EARTHQUAKE PROTECTIVE SYSTEMS FOR BUILDINGS, BRIDGES, AND OTHER STRUCTURES . . .

Taylor Devices, Inc. has been the leader in shock and vibration technology since 1955. Now, we have boldly stepped into the forefront of one of civil engineering's greatest challenges: Seismic protection of buildings, bridges, historical structures, and even residential dwellings. Extensive research has been conducted in a joint effort with the National Center for Earthquake Engineering Research (NCEER), located at the State University of New York at Buffalo. A practical approach has been developed for dissipating energy from a structure by the addition of Taylor Devices' unique Fluid Viscous Dampers. The most noteworthy features include a maintenance-free design proven by years of usage by the Military, "fail-safe" construction which insures safe operation for the life of the building or bridge, and significantly lower cost than conventional methods. Taylor Devices' Fluid Viscous Dampers can be incorporated into a newly designed structure or retrofit to existing structures to extend their ability to survive seismic events. The linear output of these devices allows ease in structural analysis using existing software codes.

This data book includes answers to the questions most frequently asked about the use of viscous damping in a structure. Application and sizing information is also provided. For more information about a custom designed seismic protection system for your specific application, please do not hesitate to contact us at our factory. Our staff of highly qualified experts is ready to help you.

taylor devices inc.

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Taylor Devices' Fluid Viscous Dampers for Buildings and Bridges

You can now protect almost any new or existing structure against earthquakes....simply and inexpensively. Taylor Devices' Fluid Viscous Dampers provide complete protection for buildings, bridges, towers, elevated freeways; virtually any structure that is subject to earthquake damage. You can also protect sensitive equipment inside your building, like computers and generators.

These dampers literally soak up the energy of earthquake induced motion, preventing structural damage. Compact, yet powerful; Taylor Fluid Viscous Dampers increase structural damping levels to as much as 50% of critical, the results being truly dramatic stress and deflection reduction.

Based on aerospace technology developed for the MX Missile and Stealth Bomber, these dampers have been proven in extensive tests at the Multidisciplinary Center for Earthquake Engineering Research (MCEER) at the State University of New York at Buffalo. These tests clearly proved that these remarkable devices will protect structures against any probable earthquake at a substantial cost savings.

Here is what you get when you specify Taylor Fluid Viscous Dampers:

Ú **Substantial stress reduction – greatly enhanced damping lowers both stress and deflection throughout a structure. This allows the structure to remain elastic during any seismic event.**

Ú **Easy to model with existing codes – these dampers are completely viscous in output and will simply and efficiently raise structural damping to 20%–50% of critical, versus 1%–3% for a typical undamped design.**

Ú **Easy installation – saving valuable time and materials. A wide range of compact sizes with linear or non-linear damping are readily available, to reduce installation cost.**

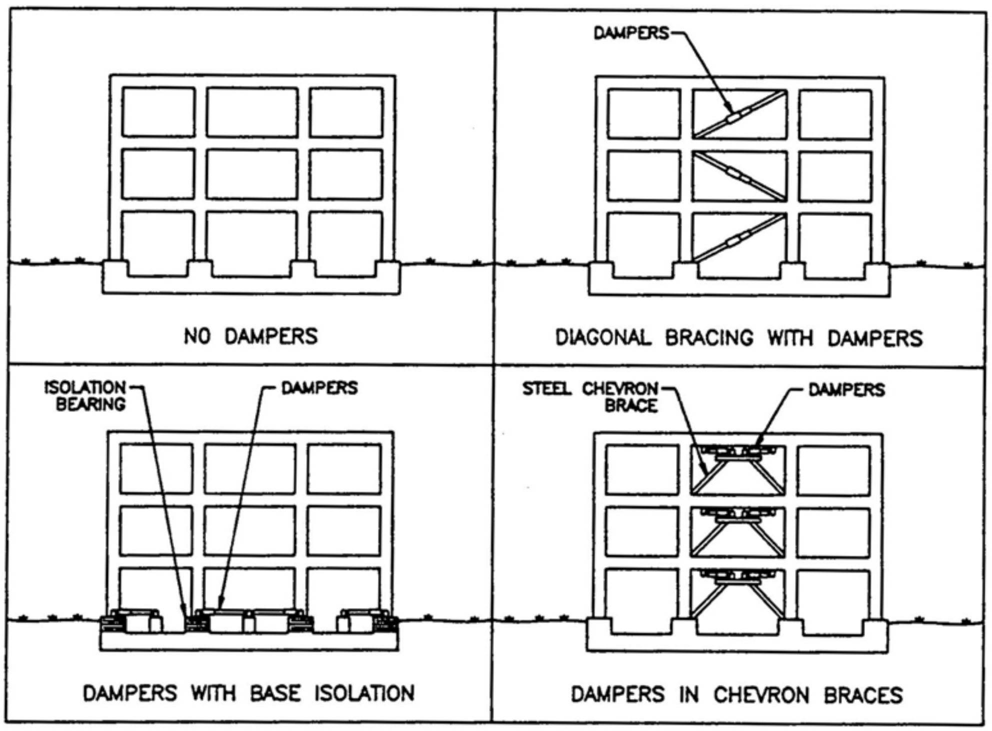
Ú **Peace of mind – totally passive dampers for extreme reliability, no dependence on outside energy sources.**

Ú **Worry-free operation – no maintenance ever. Taylor Devices' exclusive modular design uses a minimum number of moving parts. Patented seal has a history of over 50+ years of successful performance on demanding applications. Completely self-contained; no refilling, no leakage, no problems.**

- **Environmentally proven output – thermostatically controlled, virtually unaffected by temperatures from -40 degrees F to +160 degrees F. Nonflammable inert fluid and stainless steel piston rods standard on all models.**

- **Simple to apply – these dampers are truly viscous; their response is out of phase with structural stresses. Available in sizes of 10 kip to 2000 kip.**

Seismic Design is Easy with Taylor Fluid Viscous Dampers



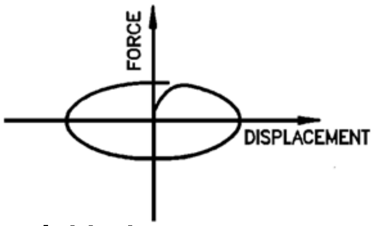
Commonly Asked Questions and Answers About Taylor Devices' Fluid Viscous Dampers

Q: Taylor Fluid Viscous Dampers are very compact, how can such a physically small product help a large building or bridge to be more survivable during an earthquake?

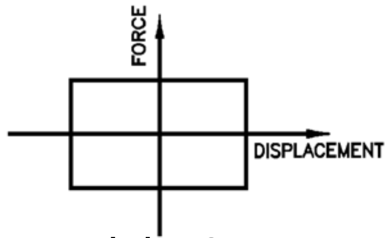
A: With most structures, a relatively small amount of damping provides a large reduction in stress and deflection by dissipating energy from the structure. For example, with an automobile suspension, the damper, or shock absorber, is used to control the motion of the springs. The damping forces required are quite small compared to the springs, which must support the vehicle and deflect under bump loadings. A similar situation exists with a building where the spring forces are supplied by the building columns or base isolators which both support the building and deflect under load. It requires only a small amount of viscous damping force to reduce building deflection by a factor of two or three while simultaneously reducing overall column stresses.

Q: How can Taylor Fluid Viscous Dampers reduce building deflection and stress at the same time? If we use dampers to limit the deflection, won't this increase the load into the building columns?

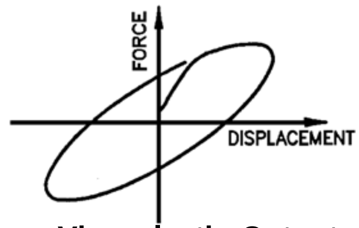
A: Fluid Viscous damping reduces stress and deflection because the force from the dampers is completely out of phase with stresses due to flexing of the columns. This is only true with fluid viscous damping, where damping force varies with stroking velocity. Other types of damping products such as yielding elements, friction devices, plastic hinges, and visco-elastic elastomers do not vary their output with velocity; hence they can, and usually do, increase column stress while reducing deflection. Consider a building shaking laterally back and forth during a seismic event. Column stress is at a maximum when the building has flexed a maximum amount from its normal position. This is also the point at which the flexed columns reverse direction to move back in the opposite direction. If we add a Fluid Viscous Damper to the building, damping force will drop to zero at this point of maximum deflection. This is because the damper stroking velocity goes to zero as the columns reverse direction. As the building flexes back in the opposite direction, maximum damper force occurs at maximum velocity, which occurs when the column flexes through its normal, upright position. This is also the point where column stresses are at a minimum. It is this out of phase response that is the most desirable design aspect of fluid viscous damping.



Fluid Viscous Output



Friction Output



Viscoelastic Output

Q: How much damping is needed?

A: A typical building normally has internal structural damping of 1 to 3 percent of critical. Optimal performance of a building with fluid viscous damping is achieved with added damping in the range of 20 to 25 percent of critical. Again, using the comparison with an automobile, most conventional autos use dampers with 20 to 30 percent of critical damping. Experiments with building models have indicated additional improvements with damping increased to as much as 50 percent of critical, but eventually the gain goes past the point of diminishing returns from the point of damper cost.

Q: We are not located in an area of seismic activity, why should we be interested in dampers?

A: Fluid Viscous Dampers are also very effective in reducing building deflections under wind loadings without changing the stiffness of the building! In the case of tall buildings, wind motion can also cause complaints of motion sickness and general discomfort from the occupants on higher floors. The motion is similar to an automobile with worn out shock absorbers. Fluid Viscous Dampers can reduce wind deflection by a factor of 2 or 3, greatly reducing occupant discomfort without creating localized stiff sections. New buildings designed with Fluid Viscous Dampers for mitigation of wind motion can be built with reduced lateral stiffness detailing, resulting in a less costly overall structure.

Q: **Why are Taylor Fluid Viscous Dampers better than friction dampers such as sliding joints and plastic hinges?**

A: **There are three major differences between our Fluid Viscous Dampers and friction devices. The primary difference is that the constant force output of a friction damper increases maximum column or pier stress under any deflection of the structure. Fluid Viscous Dampers do not increase column stresses due to their inherent out of phase response output.**

The second difference is that friction dampers put out an essentially constant force when deflected, independent of velocity. This response causes continual stress in the structure during all thermal expansion and contraction of the structure. Fluid Viscous Dampers put out virtually zero force at the low velocities associated with thermal motion.

The third difference is that friction dampers restrict a structure from restoring itself to its original position after seismic events. Fluid Viscous Dampers allow the structure to re-center itself perfectly at all times.

Q: **How do Taylor Fluid Viscous Dampers compare to visco-elastic devices?**

A: **Visco-elastic devices have an output that is somewhere between that of a damper and a spring. Under high level seismic inputs, the spring response dominates, producing a response that increases column stresses at any given deflection. This does not happen with Fluid Viscous Dampers.**

One of the most serious problems with visco-elastic devices is an unacceptable increase in force at low temperatures coupled with an accompanying overloading of the bonding agent used to "glue" the visco-elastic material to its steel attachments. At high temperatures, unacceptable softening or reduction of output occurs. This thermal variance from high to low temperature can be in the range of fifty to one.

In comparison, Taylor Fluid Viscous Dampers include a bi-metallic orifice which acts like a thermostat to provide uniform performance over a temperature range of -40 degrees F to +160 degrees F. This excellent thermal stability is combined with all steel construction, having internally threaded joints and no welded or bonded parts.

Q: **Do you have any life test data on your dampers, particularly the seals?**

A: **Taylor Devices has been building Fluid Viscous Dampers continuously since 1955. Taylor products do not use commercially available seals, but instead rely on our own proprietary machined seal design using high strength structural polymers rather than soft elastomers. This seal design does not degrade with age, and we have test units that date back to 1955 that operate perfectly today with no leakage and no refilling or seal changes of any type needed. Equally important to our seal design is our piston rod construction. All Taylor Devices' piston rods are made from solid stainless steel using aircraft quality material only. Each rod is hand finished to a mirror-like finish of less than 2 micro-inch surface roughness, then microscopically impregnated with Teflon® by a proprietary process. The long term corrosion resistance of this design has been proven in literally thousands of severe applications in steel mills, smelters, and chemical plants. In addition, our products have been applied to literally hundreds of military applications on ships, aircraft and missiles. Our total production of fluid viscous energy absorbers exceeds two million units.**

Q: **How do we go about sizing Taylor Fluid Viscous Dampers for an application?**

A: **Most structural engineering software allows for the use of viscous equivalent damping to simulate structural damping. All Taylor Fluid Viscous Dampers have an output identical to this model. Instead of running your simulation with the normal 1 to 3 percent structural damping, you can elevate these values to 20 to 50 percent of critical. This will give a tremendous improvement in seismic behavior, greatly reducing both stress and deflection.**

All we need to select the damper that satisfies your requirements is to be given the value of the required damping constant, the velocity exponent, and the maximum translational velocity of the damper. In a viscous damping model, the output of the damper is:

$$F_{damper} = C*V^{\%}$$

Where	**C**	**=**	**damping constant (lb*sec/in)**
	V	**=**	**velocity (in/sec)**
	%	**=**	**velocity exponent (0.3 # % # 1.0)**

Once performance requirements have been satisfied using linear damping (% = 1.0), further refinement can be evaluated with lower velocity exponents.

Q: **What type of mountings should be used?**

A: **Taylor dampers are available with either threaded stud mounting, clevis type mounting, and/or base plate mounting. The clevis mounts include a spherical insert bearing. The clevis mounts are normally used on bridges, base isolated structures, in chevron bracing, or on any application with more than plus or minus 2 inches of stroke. Base plate or threaded stud mounting is generally used with diagonal bracing.**

Q: **What are Taylor's materials of construction?**

A: **All Taylor Fluid Viscous Dampers utilize solid stainless steel piston rods, hand polished to a mirror-like finish, and Teflon® impregnated. Our seal has a history of over 40 years of use and is patented. For long stroke applications, the piston rod is protected against bending by a heavy walled external guide sleeve. The cylinder, end cap and sleeve are constructed of alloy steel and corrosion protected by painting, cadmium plating, or chrome plating. Stainless steel construction is available for all external parts as an option, and is recommended for bridge use or outdoor service.**

Q: **What is Taylor's operating fluid?**

A: **The operating fluid used in a Taylor Fluid Viscous Damper is a silicone fluid, manufactured in accord with U.S. Federal standards, and is cosmetically inert per U.S. FDA standards. Flashpoint of the silicone oil is in excess of 600 degrees F, thus classified as nonflammable and noncombustible under U.S. OSHA standards. This silicone fluid is a pure fluid polymer that cannot settle-out or break down into components. Potential oxidation is prevented by permanently sealing the silicone fluid volume inside the damper.**

ENGINEERING DATA AND SPECIFICATIONS

- Taylor Devices' Fluid Viscous Dampers have a successful history of more than 40 years of use by the U.S. Government and U.S. heavy industry. Taylor Devices has produced over two million Fluid Viscous Dampers since 1955, designed and manufactured at a single manufacturing site in North Tonawanda, NY, U.S.A.

- Pressure cylinders and end caps of all dampers are machined from alloy steel billet, internally threaded, and through hardened. All Taylor Devices' damper cylinders are rated and proof tested to a minimum burst pressure of 20,000 psi, per U.S. Government standards. No failure prone tie rods, welds, castings or gaskets are used in any Taylor Devices' product, providing the most compact and reliable damping device available.

- All piston rods are machined from type 17-4 PH stainless steel billet, through hardened, hand polished to a mirror-like 2 micro-inch surface finish, and Teflon® impregnated by a proprietary process.

- All dynamic pressure seals are exclusively manufactured and patented by Taylor Devices, and are machined from billets of structural polymer. Our seals are non-elastomeric, therefore no periodic seal changes or seal exercising is required.

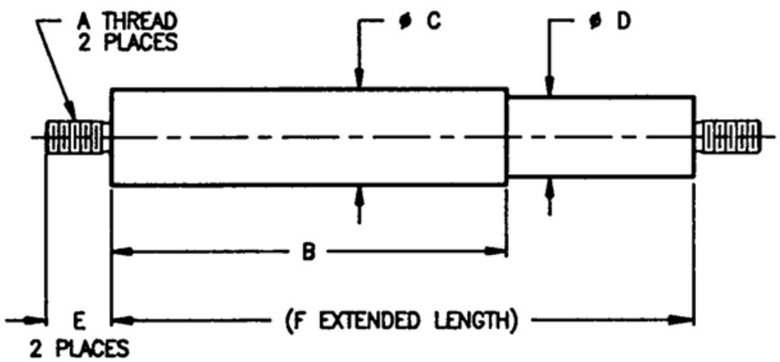
- Operating fluid is inert silicone, manufactured per U.S. Federal standards, environmentally safe, and cosmetically inert. This fluid is formulated exclusively for Taylor Devices, and is rated non-flammable and non-combustible under OSHA regulations.

- All damper internal flow passages are of the non-clogging, annular discharge type. Orifices are solid state fluidic type, passively temperature compensated, with no moving parts, springs, poppets, or spools. Operating temperature range is -40 degrees F to +160 degrees F.

- All Taylor Fluid Viscous Dampers are built to be maintenance free. No reservoirs, external plumbing, fluid level indicators, accumulators, or periodic fluid changes are needed. Thus, all users benefit from our 50+ years of experience in designing and manufacturing fluid damping products.

- Each Taylor Fluid Viscous Damper is individually tested to customer specified maximum forces and velocities prior to delivery.

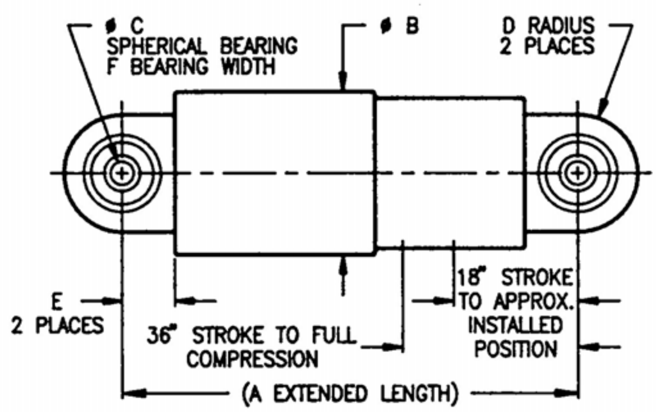
Fluid Viscous Dampers, 10 kip to 30 kip Output



Dimensional Data

MODEL	STROKE INCHES	WEIGHT POUNDS	A THREAD INCHES	B INCHES	C INCHES	D INCHES	E INCHES	F INCHES
10 KIP	4	20	1" - 8 UNC	11.9	3.0	2.5	2.0	17.5
20 KIP	5	40	1½" - 8 UNC	12.7	4.0	3.4	2.5	20.5
30 KIP	5	90	1¾" - 8 UNC	14.1	5.0	4.4	3.0	22.5

High Capacity Fluid Viscous Dampers, 100 kip to 2000 kip Output



Dimensional Data

MODEL	A INCHES	B INCHES	C INCHES	D INCHES	E INCHES	F INCHES
100 KIP	131	7.5	2.5	3.2	4.75	2.2
200 KIP	132	9	2.75	3.9	5	2.4
300 KIP	138	11.5	3	4.25	5.25	2.7
600 KIP	155	16	6	7.5	10	4.8
1000 KIP	166	23	6	9	14.25	4.8
2000 KIP	180	26	8	11	17	6

NOTE:
Various strokes available, from 2-120 inches. Any stroke change from the 36 inch stroke version depicted changes extended length by three inches per inch of stroke change.

EXAMPLE:
200 K x 10 inch stroke, extended length is 132 inch - 3 (36-10) = 54 inches

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