



The global leader in **multi-axis** force measurement and testing machines



New Six D.O.F Joint Simulator Enables More Realistic Biomechanics Research and Implant Life Testing

AMTI's VIVO™ brings new life to joint motion simulation, dramatically increasing simulation realism of kinematic and kinetic in-vivo conditions. VIVO provides accurate robotic joint motion simulation of daily activities for knee, hip, shoulder, temporomandibular, elbow, ankle and spinal joint motions.



The VIVO system provides a fully servo-controlled six degree of freedom environment in which to test total joint replacements as well as biological joint specimens. Capable of performing short-term kinematic and long-term durability evaluations, the configurable system can have from one to three joint test stations. Each test station is equipped with six servo-hydraulic actuators that can be programmed to act independently or synchronized to provide the same kinematic activity for multiple test stations.

Degree of Freedom / Axis	Specification
Axial load	±4500N
Flexion/Extension	±100 degrees
Internal/External rotation	±40 degrees
Y-Axis (AP) translation	±25 mm
X-Axis (ML) translation	±25 mm
Abduction/Adduction or Valgus/Varus	±30 degrees

VIVO enables more realistic implant wear testing than ever possible before. Its six degrees of freedom, broader range of motion, and soft tissue constraint system enable testing of real-world implant failure modes. These include testing of adverse edge loading conditions, micro-separation, stem and cup impingement, and joint subluxation.

Advanced Design for More Accurate Simulation

The unique actuator design provides a floating instant center of rotation on the lower platen which eliminates joint alignment issues found in legacy test machine designs. VIVO saves test sample preparation time and enables more reliable life testing through its flexible, programmable software implementation of soft tissue constraints, which eliminate the need to mount additional hardware to each test specimen.

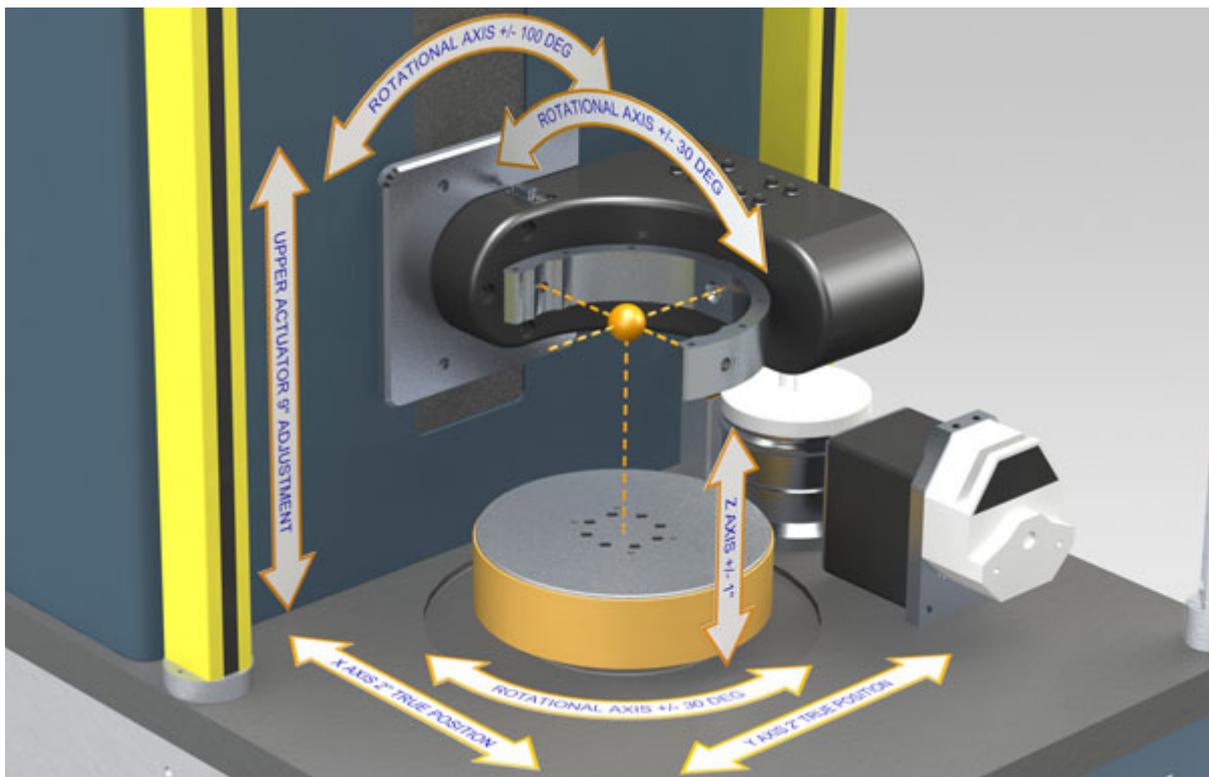
The HEART OF VIVO'S SIMULATION TECHNOLOGY: THE control system

VIVO'S control system is the most sophisticated robotic control system available today for joint motion simulation. AMTI's extensive biomechanical simulation experience coupled with the most recent advances in control technology has culminated in the new VIVO control system. The control system provides two modes of operation:

- Joint Coordinate System mode - implements the Grood and Suntay Joint Coordinate System (JCS). In JCS mode, control inputs and data outputs are resolved to represent forces and displacements. The JCS has been adopted by the International Society for Biomechanics and ISO.
- Machine Coordinate System mode - for more general purpose work, this mode provides control of kinematics and kinetics relative to an orthogonal world coordinate system.

The control system accepts two types of inputs: six reference waveforms, or temporal signals representing either the kinematics or kinetics of a particular physiologic activity.

Each test station is equipped with six precision displacement sensors to monitor translations and rotations of the joint components, and a six-axis force sensor to monitor the contact forces and moments.



VIVO'S six degrees of freedom may be controlled independently in force / torque control or displacement / rotation control. For example, a knee test can have the flexion axis in displacement control; joint compression, anterior-posterior, and medial-lateral motions in force control; and varus-valgus along with internal-external rotation in torque control.

SOFT TISSUE SIMULATION ENHANCES REALISM

The implanted joint is a composite of natural biological structure and artificial engineered structure. Understanding the kinematics, kinetics and durability of the joint structure requires

simulation in a realistic environment. To facilitate such studies the VIVO control system provides two simulation scenarios.

- Heuristic soft tissue constraint model - permit testing to today's ISO and ASTM standards as well as to proposed ASTM standards of the future.
- Multi-fiber ligament model - enables the development of testing for sensitivity to ligament balance and post-surgical ligament condition while providing the complex inter-axis coupling exhibited by the natural knee.

AMTI's heuristic soft tissue model (Patent number: 7823460) simulates the constraint characteristics of the natural joint using a two dimensional model for each of the controlled axes. The selected model input variables may be chosen from any of the stations' measured variables (either motions or forces). For example, in the case of knee simulation, constraint characteristics for anterior-posterior translation may be programmed to be dependent on anterior-posterior displacement and internal-external rotation or alternatively flexion-extension. This two-input constraint model permits characterization based on the most significant inter-axis coupling of the joint.

To provide a more realistic soft tissue constraint model that accounts for the complex interactions in-vivo, VIVO'S multi-fiber ligament model uses a database of ligament fiber elements that are user-defined or selected from a library. In the database each fiber is represented with the coordinates of a proximal and distal insertion site, an elastic tangent stiffness, a viscoelastic time constant and a reference strain. During operation, VIVO measures the relative positions and orientations of the joint components and computes the positions of the fiber insertion sites. The strain in those elements is determined, and from the strain and strain rate the tension in each fiber element is then determined. The overall joint constraint forces are then resolved from the combination of individual ligament fibers' forces.

ADVANCED TEST SPECIMEN PROTECTION AND SAFETY

VIVO sets a new standard of protecting your valuable test investment. Every physical quantity is continuously monitored and corrective or emergency actions may be programmed or enabled in the event of a fault. This rapid response prevents inadvertent specimen damage during setup as well as during operation of the machine.

Safety is enhanced with system control interlock circuits and a light curtain safety interlock that encloses the working volume of the machine.

DESIGNED FOR LONG SERVICE LIFE

For compactness and maximum service life, VIVO utilizes an all hydraulic actuator design. The main bearing of the system is hydrostatically supported to provide low friction, more accurate control, and long life. AMTI's unique seal-less actuators reduce maintenance downtime and provide maximum service life. A separate hydraulic power unit is required for operation.

VIVO PERFORMS A WIDE RANGE OF ISO AND ASTM TESTING STANDARDS

VIVO is capable of performing tests to ISO 14242-1, ISO 14243-1, ISO/CD 14243-3, ISO 14879-1, ISO 16402, ISO 18192-1, ISO/TR 22676, ISO 7206-4, ASTM F1223-08, ASTM F2790-10, ASTM F2694-07, ASTM F2777-10, ASTM F2028-08, and ASTM F1829-98.

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