Texas Department of Transportation Specifications for a 2500 kN (550,000 lbs) Test System And Construction Materials Test Packages

INTRODUCTION AND VENDOR QUALIFICATIONS

1.0 Basic Requirements and Vendor Capabilities

1.1 This is a purchase specification for a new 2500 kN (550,000 lbs) uniaxial construction materials test system.

1.2 The system shall be installed on site at the Texas Department of Transportation.

1.3 To ensure operating safety and mechanical compatibility, all major system components, must be manufactured and assembled by the supplier, and integrated by the supplier into a functioning system.

1.4 Reference lists, showing a significant installed base of similar equipment and a history of satisfactory delivery performance, must be provided.

1.5 The requested software must be developed by the system vendor, not a third party, to facilitate response to technical questions, and to provide continuity for future upgrades.

1.6 To minimize system downtime and facilitate the repair or replacement of defective or damaged parts, vendors must provide repair service and inventoried standard product spare parts within 72 hours.

1.7 To facilitate identification of parts that may require recall and repair or replacement under warranty by the vendor, a parts serialization and parts tracing service must be in place. A maintenance contract for both hardware & software must be offered.

1.8 Information regarding corporate size, history, and projected financial stability must be provided (a corporate annual report of equivalent is requested) and will be a factor in awarding the contract due to the likely need for future system service, and software and hardware upgrades.

1.9 The vendor may be required to store the system for a nominal period of time before delivery and acceptance. The vendor shall provide rates or fees, broken down into weekly and/or monthly segments, associated with storage costs as part of the bid package.

2.0 Vendor Response

2.1 All vendors shall include a line-by-line response to each paragraph number of this specification in addition to a quotation. A "comply" response indicates full compliance with every aspect of the specification. A "deviation" or "equivalent" response must include a complete technical explanation for the offer to be considered.

TEST SYSTEM DESCRIPTION

3.0 2500 kN (550,000 lb.) Load Frame

3.1 The system load frame shall be designed for static and dynamic testing and have a dynamic force rating of 2500 kN (550,000 lb.) in both tension, compression and through zero testing.

3.2 The vertical test space as measured from actuator rod end to the system load cell shall be a minimum of 3 meters (118 inches). The t-slot baseplate shall be approximately 1 meter wide by 1 meter deep.

3.3 A hydraulic actuator having a minimum tension-compression fatigue force rating of 2500 kN (550,000 lb.) shall be mounted in the crosshead of the load frame. A base mounted actuator configuration is not allowed due to facility construction, ease of use and future testing requirements. The actuator shall be equal-area double-acting with a total stroke of at least 150 mm (6 inches). The actuator bearings shall not be hydrostatic.

3.4 The load frame shall include hydraulically operated crosshead lifts and locks allowing infinite position adjustment of the crosshead/actuator assembly relative to the base platen. Hydraulic lift and lock controls and emergency stop switch shall be mounted to the front of the load frame base structure. The load frame shall provide vertical specimen and fixturing space sufficient for the required test accessories.

3.5 The actuator shall have an internally mounted LVDT type displacement transducer coaxially mounted in the actuator for measuring the full range of actuator displacement.

3.6 An off/low/high controlled hydraulic service manifold shall be directly mounted to the system actuator. The service manifold shall include pressure and return line accumulators to minimize pressure ripples. The manifold shall include provisions for mounting two servo valves.

3.7 Two 15 GPM, two-stage servo valves shall be mounted to the system hydraulic service manifold for dynamic testing. A flow-selection/shut-off valve shall permit isolation of the one servo valve. Rated flow of the servo valve shall be based on a 1000 psi pressure drop across the servo valve.

3.8 The load frame shall include a load cell with a dynamic-rated capacity of +/-2500 kN (550,000 lb.) with a static overload capacity of 150% without mechanical failure. Load cell maximum errors shall not exceed the following specifications:

non-linearity	0.10% of full scale
hysteresis	0.10% of full scale
repeatability	0.03% of full scale

4.0 Hydraulic Subsystem

4.1 The system shall include an energy efficient, variable volume hydraulic power supply (HPS) capable of supplying not less than 113 lpm (30 GPM) at 60 Hz power of hydraulic fluid at 20.7 Mpa (3000 psi) continuous duty pressure. In addition, the HPS shall include a pressure-reducing valve for operating the HPS at selectable pressures below 3000 psi.

4.2 The HPS motor shall be three-phase, 440V 60Hz.

4.3 The HPS shall be water cooled for maintaining hydraulic fluid operating temperatures at less than 52 degrees C (125 degrees F). A water-regulating valve shall be included to reduce the operating cost of the HPS.

4.4 Provisions shall be included for remote high/low/stop function control. Fail safe mechanisms shall be included with the HPS to prevent operation when either over temperature or low oil level conditions exist.

4.5 The fluid reservoir capacity of the HPS shall be at least 340 liters (90 gallons) to ensure ample residence time of the fluid in the reservoir to remove trapped air and allow adequate cooling. The HPS shall provide fluid filtration of at least 3 microns absolute. The HPS shall be shipped with its normal fill of Mobile DTE 25 hydraulic fluid.

4.6 All hoses (pressure, return and drain, etc.) and cables shall be included to install the pump at a location 30 feet (horizontal) from the testing machine.

4.7 Delta Y starter shall be included.

4.8 The free field noise level shall be less than 63dB(A) when operating at optimum duty pressure.

4.9 All electrical controls and motors shall be UF rated.

5.0 Hydraulic Grip Supply

5.1 The grip supply shall be a separate, self-contained hydraulic pump system, capable of providing 69 Mpa (10,000 psi) pressure.

5.2 There shall be separate, functioning control valves for upper and lower grips, which allow for easy, manual pressure adjustments.

5.3 The grip supply shall be designed to operate continuously.

5.4 The grip supply system shall be fully integrated and installed and shall be part of the on-site demonstration.

6.0 Servo Controls

6.1 General Configuration

6.1.1 To facilitate automated testing, a personal computer, which is fully integrated into the controls system, shall provide the main operator software interface to the test system.

6.1.2 Servo hydraulic closed loop control shall be provided by the use of a multi-station, multi-channel digital controller, which provides complete control of the servo-loop, data acquisition, and function generation. All hardware adjustments and settings are to be controlled through software.

6.1.3 A control panel, which is separate from the main controls, shall be provided at the load frame. This control panel shall provide local actuator and hydraulic control directly at the load frame.

6.1.4 A personal computer meeting the requirements of 6.8 shall be included with the control system. The warranty for the computer shall be concurrent with the warranty for the rest of the test system.

6.2 Digital Closed Loop Controller

6.2.1 A digital controller shall be provided which provides for closed loop control of the system using PIDF control algorithms. The digital controller must have the option to be

upgraded to control up to four stations and up to 8 channels. To facilitate testing productivity, PID tuning parameters shall be automatically set by the system software prior to testing.

6.2.2 For current and future testing requirements, an automatic phase and amplitude control algorithm shall be provided to match commanded and achieved sine waveform phase and amplitude relationship between control channels without adjustment of PID parameters.

6.2.3 A feed forward gain control algorithm ("F") shall be available to provide improved system response when testing non-linear materials.

6.2.4 The controller shall have the capability to control from a calculated feedback signal created by mathematically combining outputs of transducers and math functions. Up to eight (8) calculations shall be available for control or readout. The calculated control algorithm shall be inserted directly into the control loop for control in the same way that primary transducer feedback signals such as load and stroke are used for control. Using calculations outside the control loop and modifying the command signal periodically does not provide the necessary control response and is not compliant with this specification.

6.2.5 For flexibility in using multiple transducers for feedback, the controller shall have the capability to perform automated dynamic control mode switching between any connected transducer or defined calculation. Any transducer or calculation can be selected for control. Control modes shall include load control through a load cell, strain control through an extensometer, displacement control through an LVDT, or control through any other installed transducer or defined calculation.

6.2.6 The controller shall have the capability to perform load limited stroke control for ease of use and safety when loading specimens. Other cascade control modes with inner and outer loops must be provided so that servo loops with electrically noisy feedback signals can be more accurately controlled.

6.2.7 To provide a fully integrated high-speed communication, the controller chassis shall be configurable with up to eight carrier boards, which support up to four signal conditioning modules each in a single chassis. These conditioners shall be fully integrated into the control system and possess the capability for computer control of ranging, transducer zero, transducer excitation, and Delta K.

6.2.8 For maximum laboratory efficiency, the controller shall have the capability to share data and configuration files with an existing digital servo-hydraulic controller.

6.2.9 The controller shall have the capability to assign actions for limit and event detectors. The actions shall include off, indicate, hydraulics odd off, valve clamp, program interlock and others that are user definable. The user definable actions must include a hold (in a specified control mode), or a ramp (in a specified time & control mode).

6.2.10 High resolution (16-bit) digitally generated analog output shall be available as an option for easy access to internal control parameters, transducer signals, data acquisition signals, error values, limits, function generation signals, etc. These signals are available for use with external data collection devices.

6.2.11 Six high-level analog input channels shall be available, for connection to externally conditioned transducers. Resolution of these A/D channels shall be 16 bits and sampling rates (simultaneous sample and hold) of up to 6 kHz shall be possible. More analog input channels shall be optionally available.

6.2.12 Sixteen Digital I/O channels shall be available for control of peripheral devices.

6.2.13 An emergency stop shall be provided near the controller.

6.3 Transducer Signal Conditioners

6.3.1 A separate channel of signal conditioning shall be provided for each load, extensometer, LVDT or strain gage signal. Each signal conditioner channel shall be available for test control if desired with mode switching between any channel available during a test and shall have a resolution of 24-bit.

6.3.2 Two (2) calibrated ranges shall be provided for each transducer conditioner. Their ranges shall be at 100 and 10% of full-scale transducer capacity.

6.3.3 A physical calibration of each range shall be performed on site in order to provide required measurement and control accuracy. Each of the calibrated ranges for every transducer shall be traceable to the National Institute of Standards and Technology (NIST). A certificate shall be provided for each transducer range, which gives traceability to a national standard. Mathematical or software manipulation of transducer outputs to produce ranges other than 100% of full scale capacity can not be traced directly to calibration transfer standards and is not acceptable.

6.3.4 The signal conditioners shall have computer control of transducer zeroing, excitation voltage, and filters on/off, to allow for fully automated testing.

6.3.5 Each conditioner shall have the capability to detect cable faults and excitation loss for operator and system safety.

6.3.6 Zero suppression of at least 100% of calibrated transducer capacity shall be possible.

6.3.7 Each transducer conditioner shall also have a shunt calibration check for each calibrated range and computer control of Delta K for accurate, automated calibration of DC transducers.

6.3.8 The signal conditioners shall support bridge completion (2-,3- or 4-arm bridges) for the use of commercially available gages bonded to the specimen.

6.3.9 The signal conditioner shall supply software adjustable, digitally generated excitation voltages from 0 to 20V AC and frequencies to 10 kHz.

6.3.10 New conditioners shall be slide-in and customer-installable for easy upgrades.

6.4 Valve Drivers

6.4.1 A valve driver shall be provided for each servohydraulic actuator. Expansion slots shall be available in the main controller chassis for up to 8 valve drivers in the event that future additional servo-loops of dynamic control may be needed.

6.4.2 Each valve driver shall support single or dual two stage servo valves. Valve drivers to support high flow 3-stage servovalves must be available in the event that higher performance cyclic or high velocity impact testing shall be a future test requirement.

6.4.3 To facilitate fine-tuning of system operation under creep test or very slow strain rate conditions, servovalve dither amplitude and frequency shall be computer controlled.

6.4.4 To ensure accurate valve balance each individual valve driver shall have the valve balance computer controlled. Valve balance up to 1 VDC shall be possible.

6.5 Load Frame Control Panel

6.5.1 A control panel, separate from the main control chassis, shall be provided at the load frame for safety and ease of system operation.

6.5.2 The control panel shall provide for control of low, high or off hydraulic pressure. The operator shall be able to start, stop, hold, and resume a test from the load frame control panel, and an emergency stop button shall be located on it.

6.5.3 The control panel shall provide for control of actuator positioning during specimen loading and removal. Load limited stroke control shall be available for safety in specimen loading.

6.5.4 Real-time transducer feedback in engineering units of choice shall be displayed on the load frame control panel. The operator shall be able to auto-zero any installed transducer by using a function key located on the load frame control channel to select and zero the transducer signal of choice.

6.5.5 The load frame control panel shall display the current mode of control and allow the operator to select the next mode of control and automatically switch to the next mode of control by activation the actuator positioning controls on the load frame control panel.

6.6 Function Generation Waveforms

6.6.1 Function generation shall be fully integrated into the system control software and electronics with the capability to stop and start tests in an automated mode through a computer.

6.6.2 The function generator shall be capable of generating sine, haversine, square, and ramp waveforms. Command signals shall be generated with 32-bit accuracy. Accuracy of the selected period shall be within 1 microsecond.

6.6.3 The system shall be capable of generating and controlling from non-repeating wave shapes, which are defined by specific applications programs.

6.7 Data Acquisition

6.7.1 Data acquisition for internally conditioned transducers and up to 18 externally conditioned transducers shall be an integral feature of the servo controller and shall include simultaneous sample and hold capability.

6.7.2 The resolution of the data acquisition analog to digital converters shall be a minimum of 24-bit resolution.

6.7.3 The data acquisition rate shall be up to 5 kHz on all channels.

6.8 The Workstation Computer System

6.8.1	Chassis	IBM PC 300 PL III Minitower
6.8.2	CPU	Pentium III 600 MHz w/MMX technology
6.8.3	Cache	512K L2 Cache
6.8.4	Architecture	AGP 2X, PCI Local Bus, ISA Bus
6.8.5	Network Card	10/100 mbps Ethernet (integrated) w/Wake on LAN & Alert on LAN technology 10/100 Ethernet RJ-45
6.8.6	Hard Drive	10.1 GB IBM Drive (Fuijitsu)
6.8.7	Floppy Drive	3.5",1. 44MB floppy drive
6.8.8	Memory	128MB ECC supported SDRAM, Expandable to 384mb, 3DIMMS
6.8.9	Video Card	8MB Matrox Millenium Video Card (G400 Model)
6.8.10	Video Chip Set	Matrox G4+MILA/16/1B2
6.8.11	CDROM Drive	40X CDROM

6.8.12	Speaker	Built-in speaker with volume pod
6.8.13	Audio	Integrated Bus. Audio w/speakers; supports Sound Blaster Pro applications; Audio In/Audio; Microphone Jack
6.8.14	Sound Card	Sound Blaster (integrated audio)
6.8.15	Mouse	IBM Scrollpoint Mouse
6.8.16	Keyboard	IBM Enhanced 104-Key
6.8.17	Slots/Bays	6 slots (3PCI, 31SA) / 6 bays (2-3.5" Slim High Ext./2-3.5" Int/2-5.25" ½ High Ext.
6.8.18	I/O Ports	2 serial / 1 enhanced parallel (ECP/EPP) / 2 USB ports, AGP Graphics, ATA-33 Controller
6.8.19	Power Supply	200 Watts
6.8.20	Operating System	MS DOS 6.X
6.8.20	Warranty	Manufacturer's Standard Warranty
6.8.21	Monitor	17" Viewsonic GS773
6.8.22	Memory	128MB 100MHz Non-ECC SDRAM
6.8.23	Network Card	IBM 16/4 Token Ring PCI Adpt 2 W/WOL
6.8.24	Operating System	MS Windows NT Workstation 4.0
6.8.25	Printer	Hewlett Packard LaserJet 4050N
		32mb SDRAM (HP 4000/4050/5000/8000)
6.8.27	Interface	HP JetDirect 600N Internal (HP 4000/4050/5000/8000)

7.0 Software

7.1 System Software

7.1.1 The main user interface for the system shall be through a personal computer and utilize a mouse driven windowed user interface. This is a requirement for fully automated testing and to minimize the chances for operator error.

7.1.2 The system software shall allow a digital display scope, data display functions and multiple real time plots on the computer screen simultaneously as a test application is running.

7.1.3 The system software shall be access protected to allow the system manager to define the set of users and prevent inadvertent changes to calibrations and timing parameters.

7.1.4 Due to the large number of possible test configurations and set-ups, the system software shall allow multiple (at least 50) controller configurations and user preferences to be established and stored. Each user preference includes parameter settings that ensure that the controller boots up to a pre-defined state whenever a user logs on to the system.

7.2 General Purpose Application Software

7.2.1 Application software shall be included for generating and executing tests. The application software shall be fully integrated with the Microsoft Windows NT operating system. The application software shall include the ability to use any installed or externally conditioned transducer for control or to capture data.

7.2.2 For versatility in performing a wide range of static and dynamic tests, the application software shall use data acquisition routines that must include timed data collection, peak/valley data collection, and level crossing data collection. Any combination of these routines can be used simultaneously. The software shall allow selection of the master

channel to be used for peak/valley and level crossing data acquisition and the additional slave channels can be collected simultaneously. All internally or externally conditioned channels can be used as the master or as the slave channel.

7.2.3 The application software shall allow the operator to directly interact with the progress of the test through user definable software buttons. The operator can define software buttons with names and descriptions that when clicked with the mouse causes the test program to sequence to the next desired test sequence.

7.2.4 The application software shall allow the operator to set up command segment end levels that are from a different transducer or calculated channel than the channel being used for test control. The end level or "data limit" can be set up to terminate the current segment when the data limit is approached from below, above, or either direction. The data limits can also be used to trigger data acquisition and other definable test system processes. Data limits can be set up to cause the test system to go to any definable state upon detection.

7.2.5 The application software shall allow detection of digital inputs to the test system controller and allow digital output signals to be output from one of the control system digital output channels to control peripheral devices during an automated test.

7.2.6 The application software shall allow the system D/A converter channels to be servo-controlled upon command for control of temperature chambers or other devices.

7.2.7 Run time rate control software allows for user to ramp up or down rate of test in real time.

7.2.8 Test Packages offered with this system (see 9.0) shall include test templates based on vendor's interpretation of ASTM test protocols.

8.0 System Installation and Training

8.1 The vendor shall provide appropriate specifications and information regarding required utilities, compressed air, power and water at the time of order placement to allow the purchaser to prepare the site. The purchaser will provide assistance in unloading the equipment from the delivery truck (from the loading dock) and locating the equipment to approximate final location in the laboratory.

8.2 Vendor's services shall include installation and system checkout of the test system and accessories at the purchaser’s laboratory. On-site calibration of transducers and alignment check of loading frame shall be included as installation services. An acceptance plan shall be included as part of the proposal which indicates the criteria for acceptance and start of the 12-month warranty period.

8.3 Two (2) days of informal on-site training on the use and operation of the system shall be included following completion of installation. A separate quotation for additional on-site training, factory classroom training on the test equipment, or special on-site training in test methods, shall be provided.

9.0 Test Packages (All must be offered to be considered for this bid specification)

9.1 Tension Testing Packages

9.1.1 Force capacity: 2500 kN (550,000 lbs) static tension and compression, 1500 kN (330,000 lbs) dynamic tension and compression.

9.1.1.1 Upper and lower hydraulic grips shall conform to the following requirements:
9.1.1.2 Closed housing wedge grips
9.1.1.3 Inserts (or combinations) for flat specimens, 19-76 mm
9.1.1.4 Inserts (or combinations) for round specimens, 19-76 mm
9.1.1.5 Fully hydraulic reloading shall be equal to two times triaxial load capacity to ensure fully reversed testing capability

9.1.2 Force capacity: 1200 kN (264,000 lbs) static tension and compression, 1000 kN (220,000 lbs) dynamic tension and compression.
9.1.2.1 Upper and lower hydraulic grips shall conform to the following requirements:
9.1.2.2 Side-loading open housing wedge grips
9.1.2.3 Inserts (or combinations) for flat wedges for 0-67 mm full range
9.1.2.4 Inserts (or combinations) for round wedges for 4-63 mm full range
9.1.2.5 Inserts (or combinations) for vee wedges for 4-63 mm full

9.1.3 An integrated (signal conditioning and A/D as per Sub-section 5.3) axial strain (yield strength) extensometer, or combinations, each with quick attachment fixtures, of type Class B1 (or better) shall be provided which meet(s) the following gage lengths and strain (travel) ranges:
9.1.3.1 Gage length: 50 mm Strain: 4%, minimum
9.1.3.2 Gage length: 100 mm Strain: 4%, minimum
9.1.3.3 Gage length: 200 mm Strain: 4%, minimum

9.1.4 Testing module capable of running tests meeting the requirements of ASTM A370, including determination of yield point by Autographic Diagram and Total Extension Under Load methods (ASTM A370.13) shall be executable and capable of being copied and edited by purchaser.

9.2 Reinforcing Steel Bend Testing Package
9.2.1 Upper platen shall include safety chains and shall be clamped into the hydraulic grip. Upper platen shall have rollers with diameters adhering to ASTM A615, A616 and A617.
9.2.2 Bend fixture shall have the capacity to test reinforcing steel of sizes No. 3 through No. 11, Grade 40 and Grade 60, as per ASTM A370.A9.4.
9.2.3 Fixture shall have adjustable spans with attached scales.
9.2.4 Span shall be able to be configured in a four-point configuration and a three-point configuration.

9.3 Wire Rope Testing Package
9.3.1 Anti-rotate actuator/grip assembly shall be included.
9.3.2 Integrated (signal conditioning and A/D as per Sub-Section 5.3) extensometer with gage length of 600 mm and Strain of 5% (minimum), with quick attachment fixtures for attachment to wire rope shall be included.

9.4 Multi-Wire Strand for Pre-stressed Concrete Testing Package
9.4.1 Testing module capable of running tests meeting the requirements of ASTM A370.A7 and ASTM 416 shall be executable and capable of being copied and edited by purchaser.

9.5 Mechanical Coupler Testing Package

9.5.1 Testing module capable of running:

9.5.1.1 Cyclic loading in tension from 5 percent to 90 percent of a specified yield strength of the reinforcing steel for 100 cycles using a haversine wave form at 0.7 cycles per second

9.5.1.2 Fatigue loading of a spliced joint from 170 MPa (25 ksi) tension to 170 MPa (25 ksi) compression for 10,000 cycles using a sine wave form at 0.35 cycles per second

9.5.1.3 Testing Module shall be executable and capable of being copied and edited by purchaser.

10.0 Options to be offered by the vendor, as requested

10.1 1000 kN (220,000 lbs) Tension Testing Package

10.2 Increments of six (6) for a total of eighteen (18) additional high-level analog input channels shall be available for connection to externally conditioned transducers. Resolution of A/D channels shall be 16 bits and sampling rates (simultaneous sample and hold) of up to 6 kHz shall be possible (refer to 6.2).

10.3 4.4-meter vertical test space.

10.4 2-meter or 3-meter extended-length t-slot table.

10.5 Strong-floor integration of the load frame

11.0 Warranty

11.1 The vendor shall warrant its products against defects in materials and workmanship under normal use and service for one year after acceptance per Section 8.2.