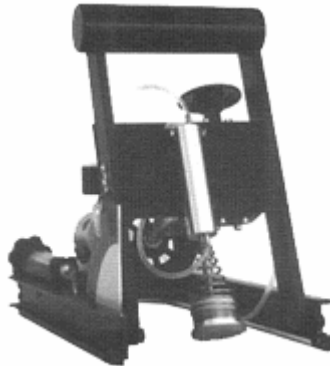


**Instruction Manual**  
for the  
**English *XL* Variable Incidence Tribometer**

US Patent 5,259,236



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## The New World Order In Tribometry

After 60 years of studying pedestrian slip resistance and its measurement which has involved considerable controversy among various factions, the dynamics of ambulation as related to pedestrian slip resistance are now pretty well defined, and there is consensus among the leading participants that (1) dry surfaces are not slippery under rubber shoe bottoms, (2) the commonest surface contaminant contributing to slipperiness so as to produce falls is water, and (3) practical slipmeters must be able to meter wet surfaces if they are to have utility to the fall prevention practitioner.

The ***XL*** Variable Incidence Tribometer was engineered primarily for testing of wet or otherwise contaminated surfaces and has become widely accepted among serious users as the slipmeter of choice for safety engineering and forensic investigation because of its extreme portability, ease of use and unsurpassed validity.

### Slipmeter Output

The term *static coefficient of friction* (SCOF) has been well defined in physics books and in NBS literature since long before my appearance on the tribometry scene. There have been two definitions of SCOF (or ways to measure it):

1. Using the **dragsled** principle, the horizontal force (required to start the object slipping) divided by the mass of the object (the vertical [gravity] force) equals the static coefficient of friction. The formula is expressed

$$H/V = \text{SCOF}$$

2. Using what has been called the **articulated strut** principle, when the strut starts in an approximately vertical position and is progressively inclined until the shoe slips, the tangent of the angle from the vertical at which it begins to slip is also the static coefficient of friction.

When testing with the same slider material on the same surface in a perfectly clean and dry state, both metering principles will yield similar results, so long as residence time is minimized to reduce adhesion. The bad news is that competent investigators the world over know that almost no one is slipping and falling down on perfectly clean, dry surfaces, so although both of these metering principles are theoretically valid under ideal conditions, meter readings by dragsleds and traditional articulated strut devices are worse than useless in the real and dirty world of moisture and other kinds of contaminants that are normally present in accidental slipping incidents.

It is silly to argue about *static* or *dynamic* and to insist upon pristine surfaces in standard testing protocols. The US has many standards based on theories of static coefficient of friction on walking surfaces (examples include ceramic tile, resilient flooring, paints and coatings, floor polishes, and quarried stone), none of which incorporates a scientifically valid metering device or specifies a safe level of traction performance.

### ***XL* Output**

Since the engineers agree that *coefficient of friction* can only obtain on clean dry surfaces, the *XL*'s output can be neither *static coefficient of friction* (SCOF) nor *dynamic coefficient of friction* (DCOF). Neither term appears in any F13 standard for testing of traction on wet surfaces. What the *XL* is measuring on wet or otherwise lubricated surfaces is *slip resistance*. There is not room to put the term *Slip Resistance Index* on the output protractor in letters large enough for you to read it without your bifocals, so the terminology has been abbreviated to *Slip Index*, the same nomenclature Charlie Irvine used on the Horizontal Pull slipmeter some 20 years earlier.

The *XL* can be said to be measuring SCOF, if you are metering a dry surface. It is measuring slip resistance if it is contaminated. Why not call it slip resistance on dry surfaces too?

There are now a number of slip resistance standards by ASTM, ANSI, NFPA, OSHA and several state codes based on the *XL*'s output, and others are being added as time passes.

### **The Transatlantic View**

Ever since the development of the SATRA Shoe Tester in England, equally erudite investigators in the EU have decreed that there is no such thing as *static* friction and have proceeded to design various testers and test methods designed to rate surface traction and shoe slipperiness in the presence of various lubricants. None of these methods has been scientifically established as valid, and none of them has been actually standardized as an ISO method. The Tortus and its successor devices, the SATRA tester and the TRL pendulum device are all purported to be *dynamic* or *kinetic* friction testers. The Europeans don't talk much about slip resistance; they're stuck on the dynamic COF term.

There have been efforts to establish the German Ramp Test and the "Surtronic" surface roughness gauge as baselines for slip resistance measurement, but neither is a slipmeter, and their measurements do not correlate with anything in ambulation.

### **The English *XL***

The VIT is able to substantially mimic certain parameters of the human gait. It is designed to embody the ergonomic correspondence to walking that leading investigators have said should characterize a valid slipmeter.



**Figure 1.** *The XL is the lightest and most portable slipmeter available, besides having unsurpassed validity on wet surfaces.*

It is self-powered by a miniature CO<sub>2</sub> cylinder, and it is the smallest, lightest and most easily portable meter yet developed. It is only about a foot long and weighs less than four pounds. Its operational principle is related to certain features of the earlier Hunter and James Machines, in that it uses a variable incidence strut, but aside from its extreme portability, its main differences are (1) that its fluidic mode of actuation applies the vertical and horizontal force components simultaneously with surface contact, thereby overcoming the well-known *sticktion* or *adhesion* problems that arise from the delay between shoe contact with the surface and the initiation of horizontal motion, and (2) its smaller area of surface contact approximates the area of initial heel contact in walking. The *XL* was designed for use on wet or otherwise lubricated surfaces, and it can be used on floors or stairs, easily fitting into places that larger machines cannot go.

This action is contradistinguished from gravity- and solenoid-actuated devices where their hard impact causes a force spike that can result in a bounce tendency, which is not only unlike human ambulation, but the bouncing tendency may contribute to a lower indicated slip index than is obtained under the more realistic dynamics of the English *XL* VIT.

Other advantages include;

- The force applied is constant. Once the working pressure is set, both force and velocity remain the same at all angles of inclination.
- At the recommended operating pressure of 25 psi, the velocity of shoe contact (of about 11 inches per second) is thought to be within the range of velocities at which the heel contacts the floor in human ambulation.
- The testfoot contacts the surface “heel” first, and the universal “ankle” joint allows it to pivot down flat onto the surface, as a heel does in walking. This action manipulates the hydrodynamic squeeze film on the interface in a manner similar to a walking heel.

- The smaller shoe diameter more closely approximates the area of contact of a human heel at set down.
- The universal foot can flex freely in any direction, facilitating testing on uneven surfaces.

### Other Uses

The *XL* is delivered with four blank shoes to permit experimentation with other shoe bottom materials using the shoe's quick-change attachment method.

The standard Neolite foot should always be used when metering floor traction, but it can be easily removed to permit the attachment of other feet for testing the traction performance of other materials. Test shoes can be easily changed in the field by unscrewing the shoe from the machine and screwing another on in its place. This is accomplished by slipping the spring back and gripping the white plastic nut with one hand while unscrewing the shoe with the other. Then screw the other shoe into the nut before releasing the spring.

Other test specimens may be attached to the blank testfeet with any good adhesive or with double-sided carpet tape. The original Neolite pad is attached with epoxy.



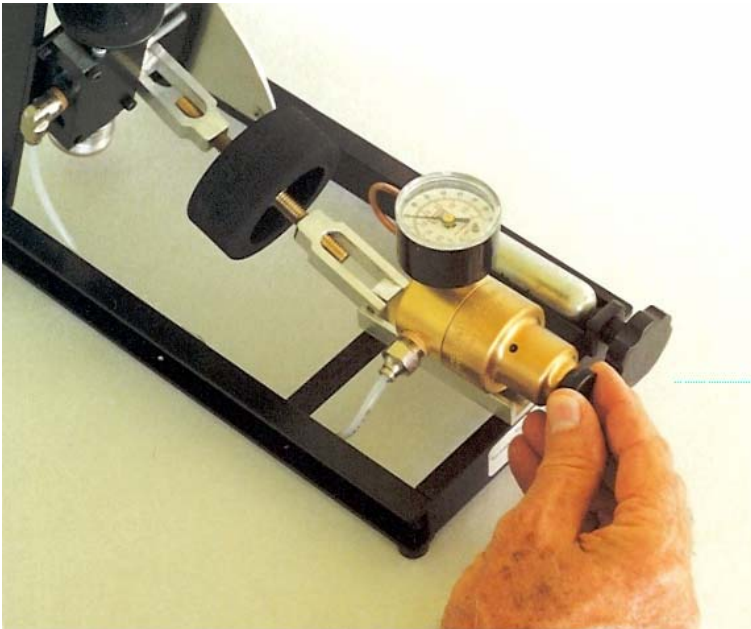
**Figure 2.** *Slide the spring back and grip the plastic nut securely when changing testfeet. Be sure not to release the spring until the replacement foot has been screwed in. Be careful not to cross-thread it so as to damage the nylon threads.*

**Caution:** Do not over-tighten the shoe into the nut. To do so would interfere with the freedom of the universal joint and bias indications upward. Just screw the shoe in until it is snug and then back it off 1/4 turn.

### Using the English *XL* Variable Incidence Tribometer

The *XL* comes completely assembled, ready to use. All that is necessary is to charge the system and verify the working pressure at 25 psi. The primary cylinder pressure is 840 psi at 70 degrees F. The design range of the regulator is 0-50 psi, though you can crank it up above that if you're really determined.

The operating pressure is set by turning the thumb screw on the back of the regulator. Clockwise raises pressure and counterclockwise reduces it. The regulator is not self-relieving, so *if you are trying to reduce the pressure, you will need to press the actuation button after turning the knob in order to relieve the pent-up pressure.*



**Figure 3.** *The operating pressure is adjusted to 25 psi by turning the thumb screw.*

Before testing, prepare the Neolite testfoot by sanding the pad with the shoe mounted on the foot using 180 silicon carbide paper with a hard backup. It is recommended that you turn the machine around (so that sanding dust won't fall onto the test zone) and lift the universal foot assembly away from the mast about 45 degrees and sand in a **circular motion five cycles** while holding the foot steady with the other hand. Brush the dust off of the pad with the brush provided and reposition the *XL* over the test zone and begin testing. **Sand the pad after each slip** when testing dry surfaces. For wet testing, sand the pad before you start, but there is no need to re-sand unless you have a reason to believe your values are shifting because of polishing of the pad.



**Figure 4.** *Grip the testfoot firmly with one hand while sanding with the other in a circular motion.*

The pad should be sanded dry. If you need to resand while wet testing, dry the foot and allow a time for complete air drying before sanding.

Using a soft backup for the 180 grit paper will result in formation of a convex shoe surface that will bias results upward significantly. Use the sanding block provided.

The universal (ankle) joint on the foot must be able to flex freely. Over-tightening the nut will cause binding, which will cause erratic indications. When installing the foot onto the nut, screw it in until snug, and back it off 1/4 turn. Verify this freedom before beginning each series of tests and after sanding the testfoot. Excessive looseness will also bias results.

Pressurize the system by putting a CO<sub>2</sub> cylinder into the channel and turning the screw in until the tip is punctured. When the system is charged, pressure will show on the gauge. Because the gas is kept in a liquid state by its own vapor pressure, the primary pressure will remain constant so long as liquid remains in the cylinder. When the liquid has been all vaporized, pressure on the gauge will rise slightly on the last two strokes before dropping to zero. Keep an eye on the pressure gauge while testing and make any minor adjustments necessary to maintain the 25 psi secondary pressure.

## **Operating the XL**

After preparing the slider and charging the pressure system the *XL* is ready to operate. To meter a floor, place the instrument down on the test surface and preselect a mast angle by turning the black handwheel near the center of the chassis. Begin by pressing down on the handle on top of the mast and then press the actuation button to stroke the cylinder. The testfoot will be thrust downward onto the test surface. Releasing the button will cause the cylinder to retract, thus completing the operating cycle.

The button should be held down for about ½ a second and released. There is no need to attempt to time the duration of force application. Just listen to the “choo-choo” sound the instrument makes, and it will be about right. Holding the button down for longer periods can result in lower indications.

Begin testing with the mast in a more vertical position and work progressively toward the higher numbers by turning the hand wheel about 1/4 turn after each stroke. When the first full-stroke slip occurs (creeps don't count), cease testing and record the Slip Index number. [Working backwards—that is, starting from the high end of the Index and progressively raising the mast with each stroke—will produce slightly different results. For best repeatability work from the lower numbers to the higher.] For more consistent results, begin testing at an angle that will permit at least two strokes before you get a slip.

## **Testing and Recording Protocol**

It has been traditional practice to test each surface orthogonally. That is, to take four successive readings in the north, east, south and west orientations and record the results. For each set of readings, the results are normally averaged to obtain a net result for that panel. This method is not to be followed blindly, however, in that some surfaces have variability and directionality to their surface grain. Each number recorded is an actual traction measurement result and each one should be considered. If there is variability of results, take more than four readings on each spot and average for an acceptable confidence factor. Six or eight readings per surface test are recommended.

Do dry testing first, followed by wet testing.

Neolite is not very absorptive, so relative humidity levels are not particularly important except that they should be recorded, if they are found to be at either extreme end of the spectrum. It is normal to record time of day and to describe weather or other relevant conditions as well. Humidity can significantly affect the test results on absorptive materials such as wood and some synthetic flooring materials.

It is usually helpful to also photograph the test scene to illustrate your report, whether testing in the lab or in the field.

Take towels with you so you can wipe up wet spots when field testing so as not to leave a hazard behind you. Do not store wet towels in your carrying case. The trapped humidity

will corrode the dickens out of the shiny aluminum and brass surfaces. Use paper towels and discard them appropriately at the test site.

### **Down-Hill Testing**

When testing in a down-hill direction on ramps, make sure the cylinder is resting against the rubber stop on the cross plate before actuation. If the slope is so steep as to cause the cylinder to swing away from its stop, the surface is either too slippery for safe walking or the ramp is too steep to be legal. This is not normally a problem, but you should beware of the possibility when testing down-hill.

### **Routine Maintenance and Inspection**

Although the English *XL* is not particularly fragile when used and transported in the recommended manner, if it is handled carelessly the actuation cylinder hinge bracket can be bent, and the high pressure line on the back end of the chassis can be bent, not to mention the possibility of scratching up the black anodized finish on the aluminum parts. However, if you always place the instrument back into its carrying case before transporting it, any kind of damage is unlikely. It was designed to fit in its case as surely as the case was designed to fit the tester.



**Figure 5.** *The stair fixture should be removed before stowing the XL in its case.*

The *XL* is a precision instrument when it leaves the factory. If you kick it around with your feet or let it roll around loose in the trunk of your car, it will not remain a precision test instrument very long. Please handle it carefully.

### **Using the Stair Fixture**

The stair fixture enables you to measure the slip resistance of stair nosings. In order to perform this operation, first attach the fixture to the bottom of the chassis by screwing the two thumb screws into the tapped holes in the bottom of the chassis. Then adjust the height of the peg-leg by putting the two front feet of the instrument on the leading edge of the stair step and turning the threaded rod in the appropriate direction to place the chassis in the same plane as the stair tread. Do not level the chassis unless the stair tread is level. Once the proper height adjustment is made, tighten the wing nut to stiffen up the assembly. You are now ready to test the traction on the nosing. Measure as close to the nosing edge as you can.

### **Handle with Care**

**Caution:** *Although the English XL VIT is a small and light-weight instrument, the primary pressure in excess of 800 psi can release a lot of force if the device is abused or mishandled. It would be difficult to turn the puncture screw out fast enough to release the cylinder in a rocket mode, however it is recommended that this means not be used to release pressure. If you need to blow down the system pressure, holding the actuation button down half way will accomplish this safely.*

*The actuating mechanism is designed to use 12-gram cylinders intended for use in pellet guns. Do not use gas cylinders that are sold for life vest inflation or carbonation. Use only pellet gun cylinders, because they contain a small amount of lubricant and will keep your piston seals lubricated. If these seals go dry, the actuation velocity will be reduced and become erratic, producing invalid results.*

*The pressure components incorporated in your XL can easily contain the pressures encountered, but be careful not to bang the pressure fittings around, especially while pressurized. The high-pressure line has been carefully located on the inside of the chassis so as to shield it from impact, but this precision instrument should be handled with respect and care. Place it back in its carrying case when not in use.*

*Be careful when picking up your XL, as when taking it out of the case. If you grab the chassis by the right-hand rail and get your grip around the high-pressure line and bend it, the solder joint will leak, and it will have to be returned to be re-soldered. Handle the instrument by the handle provided for that purpose.*

Visit <http://www.englishxl.com/> often to keep current on matters relating to the XL and its standardization. Subscribe to the e-mail newsletter at <http://www.englishxl.com/subscribe.htm> to keep up with relevant happenings.