AMTI

FORCE AND MOTION

Two of the ADL Knee Simulator's six stations

ADL Knee Simulator

Specifications

ADL-Knee-06-08 specifications

General [1]		
Test stations	**Specification**	**Comment**
Six stations	See tables below	Arranged in two banks of three motion-linked stations with independent shutoff valves at each station
Load soak stations	**Specification**	**Comment**
Four stations	Active load soak	
Axial load	4500N (1000lb)	±25 mm (±1 inch)
DOF	**Specification**	**Comment**
Axial load	4500N (1000lb)	±25 mm (±1 inch)
Flexion	±100 degrees	80 N-m (700 in-lb)
IE rotation	±20 degrees	40 N-m (350 in-lb)
AP translation	±25 mm	2000 N (450 lb)
ML translation	±6 mm	Free motion
Valgus rotation	±7 degrees	Free motion
Actuator type	**Specification**	
Axial load	Servo-hydraulic	
Flexion	Servo-hydraulic	
IE rotation	Servo-hydraulic	
AP translation	Servo-hydraulic	
Control feedback	**Typical method**	**Comment**
Axial load	Fz load cell	Force control
Flexion	Angle sensor	Displacement control
IE rotation	Angle sensor/Mz torque	Torque or displacement control
AP translation	Position sensor/Fy force	Force or displacement control
Load cells	**Specification**	**Comment**
Six independent load cells	1 per station	
Channels	6 DOF per station	Fx, Fy, Fz, Mx, My, Mz
Type	Strain gage	Amplifiers included in controls
Physical specifications	**Specification**	
Length	206 cm (81 in)	
Width	100 cm (39 in)	
Height	168 cm (66 in)	
Weight	1360 kg (3000 lb)	
Hydraulic system (quoted separately)	**Specification**	**Comment**
Type	External HPU	Required
Pressure	800 psi	Required
Required flow	15 GPM	Required
Oil temperature	38 °C	Recommended temperature at inlet
Power requirement [2]	**Specification**	**Comment**
Electric	115 VAC, 20 Amp	1 phase, 50/60 Hz

Dynamic performance			
Item	**Maximum repetition rate (repetitions/second) [3]**		
Controller	30 Hz		
DOF	**Typical repetition rate (repetitions/second) [3]**	**Maximum spectral content (Hz) [4]**	**RMS error (% FS) [5]**
Axial load	1.0 Hz	7 Hz	< 1 %
Flexion extension	1.0 Hz	7 Hz	< 1 %
IE rotation	1.0 Hz	5 Hz	< 1 %
AP translation	1.0 Hz	5 Hz	< 1 %

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Measurement instrumentation			
Data acquisition	**Channel**	**Range**	**Comment**
Data rate	All channels	10-1000 samples/sec	User selection
ADC resolution	All channels	16 bit	
Digital filters	All channels	10-500Hz	User selection
Anti-aliasing filters	All channels	360 Hz	
Strain gage conditioning	**Channel**	**Range**	**Comment**
Gain	All channels	1000, 2000, 4000	Jumper selection
Excitation	All channels	10 Volt	
Multi-axis load cell – knee	**Channel**	**Range**	**Sensitivity**
Axial load	Fz	4400 N	0.08 µV/V•N
AP force	Fy	4000 N	0.32 µV/V•N
ML force	Fx	4000 N	0.32 µV/V•N
Flexion moment	Mx	200 Nm	18 µV/V•Nm
Valgus moment	My	200 Nm	18 µV/V•Nm
Axial moment	Mz	100 Nm	13 µV/V•Nm
Angle and position	**Channel**	**Range**	**~Resolution**
Axial position	VP	38 mm	0.1 mm
Flexion	Flex	±100 °	0.1°
IE rotation	IE	±20 °	0.1°
AP translation	AP	±25 mm	0.1 mm
Other sensors	**Channel**	**Comment**	
Serum temperature			
Oil temperature			
Fluid level	High/low	Safety shutoff if leak detected	
Hydraulic pressure			
Cal amp input			

Environmental conditioning for specimens		
Specimen fluid recirculation	**Specification**	**Comment**
Pump	100 ml/min	60 RPM peristaltic pump with #25 silicone tubing
Reservoir	500 ml	Stainless steel tank
Fluid level	High/Low	Magnetic sensor/float
Specimen fluid temperature	**Specification**	**Comment**
Temperature controller		Heater/chiller
Chilling	500 watts	
Heating	800 watts	
Power		115 volts, 12 amps
Specimen fluid	**Specification**	
Suitable fluids	Bovine serum, saline solution, water	

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Control system			
NetControl interface	**Specification**	**Comments**	
Supplied computer hardware	One set per bank	Windows XP PC, monitor, keyboard, mouse	
Ethernet connection	10 mbps	Coaxial cable	
Real-time controller	**Channels**	**Range**	**Comments**
DSP controller		AD 2181	
Update rate		2000 Hz	
Output channels	16	± 10 volt	
Input channels	36	Bridge inputs	Strain gage
Analog inputs	30	± 10 volt	High-level analog
Digital inputs	8	TTL	Digital I/O
Control modes	**Channels**		
PID	16		
Gain scheduling	16		
Adaptive Control	16		
Virtual Soft Tissue	8		
Nested loops	8		
Waveform generator	**Channels**	**Range**	**Comments**
Channels	8-16		
Repetition rate		0.01 to 30 Hz	
Programmable		256 points	Interpolated
Event monitor	**Channels**	**Specification**	**Comments**
Threshold trigger	16		Rising or falling edge
Response time	All channels	0.0005 seconds	
Programmable response	All channels		Soft stop, hold, shut down
Digital outputs	**Channels**	**Update rate**	
Reference waveforms	8-16	2000 Hz	
Servo drive signals	8-16	2000 Hz	
Soft tissue constraint	8	2000 Hz	
Sum signals	8	2000 Hz	
Digital loop filters	**Channels**	**Update rate**	
	16	30-1000 Hz	

[1] Specifications may change without notice.

[2] The system is normally delivered configured for the indicated power requirements. If your available power differs in phase or voltage, please contact AMTI. The system requires cooling water for operation. This is usually available from your laboratory's infrastructure – if not available, please contact AMTI for additional information on manufacturers of suitable chillers.

[3] The repetition rate corresponds to the maximum rate at which satisfactory performance will be achieved running the ISO standard gait cycle waveforms for knee testing. This is a somewhat subjective indication of dynamic performance. Typically, overall tracking performance is reduced with higher frequency of operation.

[4] The ISO waveforms contain spectral content in considerable excess of the fundamental driving frequency. Analysis of these waveforms indicates that tracking performance at a 1 Hz repetition rate is excellent up to the indicated frequency.

[5] The RMS error provides a measure of the simulator's tracking performance (the extent that the machine's outputs differ from the target inputs). These values are typical for testing at a 1 Hz repetition rate while running the ISO waveforms and represent standard results while evaluating conventional prosthetics using AMTI's Adaptive Control Technology (iterative learning control algorithm). Different prosthetic devices or conditions may result in an increased or decreased tracking error.