Fisher Scientific

Fisher Surface Tensiomat Model 21

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The Instrument

The Fisher Surface Tensiometer, Model 21, is used to determine the apparent surface tension and interfacial tension of liquids. Employing either manual or semi-automatic procedures, the instrument is applicable to many educational, biological, medical and industrial determinations in connection with water, petroleum products, detergents, pharmaceutical materials and other substances.

The Model 21 utilizes the principles of operation originally devised by Dr. Pierre Lecomte du Nouy, the noted biochemist, for studies of blood serum and other biological fluids. Essentially a torsion-type balance, it is the kind of instrument currently specified by the American Society for Testing Materials in Methods D-971 (interfacial tension of oil against water) and D-1331 (surface and interfacial tensions of detergents).

In the du Nouy method, a platinum-iridium ring of precisely known dimensions is suspended from a counter-balanced lever arm. The arm is held horizontal by torsion applied to a taut stainless steel wire, to which it is clamped. Increasing the torsion in the wire raises the arm and the ring, which carries with it a film of the liquid in which it is immersed. The force necessary to pull the test ring free from this surface film is measured.

The Surface Tensiomat shows this "apparent" surface or interfacial tension (the latter measured at the interface between two immiscible liquids) on a calibrated dial. The dial readings can be used directly for comparative studies or converted to "absolute" values by using a correction factor chart.

Unpacking

The Fisher Surface Tensiomat is shipped in a single carton. Carefully unpack the contents, and check each item against the packing list below. If any items are damaged, save all packing material and file claim with the carrier; if any items are missing, notify your Fisher branch or representative.

Quantity	Item
1	Surface Tensiomat
1	Ring Box Assembly*
2	Torsion Wire Assembly
1	Instruction Manual

*Contains Platinum Iridium Ring. Order replacement ring under Fisher No. 14-812-5

Assembly

The Surface Tensiometer consists of a torsion wire balance with a dial calibrated in dynes/cm, a weighed platinum-iridium ring, a movable table and a small reversible motor. The motor operates on 115 volts, 50/60 cycle a/c. The torsion wire balance and movable table are mounted on the stand within the case. The ring is shipped in a wooden container which is secured to the main pedestal of the stand.

Prior to use, the instrument should be placed on a solid support (table or bench) and leveled. To do this, simply open the door and using the two knobs near the left edge of the base, adjust the feet until the spirit level indicates that the cabinet is level.

For shipping purposes, the tension has been relieved from the torsion wire. In order to restore the tension, back off the screw which is accessible through the small hole in the upper center portion of the rear of the cabinet. Loosening this screw allows the tension spring to exert pressure against the bar, thus restoring the tension on the wire. The packing material which supports the junction of the torsion wire and level arm should be removed, as should the packing material on the level arm near the index mirror and arrest mechanism. The Surface Tensiometer is now ready for calibration.

Calibration

The calibration of the torsion wire and hence of the Surface Tensiomat has been carefully tested at the factory but should be checked before use and adjusted if necessary. The calibration is carried out so that the dial will read directly in dynes/cm.

Make sure that the torsion arm arrest mechanism is holding the arm. Hang the platinum-iridium ring on the hook at the left end of the lever. Cut a small strip of paper and fit it onto the ring to act as a platform for a weight which will be used for the calibration. Release the torsion arm, and adjust the knob on the right side of the case until the index and its image are exactly in line with the reference line of the mirror. Turn the knob beneath the main dial on the front of the instrument until the vernier reads zero on the outer scale of the dial. Arrest the torsion arm.

Place a known mass for calibration on the paper platform (600 milligrams is quite suitable and simplifies calculations). Release the torsion arm. Turn the knob on the right side of the case in a counterclockwise direction until the index and its image are again exactly in line with the reference line of the mirror. Record the dial reading to the nearing 1/10 scale division (by use of the vernier).

It is now necessary to determine the accuracy of the calibration from the reading obtained. The apparent surface tension, **S**, is given as follows:

$$S = \frac{Mg}{2L}$$

Where:

M = The weight expressed in grams
g = Acceleration of gravity expressed in cm/sec^2
L = Mean circumference of the ring in cm
S = Dial reading = Apparent Surface Tension in dynes per cm

For example, suppose that a 600 mg weight was used. The circumference of the ring is 6.00 cm and the value for g is 980 cm/sec^2. Then we find that:

$$S = \frac{Mg}{2L} = \frac{0.6 \times 980}{2 \times 6} = 49.00 \text{ dynes/cm}$$

If the dial reading differs from the calculated value, then

the effective length of the torsion arm must be adjusted until these two values do agree. This adjustment is accomplished by turning the knurled knob at the left end of the lever arm so as to move the hanger hook. If the recorded dial reading is greater than the calculated value, move the hook to shorten the effective length of the arm. Conversely, if the dial reading is less than the calculated value, move the hook to lengthen the effective length of the arm. Repeat the calibration procedure until the dial reading and calculated value agree. The dial will read directly in dynes/cm.

The mean circumference of rings is 6.00 cm in general. Slight deviations may be found, and the circumference of each ring is noted on its container. In the preceding example, 600 milligrams were used to simplify calculations.

The value of g, the acceleration of gravity, varies slightly from place to place on the surface of the earth. For precise work, the use of the exact value of g for the locality is recommended. For certain localities, this value may be listed in various handbooks; or it may be determined experimentally.

Operation

In making a determination surface tension, careful preparation of the sample and the Surface Tensiomat must precede the actual manipulation of the instrument.

The sample should be placed in a glass beaker or cylindrical vessel with a diameter of at least 45 millimeters. For testing oil samples according to ASTM Method D-971, the glassware should be cleaned according to a definite procedure. Any residual oil from the previous sample is removed with petroleum naphtha or benzene followed by several washes with methyl ethyl ketone and water, then the glassware is immersed in a hot cleaning solution of chromic acid. The glassware also should be rinsed thoroughly with tap water, then with distilled water. It should be drained in an inverted position over a clean cloth, unless it is to be used immediately.

The platinum-iridium ring should be cleaned by first dipping it in benzene (to remove hydrocarbons), then squirting it with acetone (to remove the benzene) and allowing the acetone to evaporate. Following this, flash the ring in a Bunsen burner flame to remove residual hydrocarbons.

The preceding instructions are particularly applicable when preparing for oil sample determinations. A comparable degree of cleanliness, however, should be sought for other determinations as well.

Measuring Surface Tension

Since surface tension is dependent upon temperature, consideration must be given to this factor. For theoretical work, temperatures must be specified; however, 25°C is the temperature most commonly used. For control work, the operator should use the same temperature for each type of measurement.

Since the Surface Tensiomat may be employed as a manual or semi-automatic instrument, separate procedures are described below for both operating modes.

The cleaned platinum-iridium ring should first be attached to the hook at the end of the lever arm. The arrest mechanism should be holding the arm at this time.

The liquid to be measured is transferred to the clean glass vessel and placed on the sample table. The sample table is moved around until it is directly beneath the platinum-iridium ring. Raise the sample table until the ring is immersed in the test liquid. The ring should be in the liquid, beneath the surface so that the entire ring will be wetted. About 1/8" immersion is generally considered sufficient.

The torsion arm is now released and the instrument adjusted to a zero reading. Adjust the knob on the right side of the case until the index and its image are exactly in line with the reference mark on the mirror. Be careful to keep the ring in the liquid during this manipulation, raising or lowering the sample table (if necessary) by means of the knob adjustment underneath the table. Now turn the knob beneath the main dial on the front of the case until the verier reads zero on the outer scale of the dial.

Lower the sample table until the ring is in the surface of the liquid, while at the same time adjusting the knob on the right side of the case to keep the index lined up with the reference mark on the mirror. The surface of the liquid will become distended, but the index must be kept on the reference. Continue the two simultaneous adjustments until the distended film at the surface of the liquid breaks. The scale reading at the breaking point of the distended film is the apparent surface tension.

Measuring Interfacial Tension

Interfacial tension from more dense liquid to less dense liquid is made by exerting an upward force on the ring. Procedure is very similar to surface tension measurements; and cleanliness of ring and sample container is, of course, essential.

The more dense liquid is transferred to the clean glass vessel and placed on the sample table, and the table moved beneath the platinum-iridium ring. The sample table is raised until the ring is immersed about 1/8" and wetted by the heavier liquid. The torsion arm is now released and the instrument adjusted to a zero reading. Adjust the knob on the right side of the case until the index and its image are exactly in line with the reference mark on the mirror. Be careful to keep the ring in the liquid during this manipulation by raising or lowering the sample table (if necessary) by means of the knob adjustment beneath the table. Turn the knob beneath the main dial on the front of the case until the vernier reads zero on the outer scale of the dial.

Pour the lighter liquid onto the surface of the heavier liquid to a depth of about 1/4" to 1/2", depending on the two liquids. The layer of lighter liquid should be deep enough so that the ring will not enter the upper surface of the lighter liquid before the interface film ruptures.

Before proceeding with the actual measurement, it may be advisable to allow the interface to age or stabilize for a time. For example, ASTM D-971 prescribes an aging period of 30 seconds for an interface between oil and water.

Lower the sample table until the ring is in the interface between the two liquids, while at the same time adjusting the knob on the right side of the case to keep the index lined up with the reference mark on the mirror. The interface between the two liquids will become distended, but the index must be kept on the reference. Continue the two simultaneous adjustments until the distended film at the interface ruptures. The scale reading at the breaking point of the interfacial film is the apparent interfacial tension.

Interfacial tension from less dense liquid is made by exerting a downward force on the ring. The ring used on the Surface Tensiomat is weighted, and in effect exerts its own force, the effective downward force being increased by decreasing the upward force from the torsion wire as exerted through the lever arm. The procedure differs only slightly from that employed in the previously described measurement of interfacial tension; and the cleanliness of the ring and sample container is, of course, essential.

The more dense liquid is transferred to the clean glass vessel, to a depth of 1/4" to 1/2", depending on the two liquids. The layer should be deep enough so that the ring will not contact the bottom of the vessel before the interface film ruptures.

The lighter liquid is now poured onto the surface of the heavier liquid already in the vessel, and the vessel placed on the sample table moved beneath the platinum-iridium ring. The sample table is then raised by the gross adjustment until the ring is immersed in the lighter liquid and wetted by it (about 1/8" above th liquid interface). The torsion arm is now release, and the instrument adjusted to a zero reading. Adjust the knob on the right side of the case until the index and its image are exactly in line with the reference mark on the mirror. Be careful to keep the ring in the lighter liquid during this manipulation by raising or lowering the sample table (if necessary) by means of the knob adjustment beneath the table. Turn the knob beneath the main dial on the front of the case until the vernier reads zero on the inner scale of the dial.

Raise the sample table until the ring is in the interface between the two liquids, adjusting the knob on the right side of the case to keep the index lined up with the reference mark on the mirror. The interface between the two liquids will become distended, but the index must be kept on the reference. Continue the two simultaneous adjustments until the distended film at the interface ruptures. The scale reading at the breaking point of the interfacial film is the apparent interfacial tension.

Semi-Automatic Determinations

The semi-automatic operation of the Fisher Surface Tensiomat is basically similar to the manual mode of operation – the only essential difference being the use of a small electric motor to twist the torsion wire and thus raise and lower the ring in the test solution. No adjustments or complicated procedures are involved in changing from either mode of operation to the other; the use of a switch to activate the semi-automatic feature and a slightly different technique in regard to the level of the surface or interface are the soles differences. The motor is connected to the semi-automatic mechanism by means of a clutch which does not interfere with the manual mode.

The semi-automatic drive mechanism actuates the torsion arm and consequently the ring; the position of the sample table is not changed or controlled by the drive mechanism. As a consequence, the simultaneous adjustment of the torsion arm and sample table is not feasible. Therefore, it is necessary to determine the level of the surface or interface at the instant the film is broken by means of a manual determination and to maintain this level of surface or interface for subsequent determinations of similar samples. Provided the subsequent samples are of the same character (approximately the same density and surface or interfacial tension) no appreciable error is introduced by presetting the level of the surface or interface. Since a major advantage of the Surface Tensiomat is its ability to make repetitive determinations on similar samples rapidly, this determination of a level is a simple and worthwhile operation.

A practical method for attaining a reproducible level for each sample is to use a sample container with a mark showing the level. More than one sample container can be so marked and used in succession. Also, it is usually practical to introduce reproducible volumes of samples into containers of reasonably uniform size. For example, Petri dishes with identical volumes of sample will produce levels which are for all practical purposes the same.

Once the level of the surface has been determined and the approximate reading for the type of samples ascertained, the semi-automatic mode of operation is very simple. The sample is placed on the same sample table and

the ring immersed in the proper liquid. The knob on the right side of the case is used to bring the vernier scale to a point about fifteen units less than the expected reading. The switch on the front of the case is put in the UP position for surface tension measurements of interfacial tension measurements where the ring is pulled up through the interface, and in the DOWN position for interfacial tension determinations where the ring is forced down through the interface. When the surface or interface film ruptures, the lever arm actuates a contact which in turn actuates a relay and stops the drive motor. The value is then read from the proper scale on the dial.

A pilot light on the front of the case indicates when the motor of the Surface Tensiomat is running. When the film ruptures, the motor stops and the light goes out. The switch must be returned to the NEUTRAL position and the lever arm returned to the proper position prior to making the next determination.

Experience has shown that readings obtained using semi-automatic operation will be slightly different from those obtained manually. However, with any given set of conditions, these variations can be determined by manual and semi-automatic experiments, and if necessary, the variations may be taken into account by the user.

Converting Scale Readings

The Surface Tensiomat measures apparent surface tension and apparent interfacial tension. In order to obtain the true surface tension or true interfacial tension, the relationship:

$$S = P \times F$$

is used, where S is the true value, P the apparent value as indicated by the dial reading and F a correction factor. The correction factor F is dependent on the size of the ring and the size of wire used in the ring, the apparent surface or interfacial tension and the densities of the two phases. The relationships are expressed by the following two forms, either one of which may be used in preparing a correction factor chart.

1. $$(F - a)^2 = \frac{4b}{(\pi R)^2} \times \frac{P}{D - d} + K$$

2. $$F = 0.7250 + \sqrt{\frac{0.01452\,P}{C^2\,(D - d)} + 0.04534 - \frac{1.679\,r}{R}}$$

where:

F	=	the correction factor
R	=	the radius of the ring
r	=	the radius of the wire of the ring
P	=	the apparent value or dial reading
D	=	the density of the lower phase
d	=	the density of the upper phase
K	=	0.04534 - 1.679 r/R
C	=	the circumference of the ring
a	=	0.725
b	=	0.0009075

The a, b and the numerical part of K are universal constants for all rings.

The correction factor is most easily determined by reference to a chart prepared from the formula. In order to use a correction factor chart, the operator must initially calculate the value of the expression P/(D - d) for each sample and know the value of R/r. For the Surface Tensiometer, the circumference of the ring is 6 cm and the radius of the wire is .007". There may be some slight variation in these dimensions, but the value of R/r is usually 53.2. Curves are shown for R/r = 50 and R/r = 60, so that correction

factors may be found for any value of the ratio between 50 and 60.

Should a ring of different diameter be employed, the user can prepare a curve from the above equations. All quantities used in these equations are expressed in the centimeter-gram-second system, with densities expressed in grams per cubic centimeter; P (apparent surface or interfacial tension) expressed in dynes/cm; while R, r and C are expressed in centimeters.

Use of the correction factor is usually limited to theoretical work. For control purposes, reproducibility within certain tolerances is sufficient.

Maintenance

Maintenance on the Surface Tensiomat will normally be limited to an annual application of oil and occasional replacement of the torsion wire. If the motor fail to operate, check the fuse and plug-in relay as possible sources of difficulty.

Annual Application of Oil

The zero adjustment shaft and bearing should be oiled once every twelve months; two drops of light oil should be sufficient. Putting a drop or two of oil on the post and adjusting nut of the sample table is also advisable once a year.

Replacement of Torsion Wire

Replacement of the torsion wire may be necessary from time to time due to accidental breakage. The torsion arm should be held by the arresting mechanism, and the clamping block supported by a suitable wood or cardboard block between itself and the casting. The cover of the vernier pointer on the front of the case should be removed by loosening the set screw. The 4-40 screw can be seen through the small hole in the cover. This hole is just large enough to accommodate a hexagonal screw key. It must be turned clockwise to release pressure on the underside of the cap sufficient to permit the cap to be pulled off of the hub. Next, the screw at the back of the case that controls the tension spring should be turned in so as to release all tension on the wire, then the front wire holder should be loosened so as to release the front end of the wire. Following this, the screws on the clamping block of the torsion arm should be loosened. The torsion wire should now be entirely free. If it is not broken, it can be removed by pulling toward the rear of the instrument.

The replacement wire has a bar attached for holding in the tension spring. The wire should be installed by working the front end forward from the rear, being careful not to bend or kink the wire. Do not fasten the wire in the clamping block (Item 6) at this stage. It should be brought forward through the sleeve to the front wire holder. A scribed line shows the position in which the wire should be placed in order to center it. Hold the wire taut with pliers and tighten the two screws of the front wire holder.

Excess wire may now be cut off and the cover of the vernier pointer assembly replaced.

Tension should now be applied to the wire by slacking off on the screw that holds the tension spring. This screw is accessible through the rear of the case. The procedure is the same as when the instrument was originally unpacked and readied for use.

The torsion arm must now be attached to the wire. This is best accomplished by removing the left screw from the clamping block and loosening the right screw. The wire must rest in the groove in the block, and when so fitted, the two screws are tightened. Upon removing the support from under the clamping block, check and if necessary adjust the diameter of the new torsion wire as follows:

1. Level the instrument.

2. Adjust hanger assembly all the way toward torsion wire. (Hanger hook will be about 3-13/16" from wire.)

3. Cut a small strip of paper and place it on the platinum-iridium ring to form a platform.

4. Place a 1.000 gram weight on the platform.

5. Release the torsion arm.

6. Adjust knob on right side of instrument case until index pointer on arm coincides with reference line on mirror.

7. Turn knob to right of main dial on front of instrument until vernier reads zero on outer scale of dial.

8. Remove 1.000 gram weight and place a 1.800 gram weight on platform.

9. Adjust knob on right side of instrument case until index pointer on arm coincides with reference line on mirror.

   NOTE: The reading obtained should be 65.7 to 66.0. If the reading is higher, the diameter of

the torsion wire between the arm and the rear of the instrument must be reduced. Conversely, if the reading is lower, the diameter of the wire between the arm and the front of the instrument must be reduced. In each case, Crocus cloth should be used. The wire must be kept symmetrical and round with uniform diameter along its length.

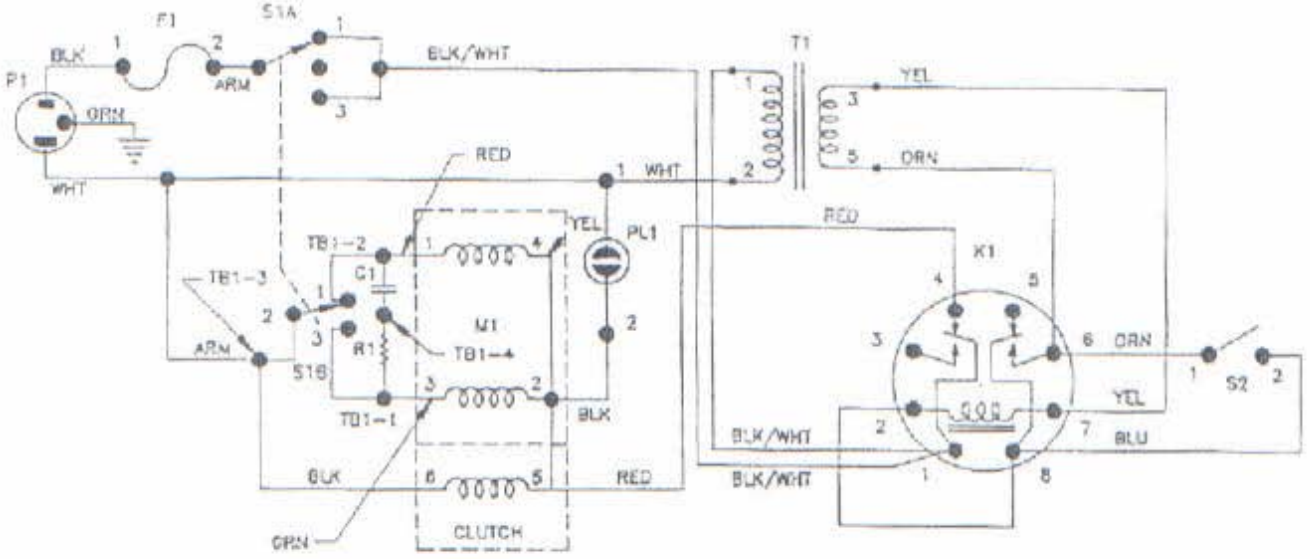
10. Calibrate instrument as directed on pages 6 and 7 under Calibration.

Replacement Parts

The following is a list of parts which may need to be replaced over a period of time. To assist in identifying each it, the tabulation includes cross reference numbers to the mechanical system drawing.

Item	Schematic Number	Code
Line Cord Assembly	28625	P1
Fuse, 1A, 3 AG	05964	F1
Fuse Holder	06296	---
Transformer	102760	T1
Relay	12058	K1
Motor	15057	M1
Includes:		
Capacitor, 1.0 mfd, 400V		C1
Resistor, 750Ω, 10W		R1
Pilot Light, NE-51H	15712	PL1
Pilot Light Holder	03476	
Lever Switch, Up/Down	12059	S1
Magnetic Catch	05666	
Knob,, Zero (on Front Panel)	20840	
Knob, Torsion (on Right Side)	28438	
Base Leveling Screw	31725	
Level	08487	
Level Insert	12144	
Sample Table	12174	
Small Table Spring	12149	
Small Bearing	12135	
Large Bearing	12136	
Tension Spring	12150	
Torsion Wire	56499	
Arm Assembly	12077	
Mirror Mount & Wire Clamp Assy.	12079	
Torsion Shaft Assembly:		
Consisting of:		
Shaft (with worm gear)	12205	
Spur Gear	12154	
Thrust Bearing	12134	
Pointer Assembly	12207	
Torsion Wire Clamp Bar	12177	
Rubber Grommet Dial Drive	06307	

Schematic


P1
BLK
ORN
WHT
F1
ARM
S1A
BLK/WHT
T1
YEL
ORN
RED
WHT
PL1
TB1-2
C1
TB1-3
ARM
S1B
R1
M1
TB1-4
TB1-1
BLK
CLUTCH
K1
S2
BLU
BLK/WHT

Two Year Limited Warranty

Fisher Scientific ("FISHER") warrants that a product manufactured by FISHER shall be free of defects in materials and workmanship for two (2) years from the first to occur of (i) the date the product is sold by FISHER or (ii) the date the product is purchased by the original retail customer (the "Commencement Date"). Except as expressly stated above, FISHER MAKES NO OTHER WARRANTY, EXPRESSED OR IMPLIED, WITH RESPECT TO THE PRODUCTS AND EXPRESSLY DISCLAIMS ANY AND ALL WARRANTIES, INCLUDING BUT NOT LIMITED TO, WARRANTIES OF DESIGN, MERCHANT ABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

An authorized representative of FISHER must perform all warranty inspections. In the event of a defect covered by FISHER's warranty, FISHER shall, as its sole obligation and exclusive remedy, provide free replacement parts to remedy the defective product. In addition, for products sold by FISHER within the continental United States or Canada, FISHER shall provide provide free labor to repair the products with the replacement parts, but only for a period of ninety (90) days from the Commencement Date.

FISHER's warranty provided hereunder shall be null and void and without further force or effect if there is any (i) repair made to the product by a party other than FISHER or its duly authorized service representative, (ii) misuse (including use inconsistent with written operating instructions for the product), mishandling, contamination, overheating, modification or alteration of the product by any customer or third party or (iii) use of replacement parts that are obtained from a party other than FISHER.

Heating elements, because of their susceptibility to overheating and contamination, must be returned to the FISHER factory and if, upon inspection, it is concluded that failure is due to factors other than excessive high temperature or contamination, FISHER will provide warranty replacement. As a condition to the return of any product, or any constituent part thereof, to FISHER's factory, it shall be sent prepaid and a prior written authorization from FISHER assigning a Return Goods Number to the product or part shall be obtained.

IN NO EVENT SHALL FISHER BE LIABLE TO ANY PARTY FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, OR FOR ANY DAMAGES RESULTING FROM LOSS OF USE OR PROFITS, ANTICIPATED OR OTHERWISE, ARISING OUT OF OR IN CONNECTION WITH THE SALE, USE OR PERFORMANCE OF ANY PRODUCTS, WHETHER SUCH CLAIM IS BASED ON CONTRACT, TORT (INCLUDING NEGLIGENCE), ANY THEORY OF STRICT LIABILITY OR REGULATORY ACTION.

Fisher Scientific
2555 Kerper Boulevard
Dubuque, Iowa 52001
Phone: 800-926-0505
Fax: 563-589-0516
www.fishersci.com