5-7-2017

Characterization of silicone tubing – Effect of pressure and irradiation on tubing diameter

Lise Tan-Sien-Hee
DOW CORNING, Belgium, lise.tan_sien_hee@dowcorning.com

Csilla Kollar
DOW CORNING, Belgium

Andrew Diehl
DOW CORNING, Belgium

Ernie Jenness
MilliporeSigma Corporation

Pietro Perrone
MilliporeSigma Corporation

Characterization of silicone tubing: The effect of pressure and irradiation on tubing diameter

Pietro Perrone and Ernie Jenness, MilliporeSigma
Csilla Kollar, Andy Diehl and Lise Tan-Sien-Hee, Dow Corning

Introduction

Single-use assemblies or systems consist of numerous flexible components connected together via heat seals, overmolds or mechanical fasteners. To reduce the probability of leaks during operation, it is important to consider how the tubing expands at the connection points when exposed to pressure. The expansion characteristics of the tubing diameter should be assessed when designing connections. The aim of the study was to characterize four different tubing types under various pressure conditions before and after gamma irradiation. Assemblies that retain their integrity at operating pressures depend on robust connections between the expanding tubing, the barb fittings and the placement of fasteners.

Materials & Methods

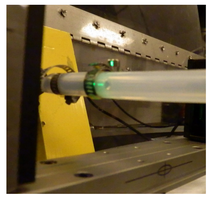
Tubing: Nominal 1/4 inch in ID (internal diameter), 1/2 inch in OD (outer diameter)

Tubing type: Pump, 50, 65 and 80 durometer tubing (Shore A hardness)

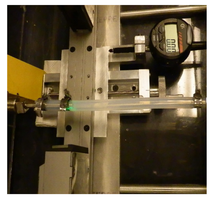
Displacement gauge with laser micrometer system combined with a tubing pressurization system. The irradiated tubing was exposed to gamma irradiation of 27-35 kGy. The inner lumen of the tubing was pressurized up to 1/3 of the measured burst pressure. The pressure was kept the same for both gamma irradiated and non-gamma irradiated tubing.

Experimental Setup

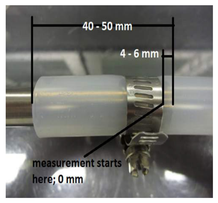
A movable laser micrometer system was fitted to the pressurized system. The laser micrometer allowed for measurement of the outer diameter without making contact with the tubing.



Position of the tubing relative to laser head



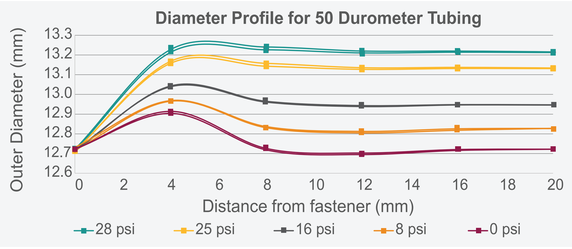
Displacement gauge and laser micrometer

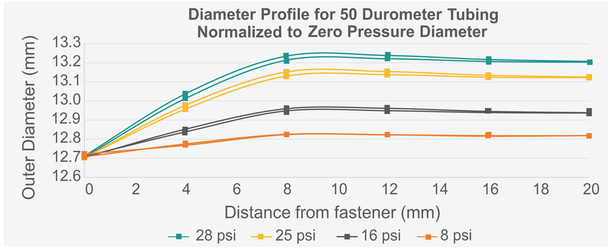


Connection of tubing and fitting

Observations & Results

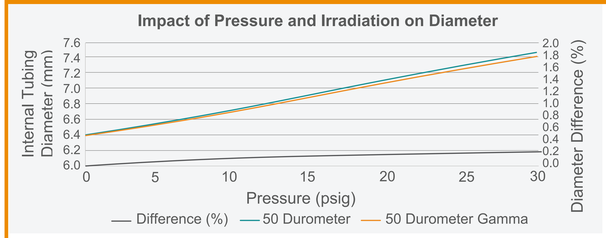
The typical tubing outer diameter profiles for 50 durometer tubing sample is shown on the charts below. The second chart exclude the fastener effect via normalizing the outer diameter by the profile experienced at zero pressure.

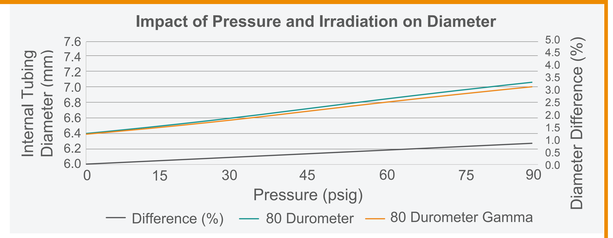




The hysteresis observed indicates the small impact of time on the expansion of the tubing especially at higher pressures. While the outer diameters are readily measured, the internal tubing diameter characteristics are of most interest, as that's where the tubing contacts the barb fitting. The balance of the graphs is based on the internal diameter.

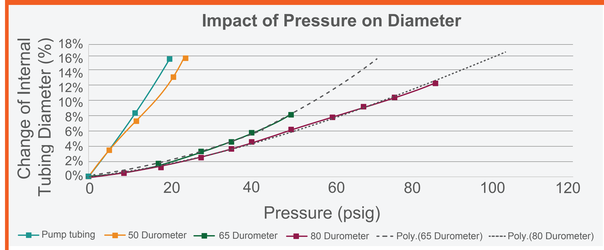
Irradiation Impact

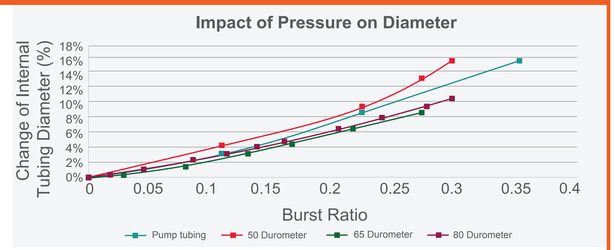




The results above highlight that the impact of irradiation is minor on the expansion of the tubing when exposed to pressure.

Pressure Impact





The two charts above show the percent change in the internal diameter increase for each tubing type vs. applied pressure and burst ratio. When the change in diameter data is plotted against the tubing burst ratio, there is alignment of the expansion between the various tubing durometers. Burst ratio = measured pressure/burst pressure of the tubing. Using the burst ratio metric, allows one to assess the diameter expansion relative to a proportionally equivalent stress level applied to the tubing independent of durometer characteristics.

Conclusions

Expansion of the internal tubing diameter of up to 15% was observed as the internal pressure increased. While irradiation of the tubing generally makes it stiffer and less likely to expand, this effect was minor. For all tubing durometers the difference in diameter expansion before and after irradiation was under 2%. The integrity (e.g. leak assurance) of single-use systems is dependent on the internal surface being continuously sealed and free of disconnects between the various components. The diameter of the flexible tubing is a key factor in achieving an integral single-use assembly both during its manufacture and at the higher operational pressures. Understanding and designing assemblies considering these factors can help produce single-use assemblies that maintain their integrity throughout their use at operating conditions.

30024284
Form No. 52-1266-01