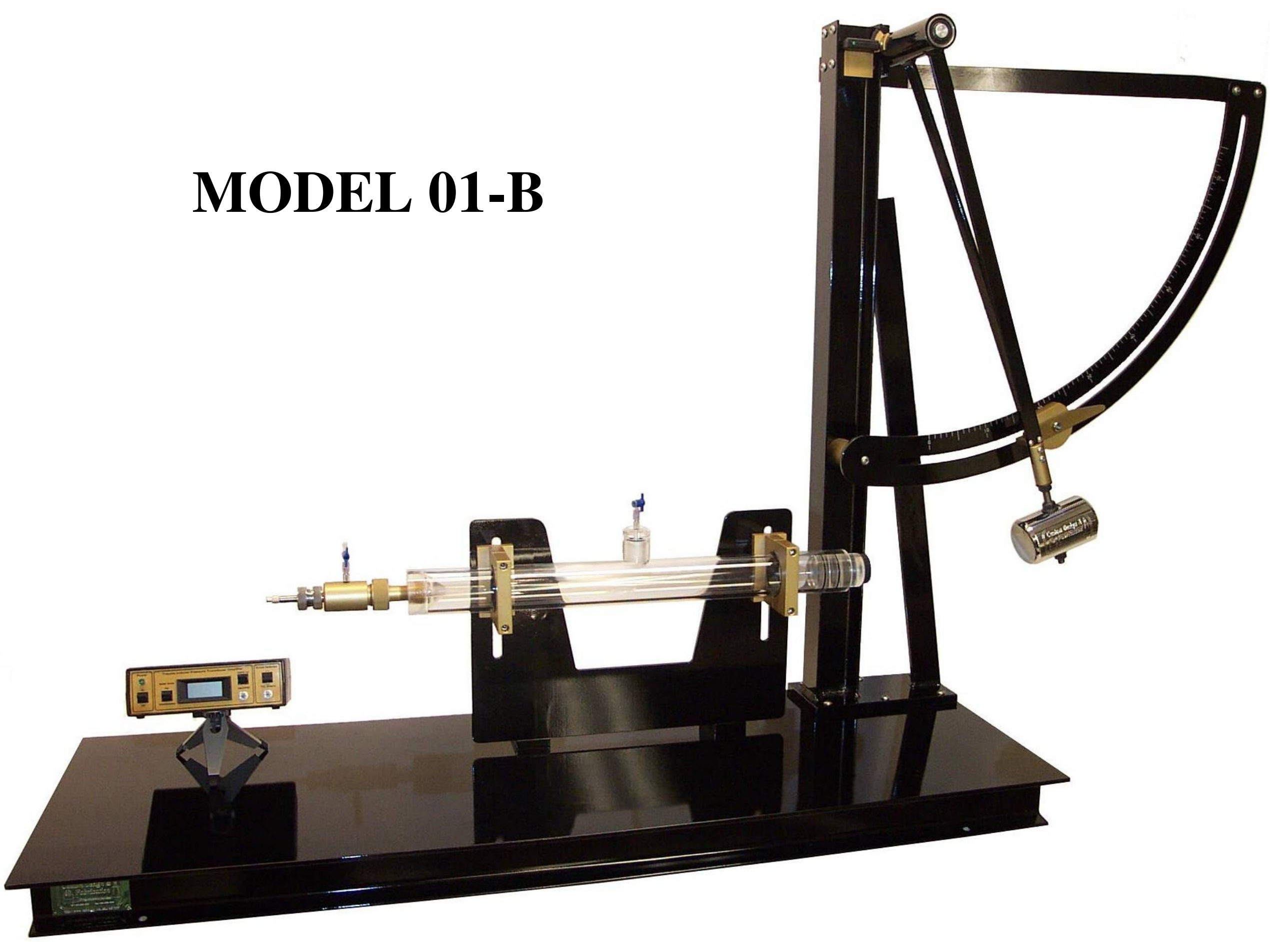
Custom Design & Fabrication Incorporated

*Giving structure to **your** ideas*

Fluid Percussion Injury

MODEL 01-B



General Operation

FPI Model 01-B General Operation

Introduction:

The Fluid Percussion Injury devise Model 01-B is the latest edition of the device originally designed by Humbert G. Sullivan at the Medical Collage of Virginia. The Sullivan device has been the basis for the subsequent production of the FPI and has provided the research community with a consistent and reproducible compression trauma model.

The most notable features new to the latest edition of the FPI are:

- **Powder Coating:** This is a baked on finish that is highly durable and easy to clean.

- **Luer-Lock Ports with Petcock:** These are placed at locations that enhance your ability to remove trapped gases from your system.

- **Engraved Protractor Angle:** Having an accurate standard unit of measure eases the task of documentation and reproduction of your exact system not only throughout your own research but also for independent verification of your results.

- **Calibrated Pressure Output:** The output from the amplifier is 10 mV per PSI with a minimum accuracy of 2%. This accuracy in combination with the 100 PSI Calibration reference completely eliminates the need to provide an external pressure source and record a series of values to correlate your acquisition readings. Eliminating the need to reconfigure for calibration also eliminates introduction of air during this step and the need to once again degas the system.

- **Industry Standard Transducer Mount:** Using a standard 1/4 inch NPT mount assures that you are never likely to have trouble finding a replacement transducer.

Fluid Cylinder Preparation:

For optimum performance the cylinder must be clean, the O-ring seals lubricated with petroleum jelly, and the filled cylinder must be free of trapped gasses. We suggest you perform the steps listed to obtain this objective any time the device has been unused for an extended period of time.

• **Cleaning:** Use a mild detergent, such as dish washing liquid, to clean the cylinder. The addition of a few drops of a wetting agent, such as that used for automatic dishwashing machines, when rinsing will help remove the soap residue and prevent air bubbles from clinging to the cylinder.

• **Lubrication:** Apply a thin coat of petroleum jelly to plunger O-rings and the first quarter inch or so inside the cylinder then replace the plunger. The other O-rings seals do not require lubrication, however, we recommend that petroleum jelly be applied to all of them as it will extend the life of the seals and, more importantly, reduce the amount of trapped air in the system.

• **Fluid Preparation:** The cylinder may be filled with water or other solution as may be required by your procedure. The transducer and cylinder assembly will not be harmed by saline solutions during normal operation, however, long term exposure to electrolytic solutions may pit the anodized aluminum components, so when using saline solutions you should drain and rinse the device when it will not be used for more than a few days.

The quality of the pressure pulse is highly dependent on the removal of trapped air from the system. The following tips will help you obtain a bubble free system:

We highly recommend degassing any fluid before you place it in the cylinder by applying vacuum equivalent to 28 inches of mercury for 5 minutes. This will remove dissolved gasses and prevent bubbles from spawning on the cylinder surface. Some things to be aware of while performing this task are:

1) **Be sure the fluid surface is several inches below the vacuum port.** The fluid will bubble violently as the dissolved gasses escape and could be drawn into the pump.

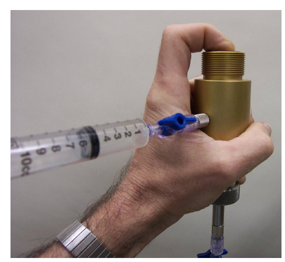
2) Most containers for vacuum are made of glass and will not promote bubble formation. When vacuum is first applied the more volatile gasses will escape quickly and the process will soon appear to be complete, however, a considerable amount of dissolved gas will remain. Tapping on the container with a hard object will provide the necessary stimulus to allow more gasses to escape. While glass does not prompt the gasses to coalesce, unglazed ceramics on the other hand, have a rough surface on the molecular level and will instigate the formation of bubbles allowing the gasses to escape. Placing a boiling chip in the container will therefore eliminate the need for mechanical shock.

• **Filling the Transducer Housing:** The transducer housing is the most difficult portion to remove air from. The various ports provide several locations where air will be trapped that are extremely difficult to remove if not filled separately.

You will need a syringe to perform the tasks that follow, with 10cc being an appropriate size. A 50cc syringe would require less refilling and is more appropriate for the latter steps, but the 10cc syringe will provide higher vacuum and remove air more efficiently.

Begin by placing the fluid cylinder at an angle as shown. This is done to prevent air from reentering the housing once it has been degassed.

Remove the transducer housing from the cylinder and cap the transfer tube. Fill the syringe with your degassed fluid and connect it to the housing's Luer-lock port. Hold the housing with the open end up and slowly inject fluid until the housing is full. Cover the opening with your finger and draw back on the syringe. This will apply vacuum to the housing and expand any air bubbles. Release the syringe plunger, then lift your finger and inject more fluid to fill housing. Repeat this process several times with the housing in different positions to help coax the bubbles to the surface. The objective is to expand the trapped air with vacuum and manipulate the housing to allow a portion of the air to rise to the surface. When normal pressure is restored, fluid will be drawn into the void allowing more air to be drawn out each time. Repeating this process 8 to10 times will remove nearly all the trapped air.



Reattach the housing to the cylinder and you are ready to fill the cylinder.

• **Filling the Cylinder:** The clear acrylic of the cylinder makes degassing straight forward.

Remove the fill cap and fill the cylinder approximately two thirds full. Pour slowly so as not to introduce air into the fluid. Remove the cylinder from the base bracket and place it horizontal, being careful not to allow air into the transducer housing. Finish filling the cylinder and replace the fill cap.

The fluid level should be such that fluid will displace air from the treads as the fill cap is installed.

Close the petcocks and manipulate the cylinder to work the bubbles to the fill port, beginning with any air at the transducer housing. **It is important to close the petcocks to ensure that the plunger will not drop out as you manipulate the cylinder.** Expel the bubbles collected at the fill port by injecting fluid at the housing and allowing the air to exit fill port.

When the syringe requires refilling, close the petcock before removal and after you reconnect the syringe, draw back slightly on the syringe as you open the petcock so that air is drawn into the syringe rather than being forced into the housing.

The air bubble at the plunger O-ring is the final trouble spot. The trick to removing this bubble is as follows:

Refill the syringe and connect it to either petcock. Open that petcock drawing any air from the connection into the syringe as described earlier. The syringe will now be used as a fluid reservoir allowing you to move the plunger to work the bubble away from the O-ring.

To coax the bubble away from the O-ring, angle the cylinder upward then slowly pull and rotate the plunger. The larger syringe will be helpful because a larger reservoir will provide more plunger displacement before having to push the plunger back in to start over. The combination of twisting and pulling of the plunger will roll the bubble away from the O-ring.

Amplifier Operation:

The amplifier converts the signal from the pressure transducer bridge to an output of 10 millivolts for every pound per square inch of pressure relative to atmospheric pressure. The pressure transducer is laser trimmed for guaranteed accuracy of 2% from 0 to100 PSI (14.7 atm) with the usable range extending to 300 PSI (44.1 atm).

Electrical Connections:

The back of the transducer amplifier has the following connections:

- **AC Power Cord** *The nominal input is 115 volts at 60 hertz but the device will function properly down to 100 volts at 50 hertz.*

- **Event Detector** *This is the plug that comes from the detector on the mast.*

- **Pressure Transducer** *Connect the cable from the pressure transducer here. The display will fluctuate erratically if the transducer is not connected.*

- **Filter Switch** *Certain amplifier models have a Low-Pass filter. This filter helps reduce the noise from tiny air bubbles that may be introduced into the system while making final connections to the subject. The filter can make the applied pressure wave easier to read. The filter only removes the high frequency noise that has no effect on the injury. It will not eliminate noise caused by significant amounts of trapped gasses as these signal degradations could impact your results and must be corrected to ensure consistent stimulus.*

The connection to your capture device is via the front panel BNC connectors.

- **Amplifier Output (10mV/PSI)** *This is the amplified output of the pressure transducer. Connect this to your oscilloscope or data acquisition system.*

- **Event Detector (TTL Output)** *This is a TTL level pulse that can be used to trigger your capture device as the hammer strikes the plunger.*

- **Pressure Transducer** *Connect the cable from the pressure transducer here. The display will fluctuate erratically if the transducer is not connected.*

- **Filter Switch** *Certain amplifier models have a Low-Pass filter. This filter helps reduce the noise from tiny air bubbles that may be introduced into the system while making final connections to the subject. The filter can make the applied pressure wave easier to read. The filter only removes the high frequency noise that has no effect on the injury. It will not eliminate noise caused by significant amounts of trapped gasses as these signal degradations could impact your results and must be corrected to ensure consistent stimulus.*

Calibration:

If you are using a device that accurately records voltage then no calibration is required.

For devices such as analog storage oscilloscopes that record relative voltages and have poor absolute accuracy, calibration is performed quickly using just two reference levels.

This is done by setting the zero level and then scaling your capture device to the 100 PSI Calibration level as follows:

- **Zero Reference:** The zero pressure reference is simply zero volts. This is generally obtained through the input coupling mode switch on the capture device. The switch is usually labeled AC-GND-DC. Select GND to obtain a zero reference. After Zero Reference is established, select DC coupling for all other operations.

- **100 PSI Reference:** The switch to the right of the display selects the 100PSI Cal output. This generates a 1 volt output which is the equivalent of 100 PSI. Use this reference to set the scale on your capture equipment.

Once these two references are established, the pressure output can be read directly as a linear function from 0 to 300 PSI.

• Digital Meter:

The meter reads static pressure. It is useful during calibration and an indicator of proper device function. It is not a measure of impact since a single value reading would be useless in characterizing the stimulus applied. A full waveform capture is required.

The Meter Scale switch allows you to select PSI or atmospheres as your unit of measure. The output from the amplifier is not affected by the meter scale. It’s sole purpose is to allow calibration of your capture device to either unit of measure without conversion tables or equations and as an indicator of calibration mode and proper device function.

• Event Trigger:

Most capture equipment will detect the rising edge of the pressure output signal making the event trigger unnecessary. The event trigger provides a TTL pulse of selectable polarity in the event your capture equipment does not derive the trigger from the pressure waveform. It could also be used to gate your capture equipment, reducing the collection of data outside of the event.

Expected Results:

Bear in mind that the pressure generated by this device is dynamic and travels as a wave. The pressures read by the transducer will therefore not be the actual pressure applied at the subject. The readings from the transducer only assure that a consistent stimulus is applied. The further the wave has to travel the longer it will take the system to reach equilibrium and the more the pressure at the subject will deviate from the transducer readings. **It is very important to keep the subject as close to the source as possible. You must reproduce the connection method exactly in order to reproduce the injury conditions.**

Proper degassing is essential to obtain good results. Air in the system will cause oscillations that will prevent you from achieving a reproducible stimulus.

Figure A shows a proper waveform. Notice that the wave is quite clean even though this is a very high impact having a peak pressure of 254 PSI (17.3 atm).

Figure B shows reflections due to the presence of air in the system.

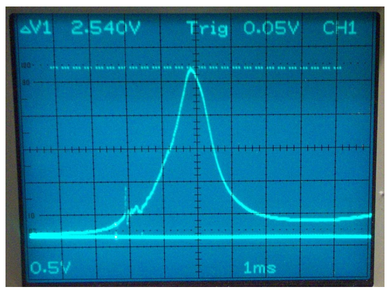


Figure A

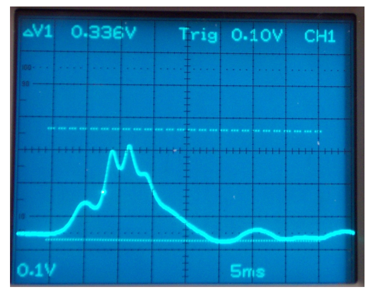


Figure B

The location of trapped air in the system also has a bearing on how it will effect the signal. A bubble in the transducer housing will degrade the signal much more than if it were in the cylinder.

The large volume of the cylinder results in a low resonance frequency making the cylinder more forgiving of bubbles. As long as the total air in the cylinder is less than 0.2 cubic centimeters, you should get a healthy waveform at any impact level.

The smaller volume of transducer housing, however, is resonant to much higher frequencies (shorter wave lengths) and is therefore much less forgiving. Even the tiny bubbles that cling to the surfaces will cause visible noise in the waveform. While this high frequency noise generated by minute bubbles in the housing will have no bearing on the injury delivered, they can certainly make the interpretation of the impact waveform difficult. The natural tendency is to record the highest peak of the waveform. This reading method would be correct on a smooth waveform, however, on a noisy wave, as depicted in the illustration of Figure C, using the highest peak results in an inflated reading. The actual injury causing waveform lies in the center of the high frequency noise.

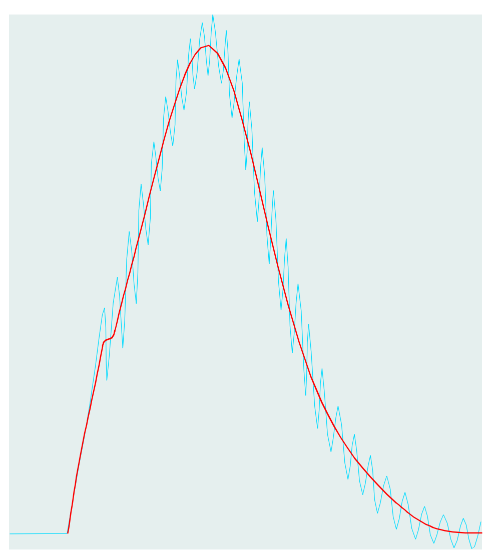


Figure C

On recent models we have incorporated a low pass-filter that removes noise generated by reverberation in the transducer housing. The purpose of the filter is only to reduce waveform interpretation errors by removing signals that are of no consequence to the injury. It will not filter out signals from a poorly degassed system. It is imperative that you ensure the system is properly degassed in order to obtain good results.

For Information or Orders Contact:

Custom Design & Fabrication, Inc.

Guy M. Blankinship III
P.O. Box 69
Sandston, Virginia 23150
USA

Email: gblankin.cdf@gmail.com
Web: www.CDF-Products.com
Telephone: 1-804-932-3933