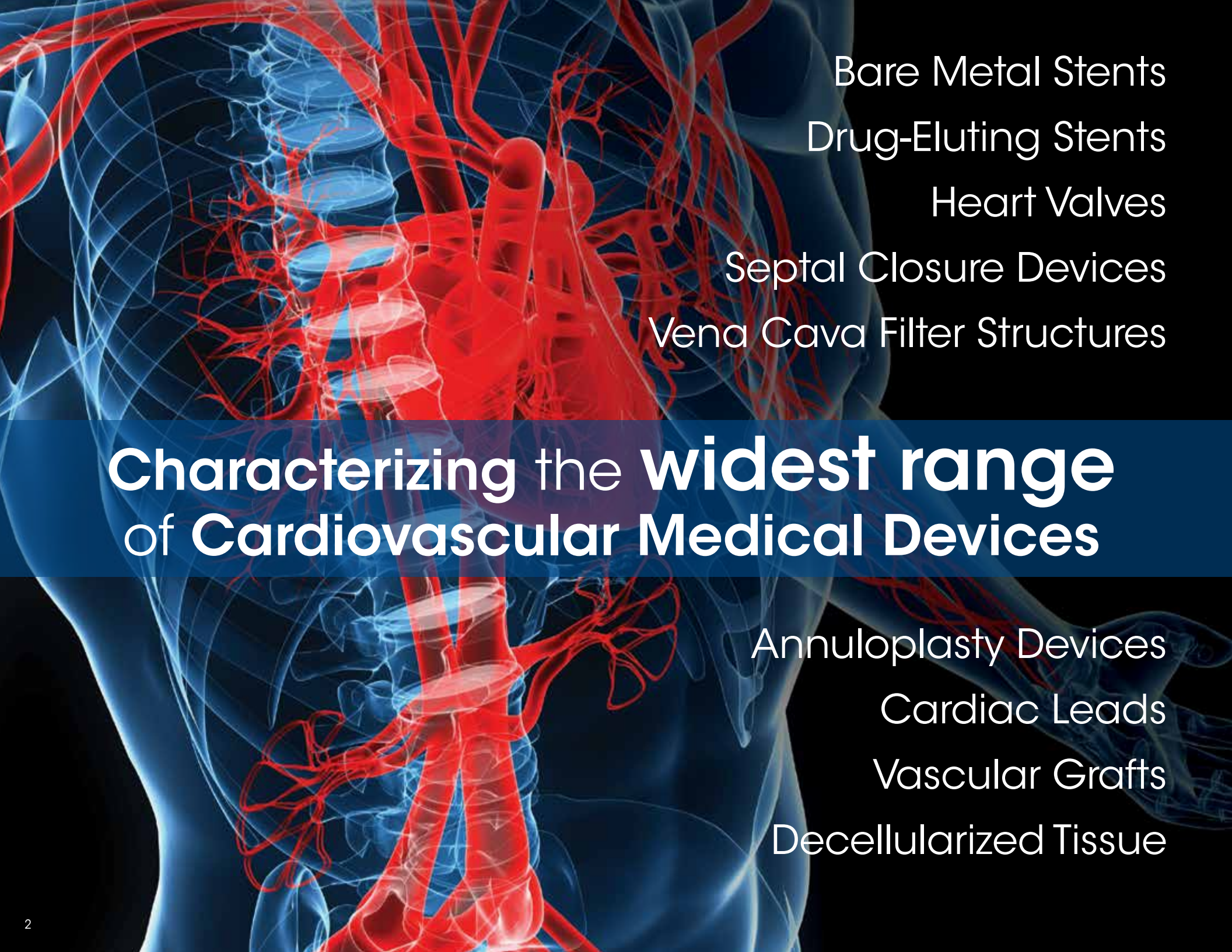


ELECTROFORCE®  
CARDIOVASCULAR  
TEST INSTRUMENTS

# Accelerating development of life-saving technologies



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Bare Metal Stents  
Drug-Eluting Stents  
Heart Valves  
Septal Closure Devices  
Vena Cava Filter Structures

## Characterizing the **widest range** of **Cardiovascular Medical Devices**

Annuloplasty Devices  
Cardiac Leads  
Vascular Grafts  
Decellularized Tissue

Unrivaled  
**dynamic Performance &  
proven Reliability**  
over **billions of cycles**

ElectroForce® Cardiovascular test instruments comprise the most comprehensive portfolio of testing solutions for endovascular and interventional cardiology medical devices. For over 20 years, our test instruments have been used for research, development, and validation of innovative cardiovascular therapies - supporting hundreds of regulatory submissions and approvals.

### **Apply physiologic loading under accelerated conditions to multiple samples**

Test multiple samples simultaneously to increase throughput and satisfy regulatory requirements for confidence of device success

### **Engineered for reliability and durability**

Designed for long-term testing use and experimental repeatability

### **Determine the properties of entire devices and the most delicate device components**

Widest range of displacement, force, and pressure control to meet the most demanding test requirements

Planar Biaxial  
TestBench Instrument

DuraPulse™ Heart  
Valve Test (HVT)  
Instrument

DuraPulse Stent/Graft  
Test (SGT) Instrument

3330 with  
Multi-Specimen Fixture

3510 Axial Drug-Eluting  
Stent Test Instrument

9210 Pulsatile Drug-Eluting  
Stent Test Instrument

9400 Multi-Axial Peripheral  
Stent (MAPS) Test Instrument



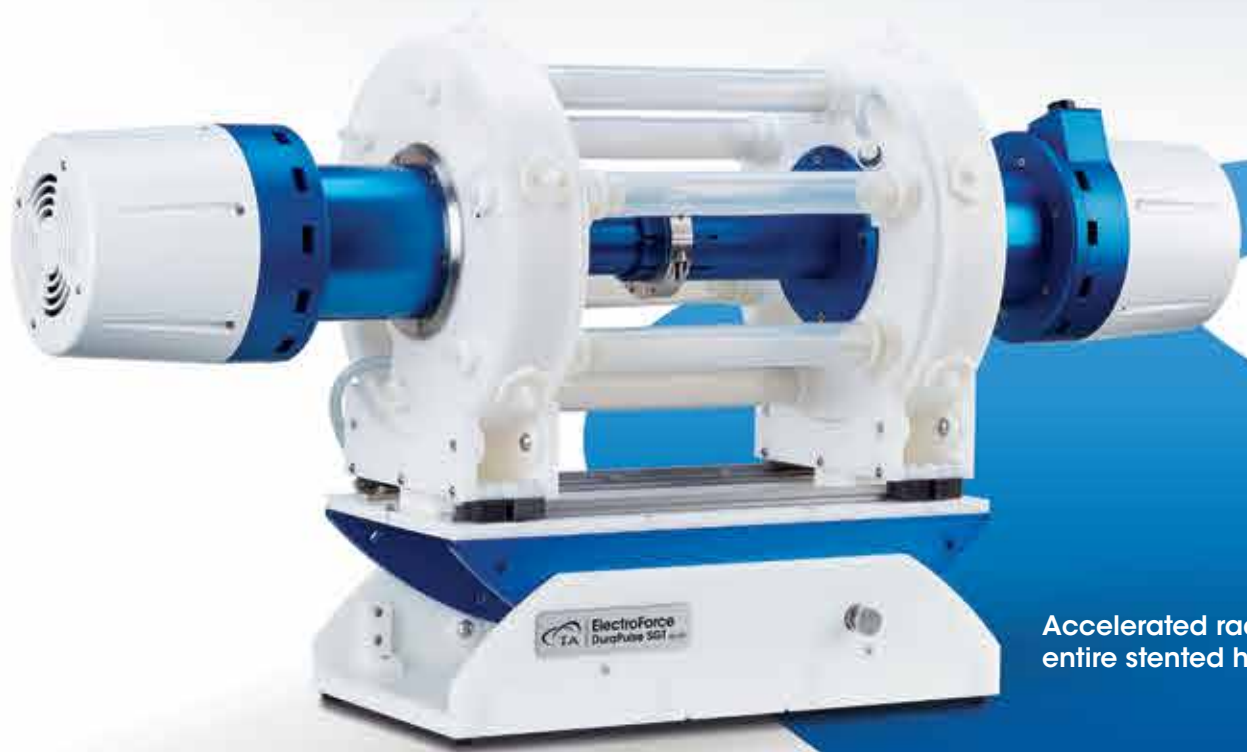
Anisotropic behavior characterization of heart valve leaflet materials



Multi-specimen fatigue of heart valve sub-structures

**TRUSTED** for **TESTING**  
along the...

**ENTIRE  
DEVELOPMENT  
PATHWAY**



Accelerated radial fatigue of entire stented heart valve frame



Accelerated wear testing of complete heart valve device

**Perform fatigue tests at the highest frequencies**

Proprietary electromagnetic motor delivers industry-leading dynamic performance

**Unmatched waveform control and repeatability**

Friction-free technology provides unmatched responsiveness enabling the precise control of displacements, forces, and pressures



**Replicate 10 years  
of device life  
in a matter of weeks!**

**Reliability that won't let you down**

ElectroForce® linear motors integrate a flexural suspension eliminating the need for rolling or sliding bearings that wear out during long-term tests

**The industry's only 10-year motor warranty**

Confidence that your test instrument will continue to perform as device designs evolve

# Pulsatile Fatigue Test Instruments

DURAPULSE™ STENT/GRAFT TEST (SGT) INSTRUMENT

DuraPulse™ stent/graft test (SGT) instruments integrate proprietary ElectroForce® linear motors to apply accelerated pulsatile distentions to stent and stented devices deployed in mock vessels. Meeting or exceeding testing requirements defined by international standards such as **ISO 25539-2** and **ASTM 2477**, DuraPulse SGTs reduce device time-to-market while providing multi-billion cycle reliability.

## Dual-sided pulse generation improves performance and consistency

- Purely symmetric pulsation provided by ElectroForce motors exceeds performance provided by single-sided or simulated dual-sided solutions
- Attain higher peak strains – particularly at higher frequencies
- Generate more uniform strain profiles along mock vessels as test frequency increases

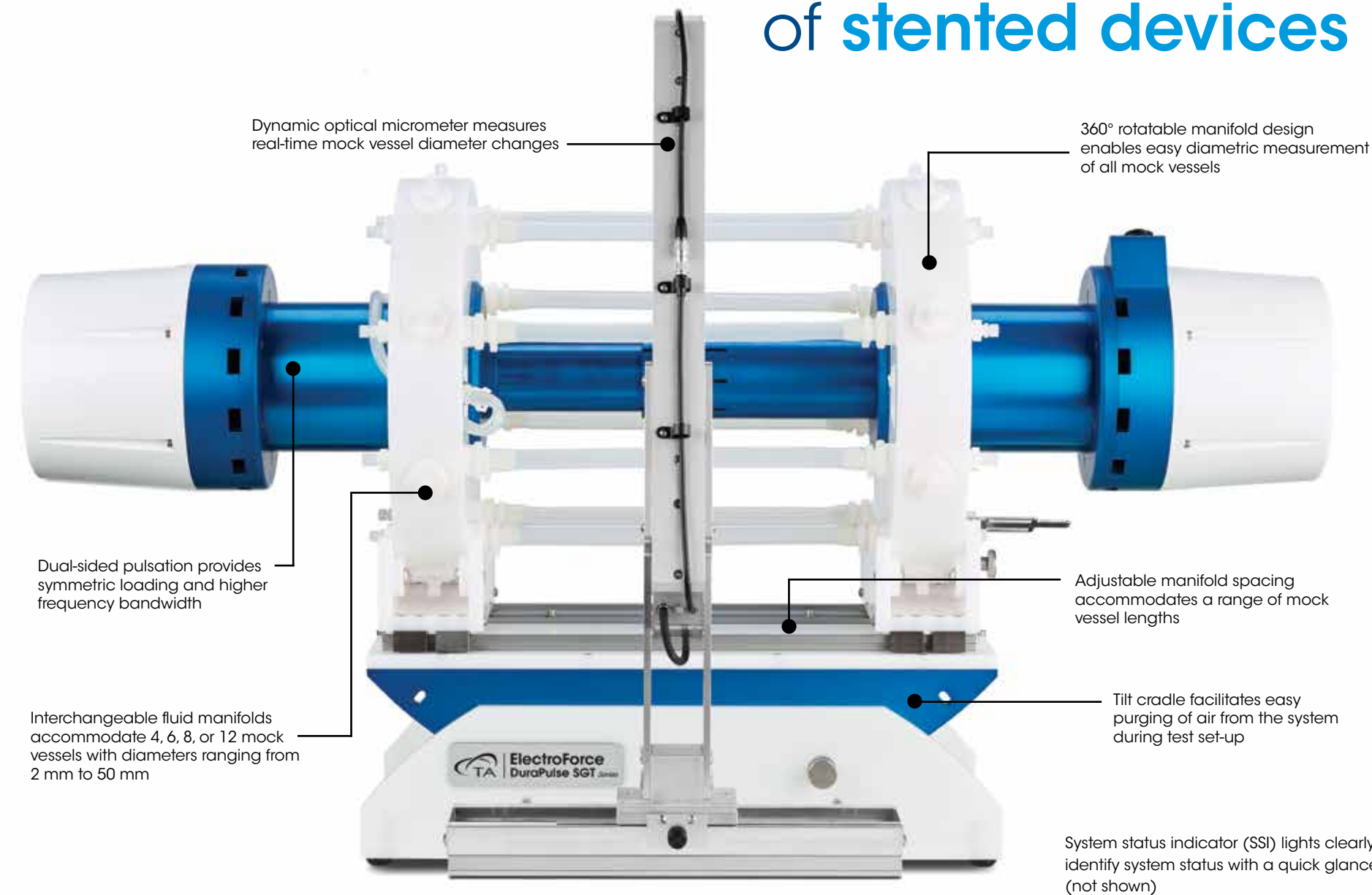
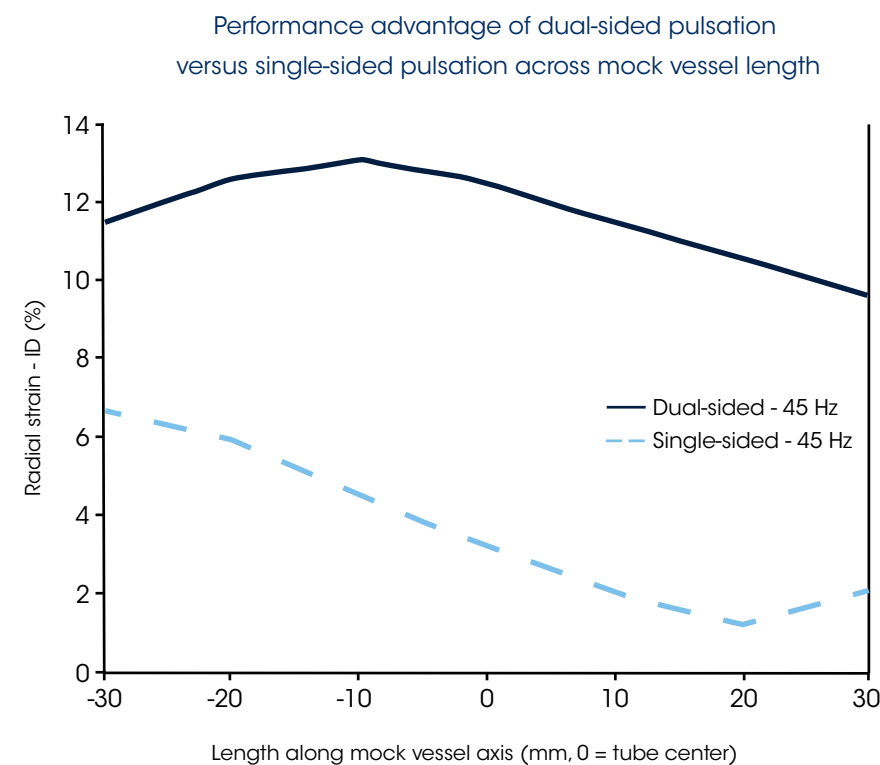
## Accommodate a variety of stented device geometries and sizes

- Device diameters from 2 mm to 50 mm
- Determine the fatigue life of intravascular prostheses such as stents, grafts, heart valve frames, occluders and shunts
- Test with straight and bifurcated tubes, or set-up devices across a curvature with the Pulse-on-Bend accessory

## Flexible software capabilities enable control over a variety of test parameters

- Select between radial strain or pressure amplitude control
- Calculate mock vessel outer diameter (OD) and inner diameter (ID) strain
- Adjust radial strain and frequency without stopping your test

# The industry standard for pulsatile fatigue testing of stented devices



# Pulsatile Fatigue Test Instruments

DURAPULSE™ STENT/GRAFT TEST (SGT) INSTRUMENT

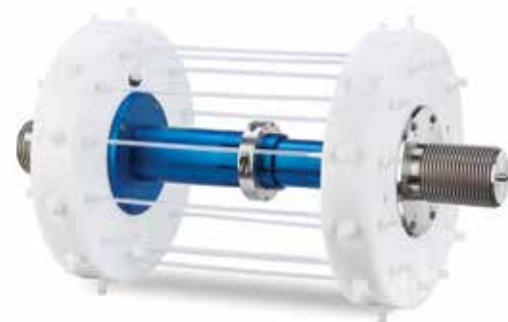


**Interchangeable Manifold Design**

**Increased Flexibility**



**Reduced Capital Investment**



## Specifications

	12-Tube DuraPulse SGT
Number of Sample Tubes (Mock Vessels)	12
Sample Tube ID Range	2 - 10 mm
Sample Tube Length Range (Fitting-to-Fitting)	96 - 180 mm
Operating Frequency Range	1 - 100 Hz
Operating Pressure Range	0 - 385 mmHg
Dimensions (W x D x H) Includes Micrometer Accessory	1.03 x 0.51 x 0.72 m

## 8-Tube DuraPulse SGT

Number of Sample Tubes (Mock Vessels)	8
Sample Tube ID Range	10 - 25 mm
Sample Tube Length Range (Fitting-to-Fitting)	170 - 340 mm
Operating Frequency Range	1 - 100 Hz
Operating Pressure Range	0 - 385 mmHg
Dimensions (W x D x H) Includes Micrometer Accessory	1.21 x 0.51 x 0.72 m

## 6-Tube DuraPulse SGT

Number of Sample Tubes (Mock Vessels)	6
Sample Tube ID Range	25 - 50 mm
Sample Tube Length Range (Fitting-to-Fitting)	99 - 272 mm
Operating Frequency Range	1 - 100 Hz
Operating Pressure Range	0 - 330 mmHg
Dimensions (W x D x H) Includes Micrometer Accessory	1.24 x 0.48 x 0.73 m

## 4-Tube DuraPulse SGT

Number of Sample Tubes (Mock Vessels)	4 (Bifurcated)
Sample Tube ID Range	10 - 18 mm (Iliacs), 18 - 30 mm (Aorta)
Sample Tube Length Range (Fitting-to-Fitting)	152 - 322 mm
Operating Frequency Range	1 - 100 Hz
Operating Pressure Range	0 - 385 mmHg
Dimensions (W x D x H) Includes Micrometer Accessory	1.21 x 0.51 x 0.72 m



# Multi-Specimen Fatigue Test Instruments

3230 AND 3330 MSF INSTRUMENTS



**ElectroForce 3330  
Test Instrument with  
Multi-Specimen Fixture**

**ElectroForce 3230  
Test Instrument with  
Multi-Specimen Fixture**

ElectroForce® multi-specimen fatigue (MSF) test instruments are designed to conduct tension-tension or compression-compression tests for developing fatigue life (s/n) curves for NiTi, CoCr, and SS devices and structures. Available with 12 loading sites, the ElectroForce 3230 and 3330 MSF test instruments perform high frequency, high cycle displacement controlled tests to determine device failure criteria.

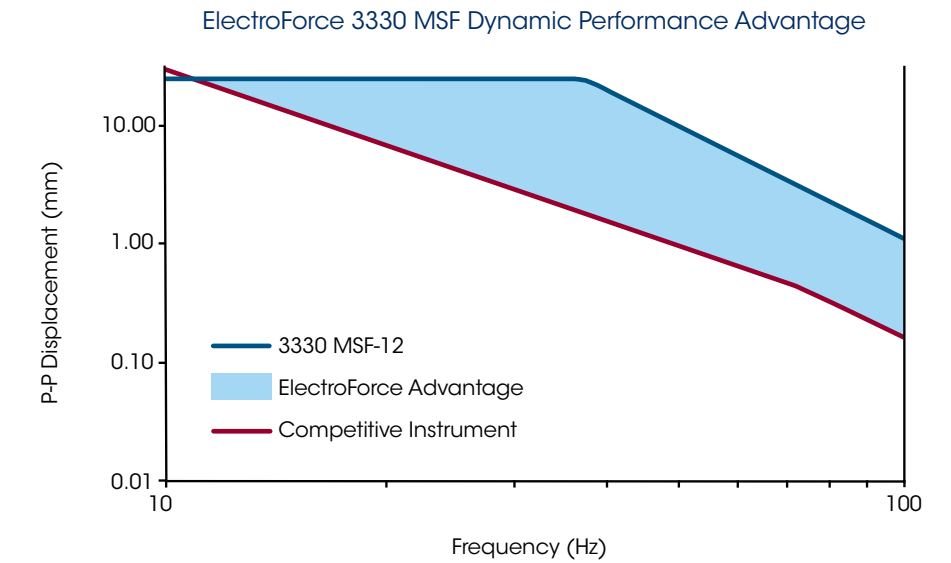
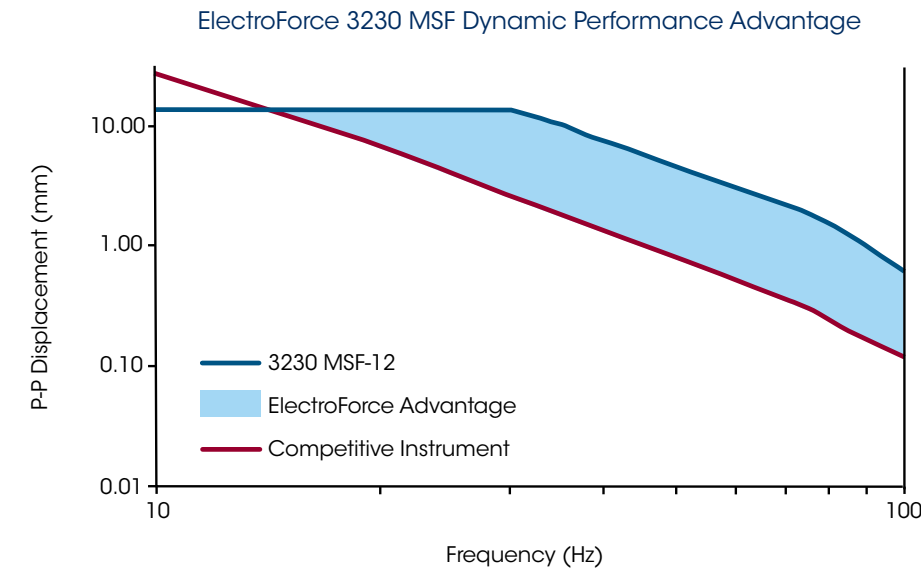
## Unequaled waveform control, frequency and fidelity

- Easily control to micron level amplitudes with high accuracy displacement sensor
- Achieve the highest frequencies in the industry and reduce overall test time
- Automated amplitude control ensures desired amplitudes are achieved at higher test frequencies
- Adjust test parameters without interrupting the test

## Simultaneously test as many as 12 samples

- Twelve independent load cells monitor force at each loading site to detect sample failure
- Up to 20 mm of test space adjustment at each loading site for easy specimen set-up
- 50 mm clearance between loading sites provides sufficient space for device fixtures
- Integrated temperature controlled bath for testing at 37° C

# The proven workhorse for multi-specimen axial fatigue



# Multi-Specimen Fatigue Test Instruments

MULTI-STATION TESTBENCH INSTRUMENT

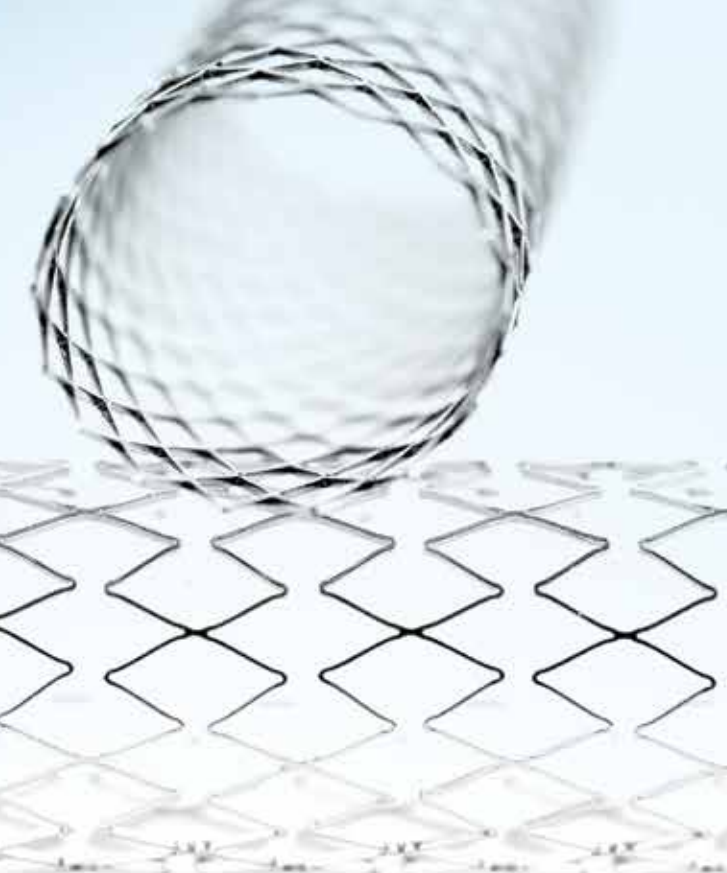
ElectroForce® Multi-Station TestBench instruments combine up to four independently-controlled, compact load frames, controlled from a single computer. Each TestBench instrument can be operated in either force or displacement control, offering the flexibility needed to perform long-term testing on devices or tissues that require stress or strain test conditions.



## Unmatched versatility in a multi-sample testing configuration

- Available in either 2-, 3-, or 4-station configurations with a single shared computer
- Independent control of each station including control mode, waveform, and test frequency
- Position the test instrument vertically or horizontally for additional test set-up flexibility
- Optional saline bath available for performing tests at physiologically relevant temperatures

Test at  
higher frequencies  
to reduce  
time to market

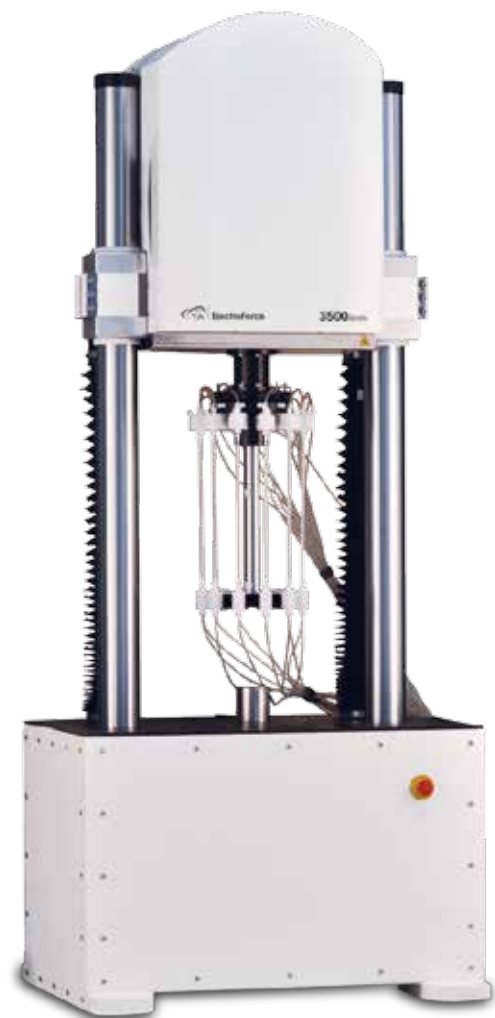


Specifications	3230 MSF	3330 MSF	Multi-Station TestBench
Number of Samples	12	12	Up to 4
Force Capacity Per Site	37.5 N	40 N	200 N
Max. Displacement	13 mm	25 mm	13 mm
Calibrated Displacement Accuracy	±2 µm	±5 µm	±10 µm
Frequency Range	0.01 - 100 Hz	0.01 - 100 Hz	0.01 - 100 Hz
Vertical Test Space	100 mm	100 mm	365 mm
Vertical Test Space Adjustment	20 mm	20 mm	365 mm
Clearance Between Loading Sites	50 mm	50 mm	N/A
Control Mode	Displacement	Displacement	Force or Displacement

# Drug-Eluting Stent Fatigue

AXIAL AND PULSATILE DES INSTRUMENTS

ElectroForce® drug-eluting stent (DES) test instruments support research and development that evaluates coating performance during accelerated testing of coated devices under simulated physiologic loading conditions. The 9210 DES test instrument and the ElectroForce 3510, outfitted with a specialized multi-specimen fixture, combine mechanical loading with flow to determine the behavior of these devices. Each instrument incorporates individual flow loops to ensure proper analysis of particulate elution per sample while easily interfacing with third-party real-time particle counters. In addition, the automated dual-filter design provides continuous particle capture.



## 3510 with Axial DES Multi-Specimen Fixture

The ElectroForce 3510, equipped with a specialized multi-specimen fixture, combines accelerated tensile loading with continuous unidirectional flow to characterize particle loss determination of coated stents.

- Accommodates a large range of stent lengths
- Ergonomic fixture design facilitates deployment of stents for easy test set-up
- Individual sample tension adjustment provides consistent device pre-loading

Specifications	
Number of Samples	12
Lumen Diameter Range	2 - 13 mm
Max. Sample Length	300 mm
Max. Displacement	50 mm
Mean Pressure Range	0 - 300 mmHg
Flow Rate Range	0 - 250 ml/min
Frequency Range	0 - 100 Hz
Temperature Range	Ambient to 37° C

# Accurately capture and count particles during accelerated fatigue

## 9210 Pulsatile DES Test Instrument

The ElectroForce 9210 DES test instrument is capable of monitoring particle loss from endovascular devices under accelerated pulsatile fatigue.

- Dual-sided pulsatile loading provides uniform strain profiles and larger distentions across mock vessels at higher frequencies
- Unique manifold design isolates flow loops from pulsatile loading to ensure more accurate particulate measurement
- Integrated optical micrometer provides direct diametric distention measurements

Specifications	
Number of Samples	12
Lumen Diameter Range	2 - 14 mm
Max. Sample Length	200 mm
Radial Distention Range	2 - 10%
Mean Pressure Range	0 - 300 mmHg
Flow Rate Range	0 - 250 ml/min
Frequency Range	0 - 100 Hz
Temperature Range	Ambient to 37° C



# Multi-Axial Peripheral Stent Testing

9400 MAPS INSTRUMENT

The patented Multi-Axial Peripheral Stent (MAPS) test instrument is the only system available that simultaneously provides the complex loading conditions experienced by peripheral arteries in vivo. Combining accelerated pulsatile fatigue with tensile, bending, and torsion modes of loading in a single test instrument, MAPS can be used to replicate the twisting and bending of the superficial femoral artery that results from motions during walking, running, or jumping. In a similar fashion, the test instrument can be used to simulate the variety of motions that the carotid artery experiences during neck motion.



## Simulate complex in vivo conditions experienced by the peripheral arteries!



### Patented simultaneous multi-modal fatigue testing

- Apply pulsatile distention, extension, bending, and rotation simultaneously or independently
- Eight or twelve mock vessels with an inner diameter range of 3 to 8 mm
- Optional bend bars with various radii replicate anatomical bending conditions experienced within the body
- Available in four system configurations including Bend/Extension, Bend/Extension/Rotation, Bend/Extension/Pulse, and Bend/Extension/Rotation/Pulse

Specifications	Range of Motion	Maximum Frequency
Pulsatile Distention	0 - 5% Strain	60 Hz
Extension	0 - 20% Strain	2.25 Hz <sup>[1]</sup>
Bending	0 - 90 Degrees	2.25 Hz <sup>[1]</sup>
Rotation	0 - 60 Degrees	4.5 Hz <sup>[1]</sup>

[1] When bending, extension, and rotation motions are combined, equivalent waveform frequency is 1.5 Hz.

# Heart Valve Accelerated Wear Testing

DURAPULSE™ HEART VALVE TEST (HVT) INSTRUMENT

Setting the standard for accelerated prosthetic heart valve testing according to ISO 5840 test protocols, the DuraPulse™ Heart Valve test (HVT) instrument is capable of testing surgical or transcatheter heart valves at frequencies greater than 30 Hz. Available in 2-, 4- or 6-station configurations, the DuraPulse HVT provides independent sample control, enabling the removal and inspection of a single device without affecting the continued testing of additional devices.

## Innovative technology that makes your heart (valve) race

- Accommodates a variety of mechanical and tissue valves, including aortic, mitral, pulmonary and tricuspid valves
- Transparent, quick-open chambers provide valve visibility from all vantage points, facilitating high-speed imaging techniques
- Proprietary PeakIQ™ control algorithm optimizes waveform to minimize pressure overshoot
- Dedicated application software reduces overall set-up time and includes interface for quick definition of test and data acquisition parameters

### Specifications

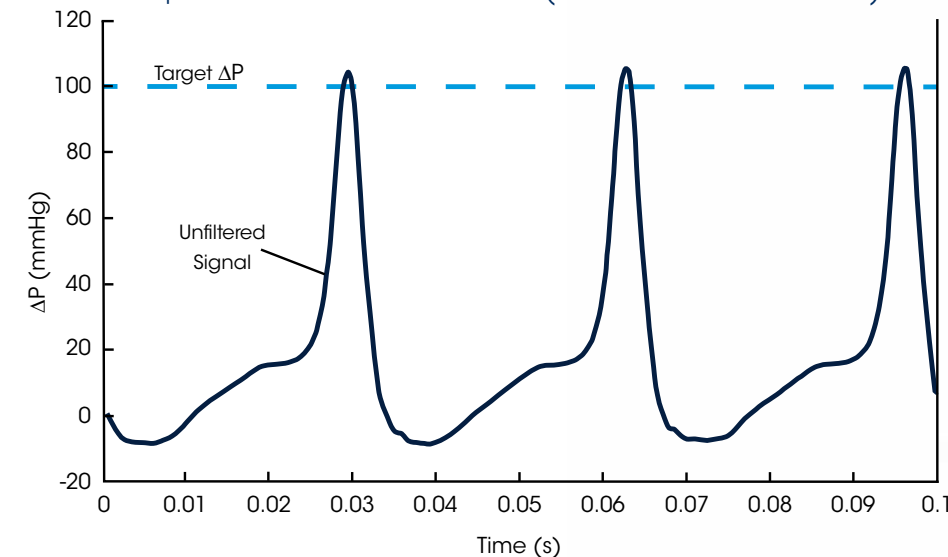
Valve Diameter Range	Up to 40 mm annulus
Valve Types	Mechanical, Tissue, Biomedical
Frequency Range	15 - 30 Hz
Valve Differential Pressure Range	Up to 500 mm Hg
Number of Samples	2, 4, or 6 samples



**DuraPulse  
2-station HVT**

# High-frequency performance and pressure control previously unachievable in heart valve durability testing

DuraPulse HVT provides superior pressure control to achieve delta pressure with minimal overshoot (27mm aortic valve at 30 Hz)



**DuraPulse  
6-station HVT**

**DuraPulse  
4-station HVT**

# Biomaterial Characterization

PLANAR BIAxIAL TEST INSTRUMENT

Perhaps the most versatile test instrument available, the ElectroForce® Planar Biaxial can be used to characterize the material properties of biomaterials and medical devices, such as pericardium or heart valve leaflets. Available in 2- and 4-motor configurations, this system can assess the anisotropic behavior of materials to support development of constitutive models, compare the mechanical properties of synthetic materials to biologic tissues, or perform fatigue tests.

## Unparalleled performance for biomaterial and soft tissue characterization

- Control each motor independently or easily synchronize opposing motor to apply equivalent loading
- Select the appropriate feedback channel for your test: displacement, force, or strain control

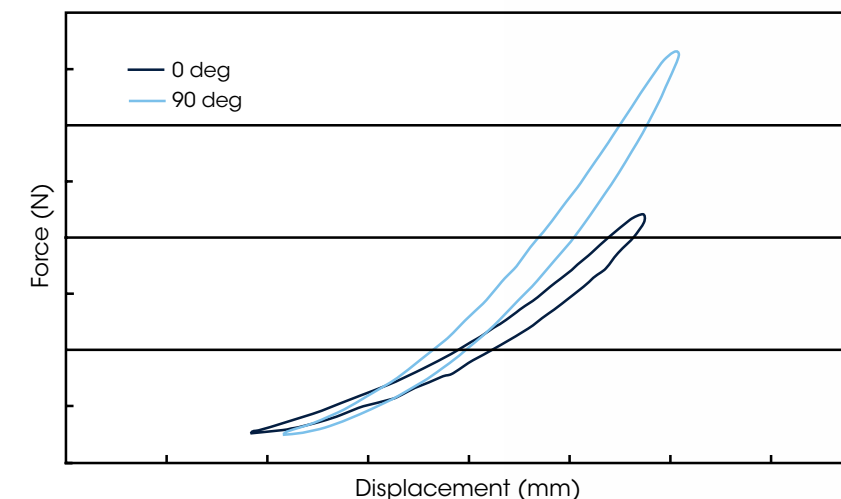
## Modular platform and breadth of accessories provide versatility as needs change over time

- Torsion and Extended Stroke (ES) motor can be incorporated to expand available testing modes
- Temperature-controlled baths and sterile bioreactor chambers facilitate testing in appropriate environmental conditions
- Capture non-contact 2D strain measurements via an integrated Digital Video Extensometer (DVE)

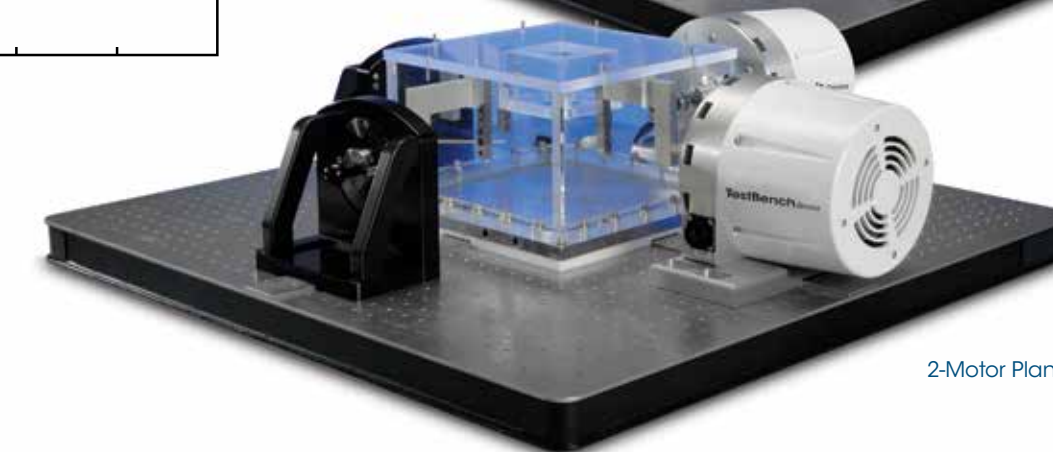
Specifications	2-Motor Planar Biaxial	4-Motor Planar Biaxial
Max. Displacement (per axis)	13 mm	26 mm
Max. Dynamic Force (per axis)	200 N	200 N
Max. Static Force (per axis)	120 N	120 N
Frequency Range	0.001 - 100 Hz	0.001 - 100 Hz
Baseplate Dimensions	914 mm x 914 mm x 50 mm	914 mm x 914 mm x 50 mm

# Superior control and dynamic performance to characterize anisotropic material behavior

Anisotropic behavior of heart valve leaflet material under equibiaxial stretch



4-Motor Planar Biaxial



2-Motor Planar Biaxial

ElectroForce® test instruments can be integrated with a variety of upgrade options, specimen fixtures, and measurement sensors to make your test yield the most physiologically-relevant results.

## Pulsatile Test Instrument

- Manifold Sets (available for DuraPulse™ SGT)
- Silicone Tubes (Mock Vessels) – various geometries available
- Optical Micrometer
- Pressure Control Assembly (PCA)
- Pressure Sensors
- Spare Bellows
- Spare Fittings

## Multi-Specimen Fixture and Planar Biaxial Test Instrument Accessories

- |                              |                                       |
|------------------------------|---------------------------------------|
| Tension Grips                | Saline Baths                          |
| Compression Platens          | Digital Video Extensometer [1]        |
| 3- and 4-Point Bend Fixtures | Planar Biaxial BioDynamic Chamber [1] |
| Hook Grips [1]               | Torsion Motor [1]                     |
| Force Sensors                | Extended Stroke Motor [1]             |
| Accelerometer [1]            | Air Bearing                           |

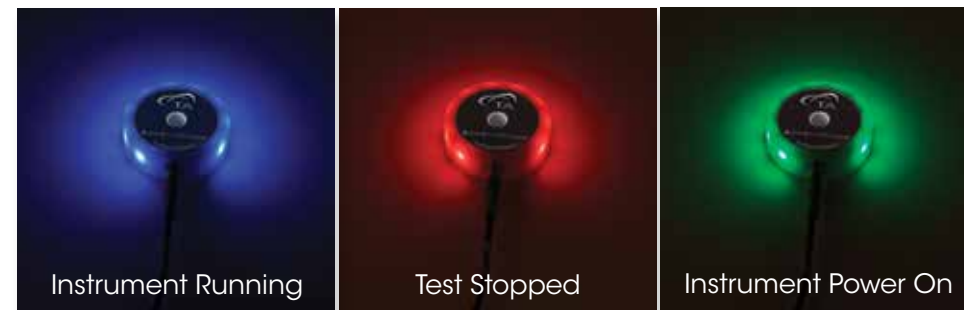
## General Accessories

- System Status Indicator (SSI) Lights
- Uninterruptible Power Supply (UPS)

[1] For use on TestBench and Planar Biaxial test instrument only



Pressure Control Assembly (PCA)



System Status Indicator (SSI) Lights



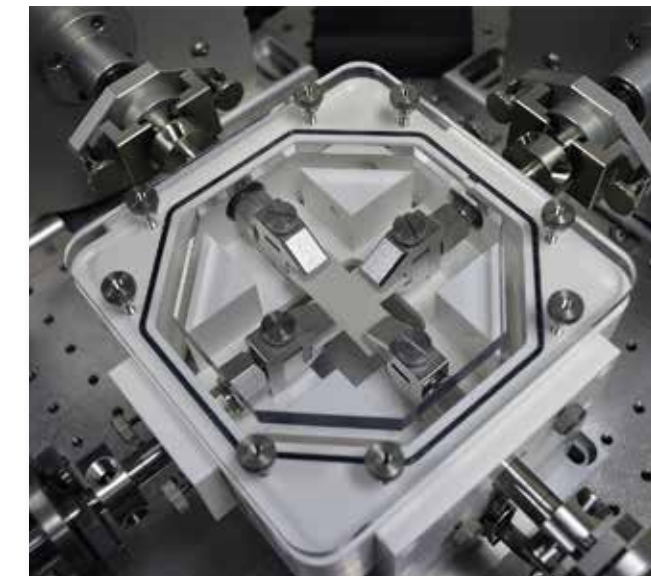
Tensile Grips



Digital Video Extensometer (DVE)



DuraPulse SGT Manifold Sets and Mock Vessels



Planar Biaxial BioDynamic® Chamber



Optical Micrometer Assembly

# The Most Flexible Control System Available

The WinTest® digital control system is a single, comprehensive package that provides an intuitive user interface, closed-loop waveform control, and data acquisition.

- Powerful waveform generation tools to quickly create periodic waveforms for fatigue tests and block grouping to create more complex tests
- Integrated data acquisition algorithms including timed data acquisition, peak/valley capture, level-crossing and additional techniques
- Advanced controls including multi-channel synchronization of phase and amplitude, and cross-channel compensation
- Calculated channels to provide real-time mathematical calculations for measurement channels
- Additional options include:
  - External Waveform Input
  - Dynamic Mechanical Analysis
  - Dynamic Link Libraries

ElectroForce® cardiovascular device test instruments incorporate software applications that guide you through protocol development, making it easier to define test conditions and reduce set-up time.

## DuraPulse™ SGT Application Software

- Select between strain amplitude and pressure amplitude adaptive control modes to ensure the achievement of user-defined end levels
- Measures the OD strain of the tube and determines the minimum/maximum values of the ID of the mock vessel and associated strain percentage in accordance with calculations identified in ISO 25539
- An intuitive data acquisition scheme simplifies collection of maximum and minimum diameter and strain data over a user-defined time for the duration of the test

## DuraPulse HVT Application Software

- Independent station windows provide unique set-up, status and real-time pressure versus time plot windows for each device being tested
- Real-time scope displays auto-scale on both axes depending on selected test parameters
- Key parameters are displayed per sample, including: % of cycles above target pressure, peak pressure duration %, pressure across the valve, total number of cycles performed, and total number of cycles that pass desired test criteria
- Collect predefined sets of data using the "Timed Snapshot" function or use the "Snapshot Now" feature to instantaneously capture what is shown on the screen

## Multi-Axial Peripheral Stent Application Software

- Easily define test conditions for multiple movers, including bend angle, extension, rotation, and bending radius

## WinTest TuneIQ®

- TuneIQ Software uses advanced proprietary algorithms to simplify the tuning process
- Provides excellent re-creation of system program waveforms, allowing for improved test control and ultimately better test results
- Advanced methods that analyze the dynamic response of the system, sensor and sample for optimal control, superior to a single-point measurement that doesn't factor in sample dynamics

## DuraPulse PeakIQ™

- PeakIQ pressure algorithm ensures optimal test conditions as heart valves change over time
- Automatically adjusts command to optimize peak pressure while maintaining desired threshold for peak pressure duration as desired for ISO 5840
- Prevents high-pressure spikes during valve closing that may lead to unnecessary valve damage

## HADS (High Accuracy Displacement Sensor)

Available on 3230/3330 MSF test instruments, HADS provides up to 1nm resolution and micron level of accuracy.

- Class A, ASTM E2309 calibrated accuracy
- Extremely low noise to eliminate the need to filter data
- High responsiveness extends the dynamic performance of system
- Single displacement channel to provide both absolute and high resolution measurements



# Industry-Leading Sales & Support

TA Instruments' leadership position results from the fact that we offer the best overall product in terms of technology, performance, quality, and customer support. While each is important, our demonstrated commitment to after-sales support is a primary reason for the continued loyalty of our customers. To provide this level of support, TA Instruments has assembled the largest worldwide team of field technical and service professionals in the industry. Others promise good service. Talk to our customers and learn how TA Instruments consistently delivers on our promise to provide exceptional service.

With direct support staff in **24 countries** and **5 continents**, TA Instruments can extend its exceptional support to you, wherever you are.





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