Constant-Differential-Pressure Two-Fluid Accumulator

**An improved design does not rely on the spring rate of the accumulator tank.**

John H. Glenn Research Center, Cleveland, Ohio

A two-fluid accumulator has been designed, built, and demonstrated to provide an acceptably close approximation to constant differential static pressure between two fluids over the full ranges of (1) accumulator stroke, (2) rates of flow of the fluids, and (3) common static pressure applied to the fluids. Prior differential-pressure two-fluid accumulators are generally not capable of maintaining acceptably close approximations to constant differential pressures.

The inadequacies of a typical prior differential-pressure two-fluid accumulator can be summarized as follows: The static differential pressure is governed by the intrinsic spring rate (essentially, the stiffness) of an accumulator tank. The spring rate can be tailored through selection of the tank-wall thickness, selection of the number and/or shape of accumulator convolutions, and/or selection of accumulator material(s). Reliance on the intrinsic spring rate of the tank results in three severe limitations:

(1) The spring rate and the expulsion efficiency tend to be inversely proportional to each other: that is to say, as the stiffness (and thus the differential pressure) is increased, the range of motion of the accumulator is reduced.

(2) As the applied common static pressure increases, the differential pressure tends to decrease. An additional disadvantage, which may or may not be considered limiting, depending on the specific application, is that an increase in stiffness entails an increase in weight.

(3) The additional weight required by a low expulsion efficiency accumulator eliminates the advantage given to such gas storage systems. The high expulsion efficiency provided by this two-fluid accumulator allows for a lightweight, tightly packaged system, which can be used in conjunction with a fuel-cell-based system.

The design of the present two-fluid accumulator does not rely on the intrinsic spring rate of an accumulator
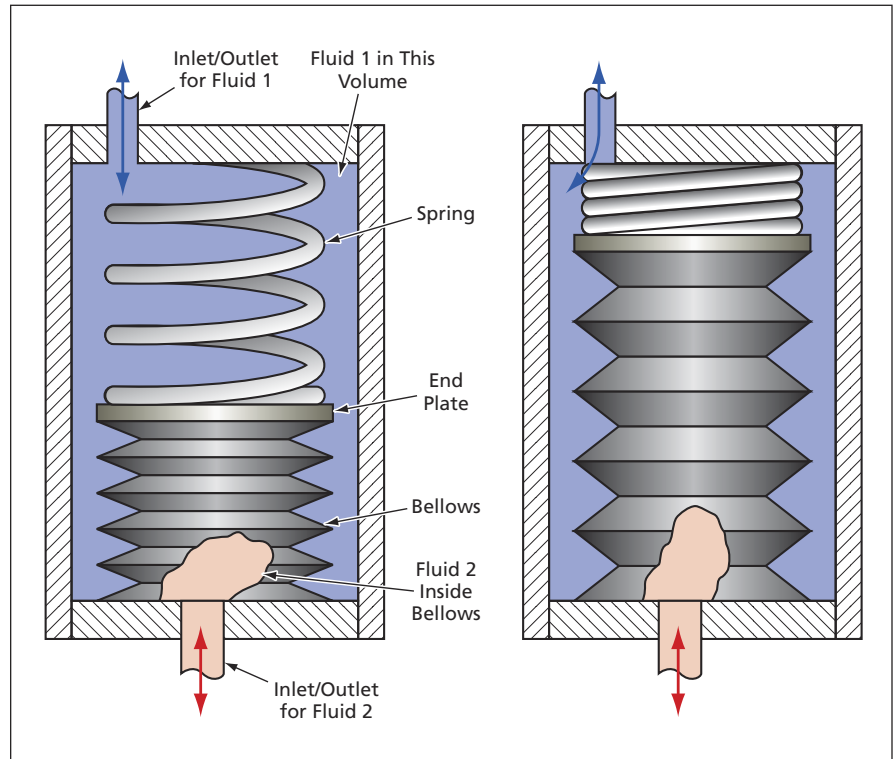
The **Spring Exerts an Approximately Constant Force** on the bellows throughout the stroke range, thereby maintaining approximately constant differential pressure between fluids 1 and 2.

tank to establish the differential pressure. Instead, the accumulator tank is a relatively rigid cylinder, within which is placed a bellows that separates the two fluids. A constant-force spring pulls on the end plate of the bellows, as though the end plate were a piston. This spring action, applied over the area of the end plate, results in the desired differential pressure. The differential pressure can closely approximate a constant value because the constant spring force is at least an order of magnitude greater than the spring rate of the bellows. As a result, for challenging differential pressures below 5 psi (34.5 kPa), this new design can achieve a stroke that permits greater than 75 percent expulsion efficiency with an absolute operating pressure as high as 2,400 psig (≈16.6 MPa) and maintain the differential pressure within 10 percent of the nominal. The

separate spring assembly also permits the differential pressure to be customized with whatever constant-force springs can be manufactured. The outer cylindrical housing can be made of a number of lightweight materials as the application requires. An example of prior art had 50 percent variability in differential pressure over a short stroke that permitted less than 10 percent expulsion efficiency with an absolute operating pressure of only 150 psig (≈1.14 MPa).

This work was done by Benjamin Piecuch and Luke T. Dalton of Proton Energy Systems, Inc. for Glenn Research Center.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18133-1.