolerance band, identified by the dotted lines on the graphs.





CONCLUSION

By utilizing a long practiced method of preloading to eliminate the effects of fatigue on mechanical devices a pressure relief device can now be reliably and economically manufactured - fully meeting industry's demanding needs. In short, the **ASME certified Accu-Shear** pin device is a major step forward and should be used in all critical large diameter pressure relief applications.



[i] Instrument Engineers' Handbook, Fourth Edition, Volume One: Process Measurement and Analysis, Bela G. Liptak CRC Press, Jun 27, 2003 p. 1018