

# Gravity Offload Tool for PIP-II

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## Purpose

The Accelerator Division found it was difficult to adjust the current vertical struts on the PIP-II cryomodules.

## Hydraulic Test

~insert data found~

The Tech Department has assisted in an experiment to measure the spring constant of the current hydraulic cylinders used at Fermilab.

## Methods

The charts below were used to determine the combined spring constant for each potential Gravity Offload Tool. This data concluded that the pneumatic cylinder was softer than the disc springs, and therefore not ideal. The hydraulic cylinder, however, proved to be stiffer than the disc springs.

	spring constant (lbs/in)	spring 1 (cyl)	spring 2	# of springs
ideal spring + pneumatic	1076.271186	1500	3810	NA

	spring constant (lbs/in)	spring 1 (cyl)	spring 2	# of springs
disc spring1 + pneumaticH16	914.9830667	1000	10762.36264	26
disc spring1 + pneumaticH17	870.4266035	937.5	12166.14907	23
disc spring1 + pneumaticH18	830.0081218	882.3529412	13991.07143	20
disc spring1 + pneumaticH19	790.934787	833.3333333	15545.63492	18
disc spring1 + pneumaticH20	757.4195211	789.4736842	18654.7619	15

Fig 1: Top: Ideal Spring & Pneumatic. Bottom: Pneumatic Cylinder & Disc Springs

	spring constant (lbs/in)	spring 1 (cyl)	spring 2	length (in)	# of springs
disc spring1 + hydraulicH29	17144.29305	870228	17488.8393	20.992	16
disc spring2 + hydraulicH29	11836.77689	870228	12000	20.98	20
disc spring3 + hydraulicH29	43367.77595	870228	45642.3611	20.844	12
disc spring4 + hydraulicH29	15489.60485	870228	15770.3081	21	17
disc spring5 + hydraulicH29	9795.461816	870228	9906.97674	20.685	15

Fig 2: Hydraulic Cylinder & Disc Spring

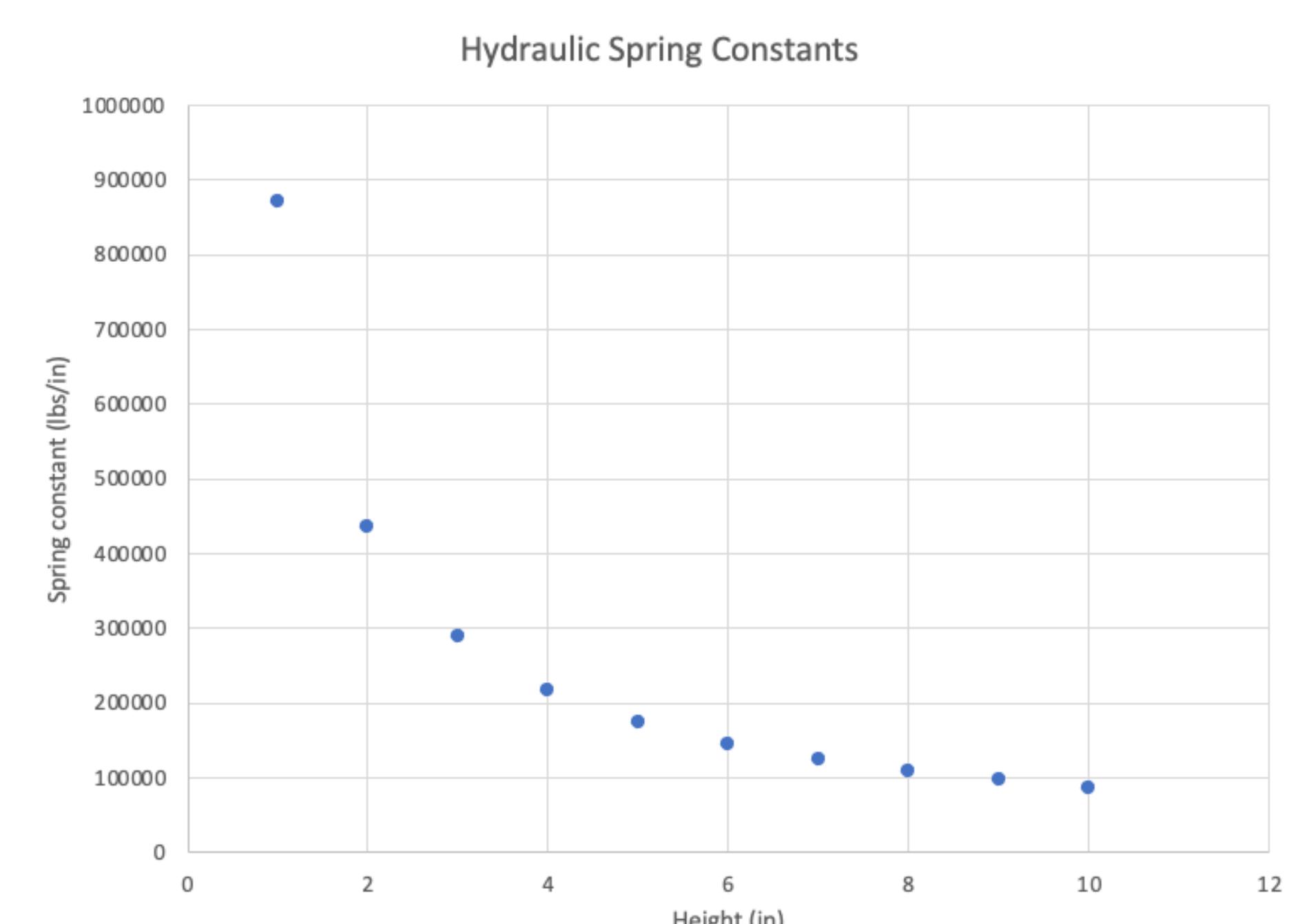
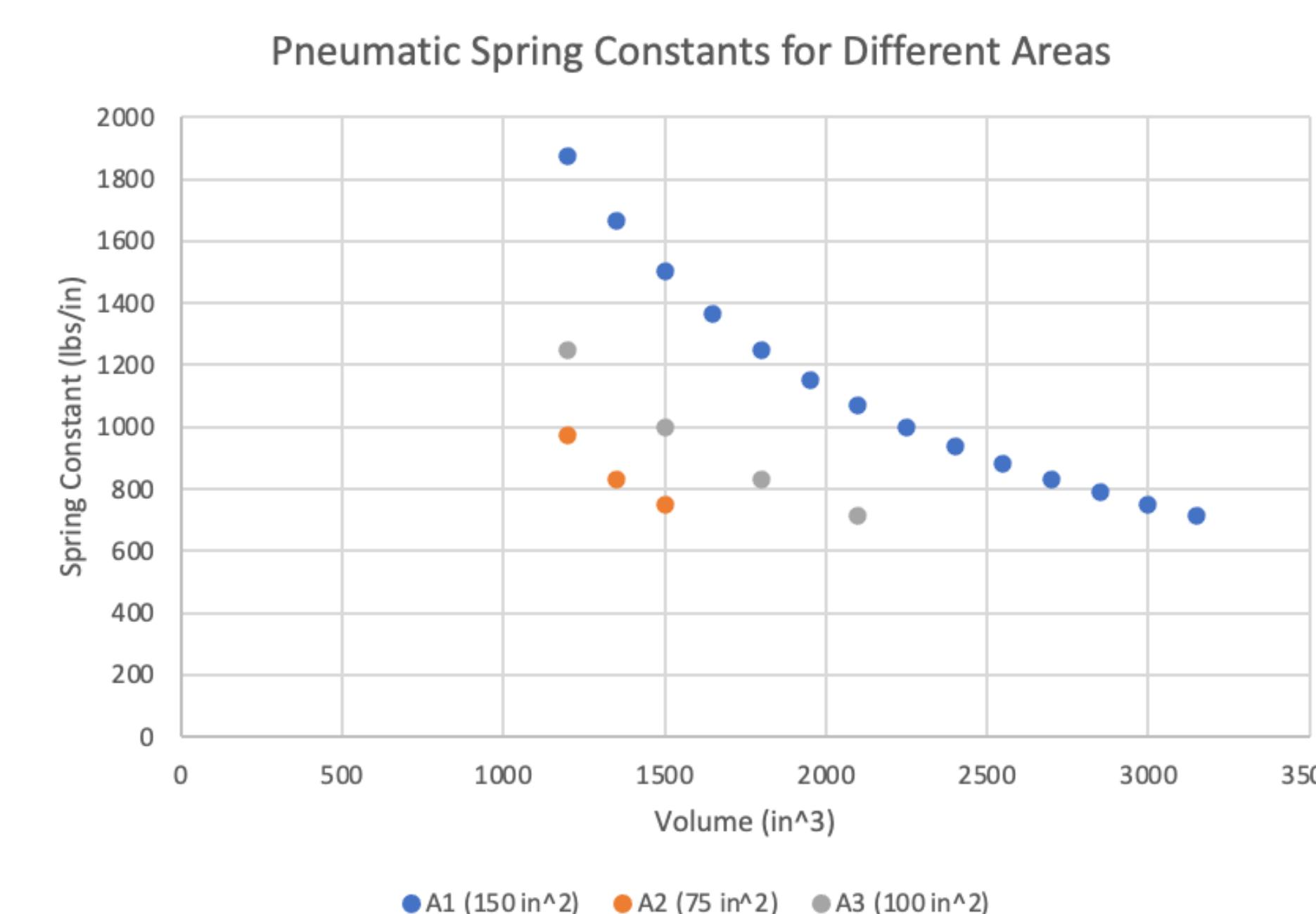
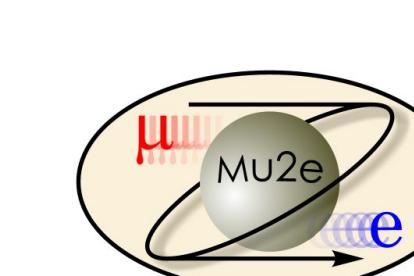
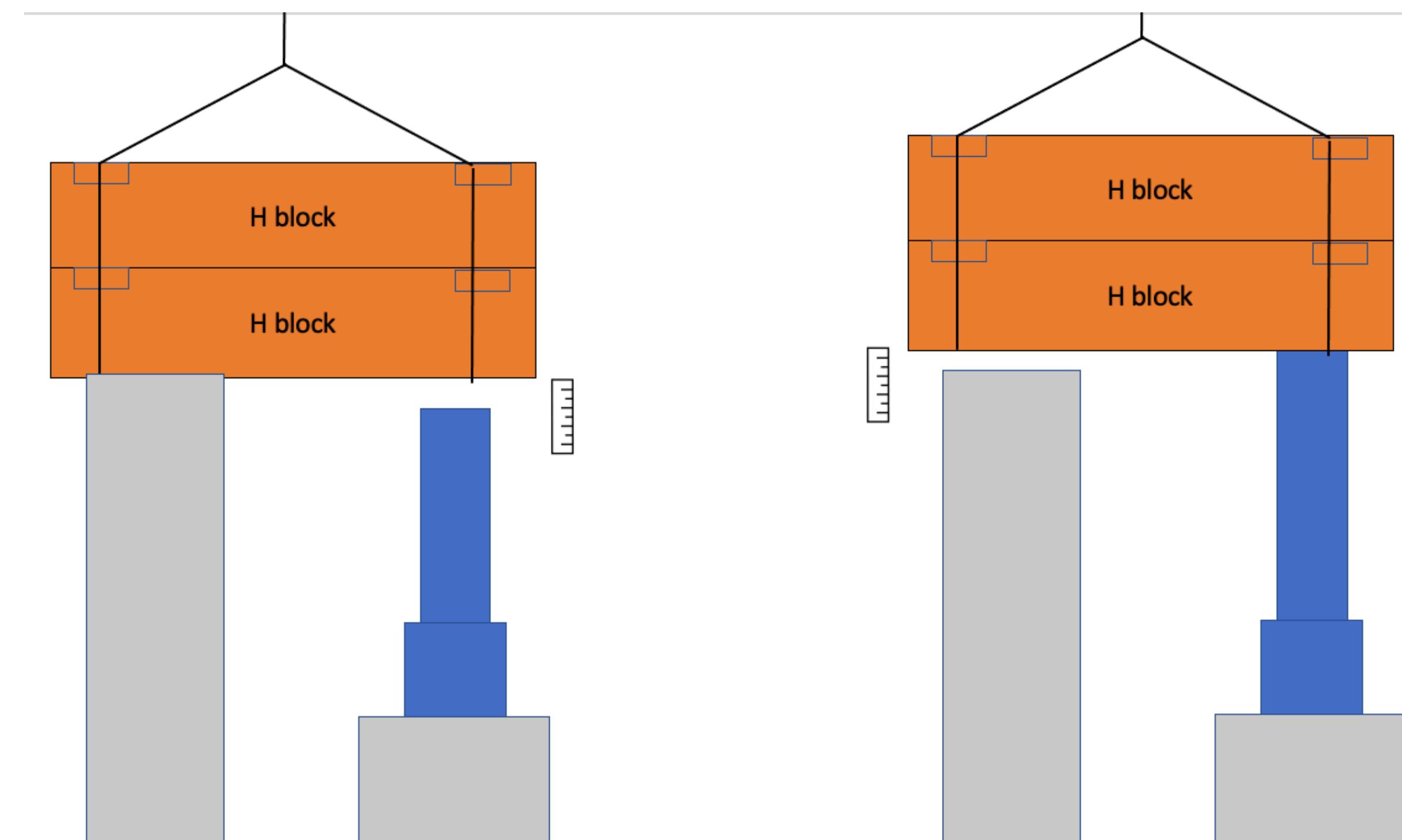


Fig 3: Top: The relationship between the pneumatic spring constant and its volume.  
Bottom: The relationship between the hydraulic spring constant and its height.



## Concept Design

This Gravity Offload Tool will include a hydraulic cylinder and 15-disc springs and will be compressed and held together with a plunger.

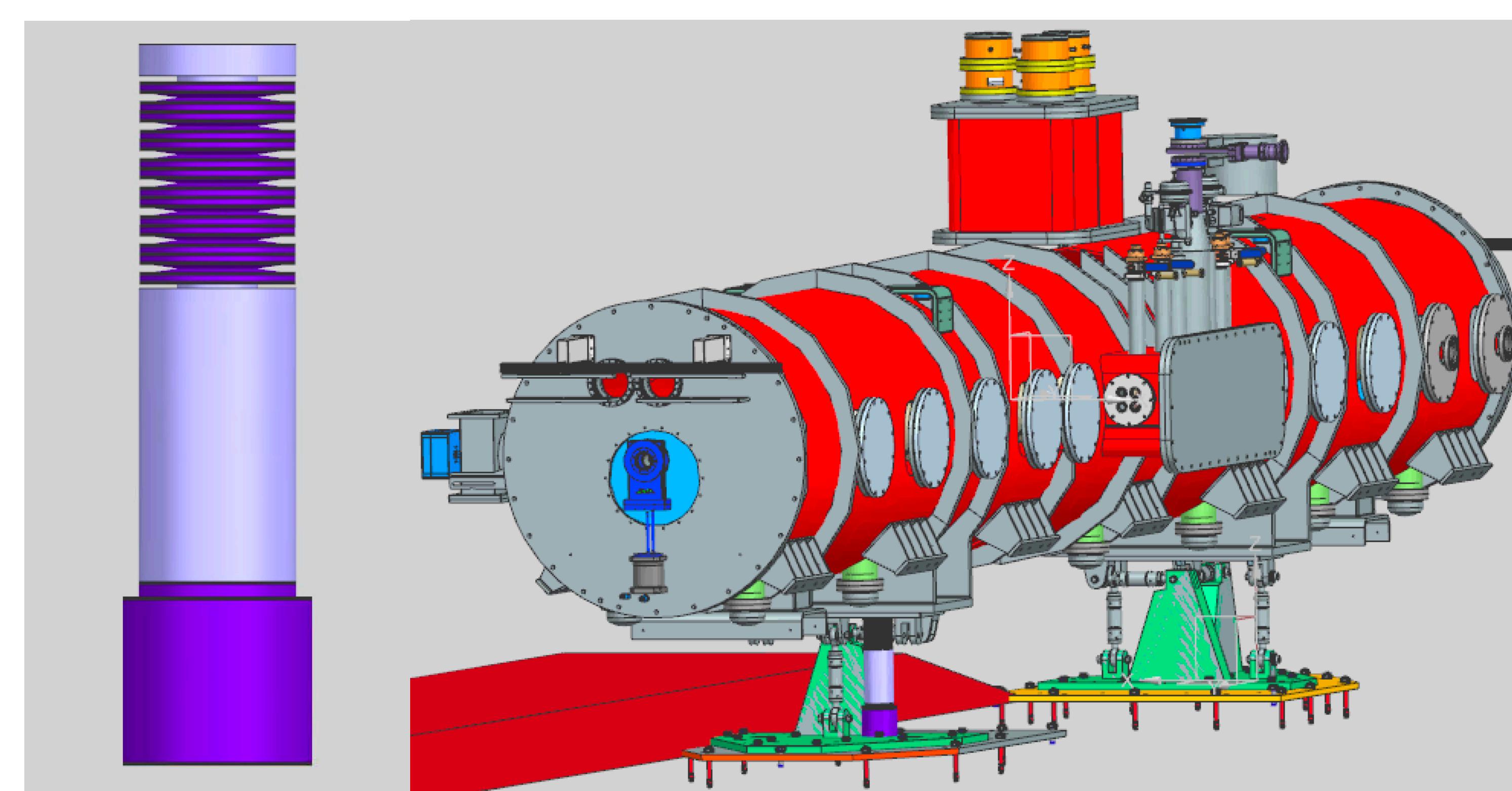


Fig 5: NX 3D CAD Models of the Hydraulic Cylinder & Disc Spring System