High-Rate Test Systems

Extensive capabilities for repeatable results

be certain.

AROUND THE WORLD, LEADERS IN TRANSPORTATION, CONSUMER PRODUCTS AND OTHER INDUSTRIES RELY ON **MTS HIGH-RATE TEST SYSTEMS** TO ACCURATELY CHARACTERIZE COMPONENTS AND MATERIALS THAT ARE SUSCEPTIBLE TO HIGH-RATE DEFORMATION.

Versatile Systems for a Full Spectrum of High-Rate Testing

Many material properties are strain rate sensitive, meaning they react differently across various rates of loading. Dynamic mechanical testing helps engineers understand how susceptible these materials are to damage during high strain rate events, so that components and structures made from them are not designed with excessive mass or vulnerable to early failure.

High-rate dynamic tests are used to simulate automotive accidents, airplane crashes, munitions explosions and other high-impact events. In these and other critical applications, test engineers need equipment that can perform a variety of tests at the correct strain rate. These systems need to capture high-quality data throughout the test, with streamlined setup and enhanced control of the test.

To meet all of these challenges, MTS delivers a family of high-rate servohydraulic test systems specifically designed to support a full spectrum of dynamic testing. MTS High-Rate Test Systems are deployed worldwide to produce accurate, reliable results for leading companies in industries as diverse as automotive, aerospace, rail, consumer products, and construction materials.


1.


2.


3.


4.


5.

MISSION-CRITICAL APPLICATIONS

Dynamic high strain rate testing is required by numerous standards from ASTM, ISO, EN, DIN, BS and AFNOR. Typical high strain rate tests include:

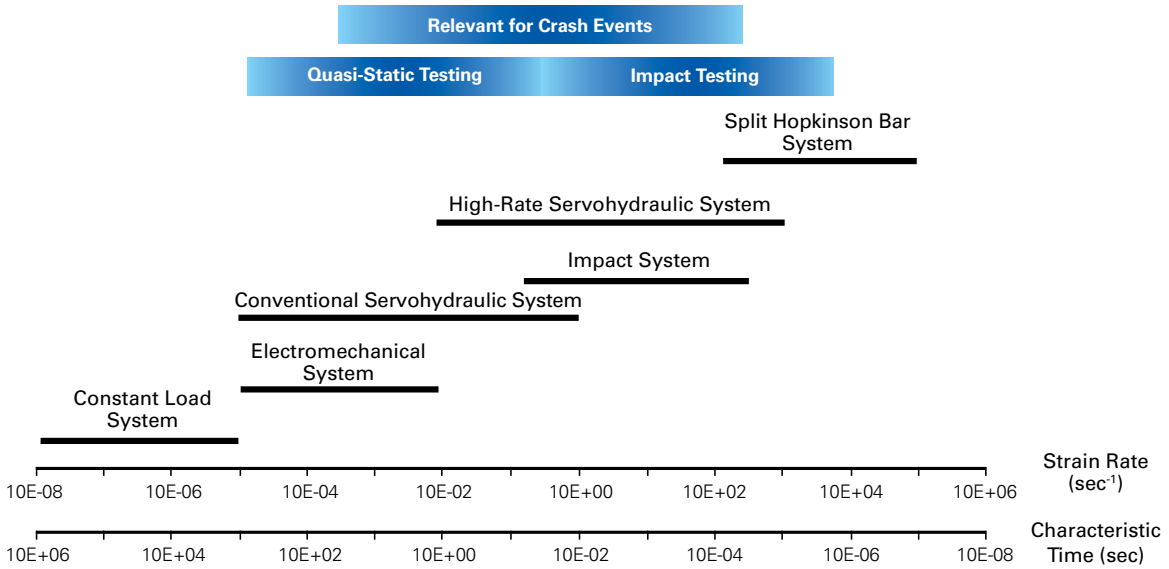
- High strain rate tensile: ISO 26203-2, ISO 18872, SAE International J2749
- Dart impact penetration: ASTM D1709, ISO 7765-2
- Puncture impact behavior: ASTM D3763, ISO 6603-2
- Impact compression

High strain rate test applications include:

1. Crash-worthiness of vehicles
2. Safety of football helmets, baseball bats and other sports equipment
3. Reliability of aerospace components and structures
4. Characterization of lightweight materials, including metals, plastics and composites
5. Behavior of concrete during blast impact events

Choose the Right Range

Test engineers have developed a variety of testing techniques to characterize materials within specific strain rate ranges that are relevant for crash events.



To configure a suitable servohydraulic high-rate test system that accurately simulates dynamic impact events, it is important to consider the amount of energy that is required for the test, the needed strain rate and the force at velocity. Balancing these three elements sometimes requires tradeoffs for a cost-effective solution.

Kinetic energy

The energy or work required to break a specimen depends on the material properties and the required deformation for the test; it can be approximated by determining the area of the static material tensile curve up to the desired total strain level.

The kinetic energy supplied by the high-rate system is a function of the total moving mass, including piston and fixture, and its velocity. In order to maintain a constant velocity throughout the test, the kinetic energy must be significantly greater than the work required to break the specimen.

The moving mass can be varied in order to achieve the necessary kinetic energy for a required velocity.

Strain rate

For an initial approximation, it can be assumed that the actuator velocity is equal to the specimen deformation rate.

Actuator Velocity = $(l_i - l_o)/\Delta t$

l_i = Instantaneous specimen gage length
l_o = Original specimen gage length
Δt = Time interval
$\dot{e}$ = Engineering strain rate

The required maximum actuator velocity can be estimated based on the needed strain rate and specimen gage length.

Actuator Velocity = $l_o \dot{e}$

The assumption for calculating the actuator velocity can be improved by eliminating the system compliance at the loads of interest and deducting it from the displacement data.

Force at velocity

The force and the velocity of a linear actuator depends on the piston surface area, the available differential pressure of the hydraulic fluid and the available flow rate. The hydraulic system needs to be carefully configured to enable the system to deliver the required force at velocity.

In practice, design and configuration of high-rate systems require complex modeling to fully characterize the dynamic response. MTS has developed special software programs to configure an economical system solution for the required performance.

Common MTS high-rate test systems solutions include the following servohydraulic load frames that suit a variety of applications:

System	Static force capacity (kN)	Servovalve size (lpm)	Maximum velocity (no load, m/s)
819.15	15	342	6
819.25	25	684	12
819.40	40	1520	18
819.100	100	3040	15

Complete Test Solutions for Superior Performance

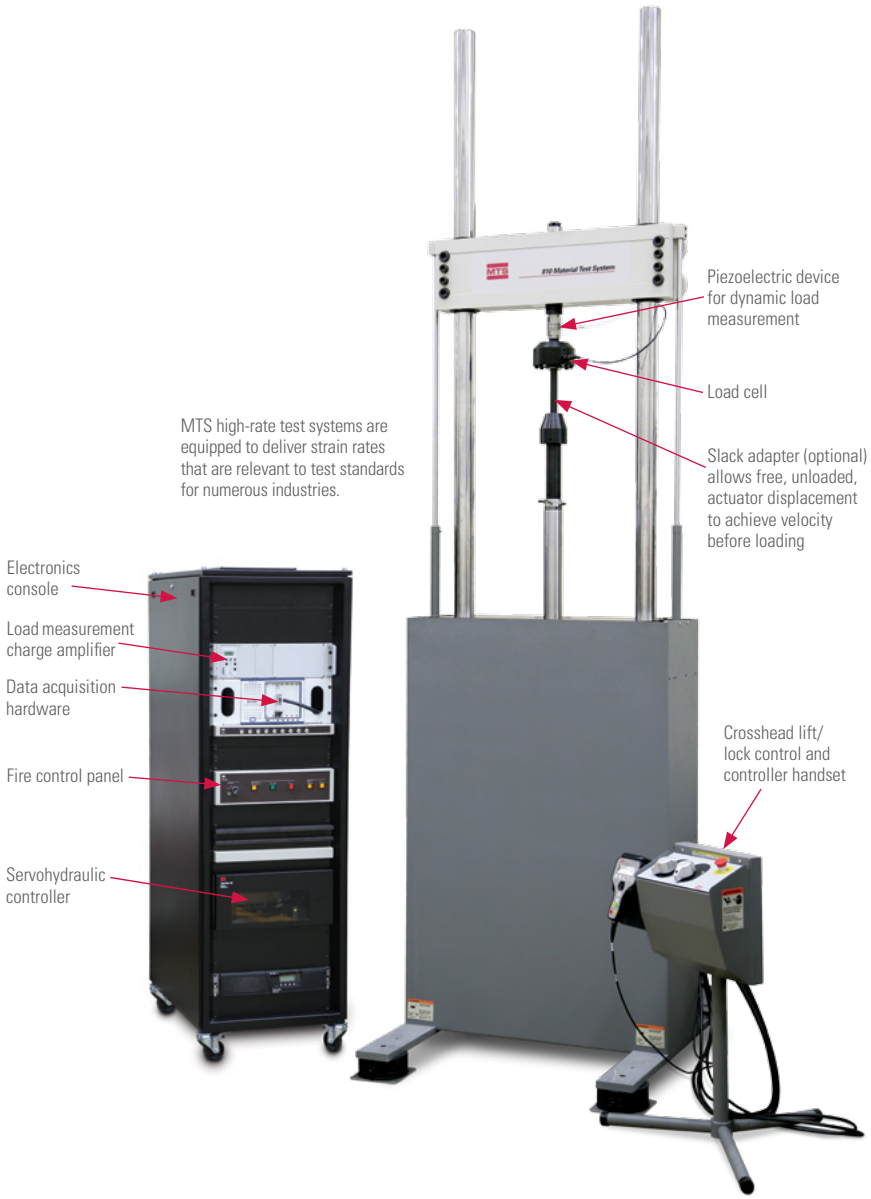
MTS provides specially designed high-rate servohydraulic systems with all of the technology test engineers need to conduct accurate, repeatable high strain rate tests. These fully integrated solutions start with stiff, durable load frames and high-response servohydraulics that apply forces from 5 to 500 kN (1 to 110 kip) and achieve velocities from 1 to 21 m/sec (39 to 830 in./sec).

MTS FlexTest® digital controls enable high-speed control and data acquisition, while TestSuite™ TW Elite Software helps streamline and standardize test programs. In addition, a full complement of accessories, including grips, fixtures and a piezoelectric load washer, address the unique needs of specific high-rate tests.

Together, these components deliver an intuitive testing experience that provides high-quality data as well as flexible test analysis and reporting.

KEY SYSTEM ATTRIBUTES

- 250 mm dynamic-stroke, low-friction actuators with hydrostatic bearings
- Extra-long hydraulic cushions prevent actuator damage after specimen failure
- Hydraulic accumulators supply high amounts of energy quickly
- Eight data acquisition channels record at rates up to 1.25 million samples per second simultaneously
- Eight optional data acquisition channels available
- Test area enclosure and fire control panel protect operators and the system
- Grips and fixtures accommodate a wide range of specimen types
- Three-stage servovalves meet the large hydraulic fluid flow requirements of high-rate testing
- Piezoelectric load washer enables fast, accurate force measurement



Servovalves

Three-stage servovalves from MTS provide superior performance and exceptional durability, and have been proven over decades of use in test labs worldwide.

Reliable, Durable Components

MTS High-Rate Test Systems are configured with trusted components that are specifically designed to work together seamlessly in a variety of dynamic testing applications.

Heavy-duty load frames

Rigid load reaction frames minimize signal distortion caused by unwanted vibrations, which are common in high-velocity testing applications. Load frames are typically oversized to accomplish this. It is not uncommon to have a 250 kN frame with 40 kN actuators, for example.

Because the actuators often have long strokes of 250 mm, the load frames are very tall. This height puts the test space out of reach for many testing personnel, which can be alleviated with a platform located in front of the machine.

High-rate actuators

MTS high-rate actuators are designed with extra cushions to help decelerate the piston rod without the risk of damage. These actuators feature relatively low mass while retaining sufficient stiffness for high-rate compression tests.

Accumulators

Most labs use accumulators because of the short duration and high flow requirements of this type of test. A hydraulic power unit (HPU) reacts too slowly—by the time the HPU recognizes the need for hydraulic fluid and tries to respond, the test is over. And even if the HPU could respond quickly, a very large HPU would be required to meet the high flow requirements. Accumulators, charged using a smaller HPU, are capable of supplying high volumes quickly and are therefore much more cost-effective for high rate testing.

Load measurement

MTS high-rate test solutions incorporate piezoelectric load measurement transducers and conditioners. The piezoelectric transducers are stiffer and have less mass than conventional strain gage based load cells, which are too elastic for high rate testing. It's their elastic deformation measured by attached strain gages that is a measure of load. The time required for the elastic member to become uniformly deformed is similar to the elapsed test time. For this reason MTS uses highly stiff, low mass, piezoelectric load measurement transducers.

Resolving load oscillation

One potential issue with high-rate tests is load oscillation, or ringing in the stress strain curve, which occurs as the slack adapter components slam together and excite resonances within the load frame. Ringing is seen in the data as a regular high-frequency oscillation. MTS high-rate test systems mitigate this issue by minimizing the moving mass and by damping critical areas.

To further reduce potential ringing at strain rates greater than approximately 50 s-1 to 100 s-1, it is recommended to measure force with a strain gage applied to the test specimen or the grips.

Displacement measurement

Actuator displacement is measured with a magnetostrictive device that provides exceptional accuracy. The absence of physical contact between moving parts ensures stable performance. The sensing coils generate high-output signals and provide common mode rejection from external sources of noise. In addition, the converter design responds only to torsional strain pulses, so longitudinal pulses caused by shock or vibration are not detected.

Data acquisition

MTS-supplied data acquisition boards feature eight channels of differential signal acquisition. One channel is dedicated to force transducer data, one to actuator displacement and six to other sources as test needs dictate. Data is collected at a maximum of 1.25 MHz on all channels simultaneously. Load and displacement signals are routed to the MTS FlexTest digital controller and data acquisition board.

Accessories

Choose from a variety of grips and fixtures tailored for testing plastic dog bones and flat or round specimens made from metal, composites and polymers. Standard grips are available for tensile testing of sheet metal specimens, plastics and rubber specimens and specialized items such as cords or O-rings.

MTS grips for high-rate testing are designed to be light and stiff, which minimizes the noise/ringing contributed to the load data on impact.

Special fixtures

Puncture fixtures are ideal for testing sheet metal or film materials and can accommodate a variety of specimen dimensions. These fixtures provide a clamping restraint that can be mounted on the load frame or on the actuator. Fracture test fixtures help determine the energy absorbed in fracture toughness studies.

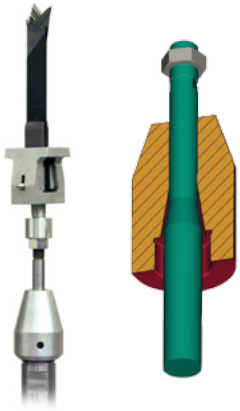
Environmental simulation systems

MTS complements high-rate systems with a selection of environmental simulation systems to test materials and components under a variety of real-world conditions.

Slack adapter

The slack adapter connects the specimen to the load train but allows actuator travel under no load until the desired velocity is achieved. The adapter has two pieces: the red piece (see diagram) is connected to the actuator while the green piece is attached to the specimen—or to a grip attached to the specimen.

After the specimen is loaded into the test system, the actuator is raised so that the two conical surfaces (one on each piece) are separated by a distance slightly greater than what is required for the actuator to reach the desired test velocity. As long as these two cones are separated, the actuator moves freely. The slack adapter travels under no load until the two conical surfaces connect and instantaneously load the specimen.

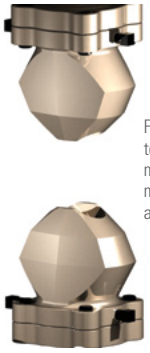


A-frame grips

These grips are rated for 50 kN (11,000 pounds) and are supplied with two sets of wedges: 0 mm to 4.3 mm (0 to .17 in) and another set for 3.81 mm to 8.12 mm (.15 to .32 in).

Low-mass grips

MTS high rate, low mass grips for flat specimens have two standard wedge sets: one for .25 mm to 1.5 mm (.01 to .06 in) and another for 1.3 mm to 2.79 mm (.05 to .11 in). Total mass for both grips is one kilogram.



Flat specimen, low-mass tensile grips are specially machined to remove as much extraneous mass as possible.

Non-contacting strain measurement

Measuring strain for high rate testing can be challenging. Contacting extensometers are lower cost but can't be used at higher strain rates. Strain gages are often expensive to prepare, install and monitor and the maximum strain that can be measured is limited.Video extensometer solutions with high-speed camera systems can often meet the needs for both precision and cost effectiveness. An MTS Applications Engineer can help you configure the appropriate solution for your testing needs.

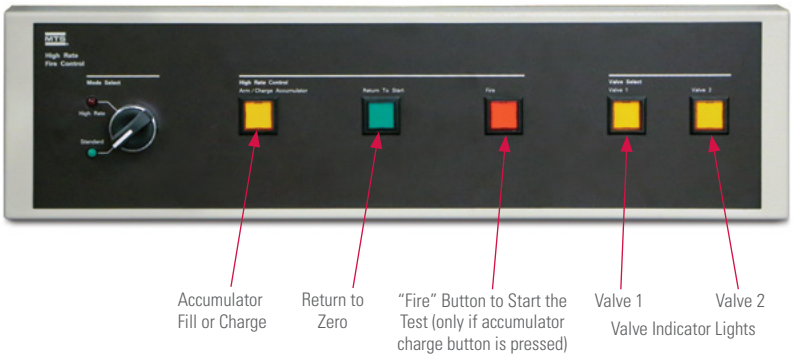
Designed for Operator Safety

Test area enclosure

The test area enclosure helps maintain operator safety and protect others in the lab. Each enclosure is fabricated from extruded aluminum and acrylic sheet. Front and rear access doors provide full access to the machine for maintenance and test setup. These doors are safety interlocked to the system controller to prevent system operation—except at very slow rates—during specimen installation and calibration.

Fire control panel

Electronic hardware includes a high-rate fire control panel located in the electronics console. This panel is used to select a servovalve (the two-stage valve or the high-flow, three-stage valve), fill the accumulators and discharge the accumulators through the servovalve and actuator.



Dependable Hydraulic Performance

Industry-leading hydraulic products enhance the performance of MTS high-rate test systems. Key components of the solution include MTS servovalves and SilentFlo™ Hydraulic Power Units (HPUs). MTS servovalves are available with flows of 112, 340, or 680 lpm rated at 70 bar pressure drop. Servovalve pilot pressure ensures tight control of the system actuator at startup.

MTS SilentFlo HPUs offer the latest advancements in servohydraulic power generation. Available in a variety of capacities to accommodate required test loads and speed, they deliver clean and quiet hydraulic power. They can be deployed directly in the lab, eliminating the cost of special pump housing facilities and reducing supply line cost and space requirements.

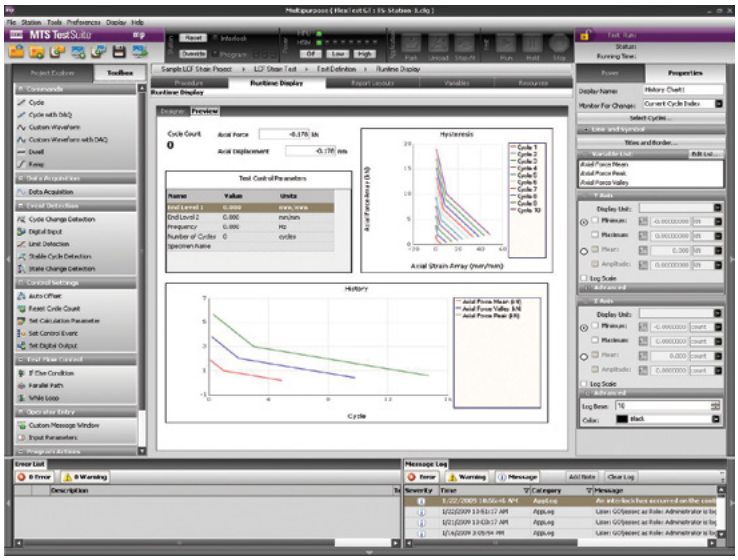
The SilentFlo 515 family features innovative energy efficiency, health monitoring and system integration options to reduce total cost of ownership.

State-of-the-art Digital Controls

Stable, precise system control, which is critical for conducting high-rate testing, is provided by a state-of-the-art FlexTest controller. FlexTest digital controllers equip users with all the tools needed to define and automate virtually any material, component or structural test. Versatile FlexTest controllers provide high speeds and channel densities to keep pace with evolving test demands, and share common hardware boards and user interface tools to simplify test standardization and optimization across test laboratories. FlexTest controllers support the full offering of MTS test application software, including MTS TestSuite MP software.

Versatile test software

MTS TestSuite Multipurpose Testing Software lets you graphically build and run monotonic and cyclic tests with efficiency, from an easy-to-use interface that is readily adaptable to your evolving needs. You can easily test to specific industry standards—or pursue your own interpretation of a standard—with customizable, "plug-and-play" test methods. The software also captures all setup data and test results, allowing you to quickly repeat tests, analyze data with stand-alone Analysis Software, and design and create reports with a convenient Excel Add-In.



High-rate closed-loop control vs. open-loop control

Servohydraulic materials testing systems are normally run in closed-loop control. However, for high-rate tests, the piston is moving at such a velocity that real-time control is not as effective because servovalve response, the inertia of the moving mass and the compliance of the hydraulic fluid become limiting attributes. In addition, the control loop's ability to correct disturbances diminishes as the event time approaches the response time of the valve.

For servohydraulic high-rate testing, a command waveform is created and sent to the servovalve, at which point the test is essentially open-loop. There is no time for real-time corrections based on the error signal. This situation is overcome by iterating the command waveform before the test using dummy specimens to achieve the desired response. Once the command waveform is created, testing can begin.

Unparalleled Service and Support

MTS high-rate test systems are backed by the global MTS Service and Support organization. This highly experienced team offers lifecycle management services for all MTS test systems and is committed to maximizing the uptime and operational efficiency of each system. With the expertise to support test equipment from pre-installation to decommission and at every point in between, MTS has the service solutions to meet your needs for test schedule predictability, data integrity, system performance optimization and budget management.

Onsite services

MTS field service engineers have a worldwide reputation for applications expertise and will respond to requests for support or repair quickly and efficiently.

Engineering services

MTS offers a complete set of professional engineering services, including systems engineering, test consulting and facilities design services.

Training

MTS training programs are designed to improve operator efficiency and optimize system performance. Expertly led and completely customizable, these courses provide engaging hands-on learning experiences.

Calibration and alignment

All test labs must calibrate their testing equipment to help ensure data accuracy. MTS provides top-quality, accredited calibration services and load frame alignment services to minimize data variance.

Maintenance and monitoring

Based on decades of service experience, MTS has developed a set of well-defined routine maintenance offerings tailored for specific systems and components, to help extend equipment life.

Upgrade solutions

As technology improves, an upgrade is often the most economical way of expanding lab capabilities and extending the life of existing test equipment. MTS offers upgrades and replacements for mechanical components, controllers and software.

Regional Business Centers

THE AMERICAS

MTS Systems Corporation
14000 Technology Drive
Eden Prairie, MN 55344-2290
USA
Telephone: 952-937-4000
Toll Free: 800-328-2255
Fax: 952-937-4515
E-mail: info@mts.com
Internet: www.mts.com

EUROPE

MTS Systems France
BAT EXA 16
16/18 rue Eugène Dupuis
94046 Créteil Cedex
France
Telephone: +33-(0)1-58 43 90 00
Fax: +33-(0)1-58 43 90 01
E-mail: contact.france@mts.com

MTS Systems GmbH
Hohentwielsteig 3
14163 Berlin
Germany
Telephone: +49-(0)30 81002-0
Fax: +49-(0)30 81002-100
E-mail: euroinfo@mts.com

MTS Systems S.R.L. a socio unico
Strada Pianezza 289
10151 Torino
Italy
Telephone: +39-(0)11 45175 11 sel. pass.
Fax: +39-(0)11 45175 00-01
E-mail: mtstorino@mts.com

MTS Systems Norden AB
Datavägen 37b
SE-436 32 Askim
Sweden
Telephone: +46-(0)31-68 69 99
Fax: +46-(0)31-68 69 80
E-mail: norden@mts.com

MTS Systems Ltd. UK
40 Alan Turing Road
Surrey Research Park
Guildford
Surrey
GU2 7YF
United Kingdom
Telephone: +44-(0)1483-533731
Fax: +44-(0)1483-504564
E-mail: mtsuksales@mts.com

ASIA/PACIFIC

MTS Japan Ltd.
ArcaCentral Bldg. 8F
1-2-1 Kinshi, Sumida-ku
Tokyo 130-0013
Japan
Telephone: 81-3-6658-0901
Fax: 81-3-6658-0904
E-mail: mtsj-info@mts.com

MTS Korea, Inc.
4th F., ATEC Tower, 289,
Pankyo-ro, Bundang-gu
Seongnam-si
Gyeonggi-d, 13488
Korea
Telephone: 82-31-728-1600
Fax: 82-31-728-1699
E-mail: mtsk-info@mts.com

MTS China Hechuan Office
Room 703 Building #B,
Venture International Park,
No. 2679 Hechuan Road,
Minhang District,
Shanghai 201103,
P.R.China
Telephone: +86-21-5427 1122
Fax: +86-21-6495 6330
E-mail: info@mtschina.com

MTS Systems Corporation
14000 Technology Drive
Eden Prairie, MN 55344-2290 USA

ISO 9001 Certified QMS
http://www.mts.com

100-351-634 HighRate Printed in U.S.A. 4/17