# Technical Information

## MPM 9800 Series Drop Tower Impact Test Machine and Peripheral Equipment

MPM is pleased to provide technical information for a drop tower test system and optional peripheral equipment. MPM distinguishes between impact testing and shock testing. Drop towers are used to accomplish both purposes. In impact testing, a striker instrumented with strain gages is used to impact a test specimen and measure the force-deflection response. For shock testing, the usual configuration is to mount the product on the falling rail cart which is instrumented with an accelerometer. The Impact software supports both testing modes and can be easily set up for automated testing.

Several equipment additions can be considered, including an instrumented striker system, accelerometers, and, optionally, an in-situ heating and cooling system. As discussed in detail below, the MPM drop tower and instrumented striker/shock testing system is the most advanced impact testing system in the world. It is very versatile and a wide variety of standard tests and research experiments can be easily configured. Additionally, the MPM data acquisition system can be interfaced with the exiting test systems in your laboratory. The MPM drop tower can be used to satisfy the impact testing requirements of several ASTM and ISO standards including notched bar impact testing and high speed puncture testing of plastics. In addition, MPM drop towers can be easily configured for testing a wide variety of materials, systems, and components. MPM manufactures towers with a wide range of energy capacities covering table top applications all the way to fracture testing of structural components and high ductility steels.

Since drop towers are so versatile, it is impossible to cover all of the test machine types and systems built by MPM over the years. Accordingly, the remainder of this brochure is focused on providing a few examples of MPM drop tower system configurations. Please contact MPM so we can assist with your particular application.

## MPM 9800 Drop Tower Test Machine

The MPM 9800 drop tower test machine is fully responsive to all of the technical specifications and performance requirements given in applicable ASTM and ISO impact standards such as ASTM D 3763, D 2444, D 256, E 23, E 436, E 208, and ISO 148. The MPM drop tower machine has some unique features and options. The rails are constructed from precision ground steel, the diameter of which is matched to the bearings. MPM uses light weight shock bearings and maintains a very close radial tolerance to prevent rail cart rocking. In addition, MPM provides two or four structural beams next to the rails to provide rigid support. The beams also enable pre-tensioning of the rails to ensure proper straightness and alignment. The machine base allows for various test configurations to be installed such as Charpy, penetration, Izod, etc.. The machine can be equipped with an optional infrared (IR) light beam sensor to measure the impact velocity for every test.

The basic test machine is provided with a pneumatic rail cart release. The release push button is provided on a consolette which contains a safety interlock switch. The pneumatic release is needed for the high release elevations and it also standardizes the release latch performance. A photograph of an MPM drop tower machine configured for testing in accordance with ASTM D 3763 is shown in Figure 1 to illustrate some of the basic features of MPM machines. Higher capacity impact machines are discussed further later.

*Test Machine Energy Capacity*

Most drop tower test machines are provided with weights to enable testing at several energy capacities. MPM will coordinate the final weight selection at the time the order is placed. The machine will allow continuous adjustment of drop height up to the maximum drop height which must be specified at the time of order. The drop height can be set to provide any desired energy capacity.

*Test Machine Velocity*

The test machine will be capable of continuous velocity adjustment over the range of 0 to the maximum obtainable for the drop height specified. The velocity (v) is related to the drop height through $v = (2gh)^{0.5}$, where g is the gravitational constant and h is the drop height measured from the tip of the striker to the test specimen top surface. The actual impact velocity differs slightly from the formula value due to friction and wind resistance. Therefore, the data acquisition system can acquire the impact velocity for every test using an IR velocity detector which is automatically acquired by the Impact™ v6.3 software. MPM can also supply the test machine with an increased impact velocity option. Further discussion on this is given later.

*Safety*

There will be a sturdy mechanical stop mounted on the tower high enough from the strike zone to allow test specimen placement and specimen support change out. The mechanical stop will consist of a thick plate which is moved into place pneumatically to protect the operator. A control will be provided on the test machine consolette. Whenever work is done around the base of the machine, it is recommended that the rail cart be in the drop position above the safety plate with the safety plate extended to protect the operator. In addition to the safety plate, an interlocked polycarbonate enclosure is recommended which surrounds the base of the test machine and which extends upward from the base about 6 feet (see options below).

*Striker*

MPM will provide a hardened striker in accordance with the applicable ASTM/ISO standard. The striker (and anvils) will be hardened to Rockwell 58-60. Further details on the Instrumented Striker System are provided later in the proposal.

*Test Specimen Support*

The MPM 9800 test machine base is equipped with threaded holes for setting the position of various test specimen supports. In the case of tests performed in accordance with ASTM D 3763, a pneumatically clamped support arrangement with a 3 inch diameter hole is provided. In

the case of Charpy impact testing, hardened anvils are provided. In the case of NDT and drop weight tear, three point bend fixtures are provided. In the case of D 2444, a hardened base block with a shallow groove can be supplied.

*Data Acquisition Computer*

A data acquisition computer is needed to control the rail cart release height system, to record the instrumented striker data, and to record the impact velocity. MPM will provide this computer along with hardware installation, software configuration, and calibration. The MPM supplied computer has the following specifications:

- Computer with Pentium processor
- 21 inch flat panel color monitor
- Windows operating system
- Keyboard and mouse

*Units*

The units (English to metric) can be changed at any time and the change is applied universally throughout the program. This is very convenient for publication preparation.

*Software Features*

In addition to data acquisition and report printing, the software includes several other analysis features. The data can be read back into the program at any time to perform additional analysis, change units, or print out test reports. In addition, the software includes a statistical process control (SPC) module for tracking changes in key variables. Another useful feature of the software is the Table function. The user can define the test parameters to be included in a table and the order in which the parameters appear in the table. The user then simply points to a folder and the software will automatically open each file (can be for hundreds or thousands of tests), extract the data, and construct the data table (all of the post-test analysis options work this way). The table can be printed or exported to various spreadsheet programs. The software also allows the data files to be organized by groups.

## Options

The drop tower can be provided with any of the below listed options.

*Safety Enclosure*

A polycarbonate enclosure will be provided which surrounds the base of the test machine and which extends upward from the base about 6 feet. The purpose of the enclosure is to protect the operator from the falling weight and from chips which may be ejected from the specimens being tested. The door will be interlocked with the pneumatic striker release to prevent release of the rail cart until the door is shut.

*Automatic Drop Height Setpoint and Measurement*

An automatic drop height setting system can be provided. With the MPM system, the drop heights will be measured using an optical encoder and the system will be equipped with a digital readout. The desired drop height can be input to the controller and the system will automatically position the weight. The system is computer controlled and MPM also provides a hand held control for optional manual control. The height can be automatically set by the computer system with an accuracy of 0.020 inches.

*Striker and Anvils for other Experiments*

The test machine will meet the requirements of several ASTM standards and related European standards such as those listed below:

- ASTM D 3763 - "Standard Test Method for High Speed Puncture Properties of Plastics Using Load and Displacement Sensors".
- ASTM D 2444 – "Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)".
- ASTM E 23 - "Notched Bar Impact Testing of Metallic Materials".
- ISO 148 – "Charpy Pendulum Impact Test".
- ASTM D 256 - "ASTM D 256, "Determining the Pendulum Impact Resistance of Notched Specimens of Plastics".
- ASTM Standard E 436, "Standard Test Method for Drop-Weight Tear Tests of Ferritic Steels".
- E 208, "Standard Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels".
- E 604, "Standard Test Method for Conducting Dynamic Tear Energy of Metallic Materials".

Therefore, the MPM test machine has been designed to accommodate strikers and anvils which meet other testing standards. The striker can be easily removed and replaced with other striker geometries and the anvil assembly can be unbolted from the base and replaced with another assembly with different anvils. The basic machine includes one specimen support configuration which must be specified at the time of order. Other configurations can be purchased at an additional price.

*Increased Impact Velocity*

Some customers may want to consider an option to increase the impact velocity. The impact velocity can be increased by raising the drop height or by increasing the initial velocity of the rail cart. MPM will work with customers to produce a test machine which will meet the laboratory head room requirements. In some cases, a velocity is needed which is higher than that which can be achieved with the head room available. The MPM rail cart launch system can produce very large initial velocities.

*Summary of Test Machine Features*

A typical drop tower test machine will have the following features:

- The machine will satisfy applicable ASTM or ISO standards.
- The machine will be constructed to allow a drop height which meets customer specifications and will have falling masses which accommodate energy capacities of interest.
- The machine will have continuous velocity adjustment capability.
- The drop weight release will be manually controlled using a pneumatic release push button. A control consolette will be provided with the release button and the safety switch.
- The test machine will include a safety plate to protect the operator while working on the test machine base.
- The test machine will include a base plate with tapped holes so that anvils for various experiments can be easily attached.
- The test machine includes one specimen support configuration which must be specified at the time of order. Other configurations can be purchased at an additional price.
- A hardened striker will be provided.
- A data acquisition computer will be provided.

*Summary of Options*

- The base of the test machine will be enclosed inside a six foot tall polycarbonate enclosure with a door for safety during testing. The door will be designed to permit easy access to the test machine specimen supports. The striker release will be interlocked for safety with a sensor in the polycarbonate door.
- The machine will be equipped with a digital readout and computer control to accurately set the drop height. The machine will have an electrically driven motor/cable for raising the weight to the desired drop height. Once the desired height is achieved, the software or consolette can be used to release the rail cart and impact the test specimen.
- If requested, MPM will provide an anvil assembly and striker for performing other ASTM/ISO impact tests such as Charpy, penetration, or Izod.
- If requested, MPM will provide a pneumatic rail cart launch system to increase the impact velocity without increasing the height of the tower.
- If requested, MPM will provide a velocity sensor so that the impact velocity can be recorded for every test.

## Electrical Power

All quoted systems will be powered by 120 V or 220 V, 60 Hz single phase. The desired electrical requirements must be specified at the time of order.

## Crating and Shipping

MPM will build a crate and transfer it to the shipper's truck for inland shipping. If requested, MPM will arrange for shipping and include the costs in the final invoice.

## Training

MPM offers various courses in impact testing, machine calibration and maintenance, and instrumented impact testing. In addition, MPM offers on-site operation/maintenance courses. A price quotation will be provided upon request.

## Test Machine Concrete Base Installation

MPM offers an on-site concrete base installation service. In addition, MPM offers a test machine base installation kit to assist customers in setting up their machine for the first time. MPM will be happy to provide a price quotation.

## Warranty/Support

MPM warrants that the test machine will operate satisfactorily for six months from the time of delivery. MPM will make any necessary repairs at no charge during the warranty period. In addition, MPM will provide telephone support at no charge during the warranty period.

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# Peripheral Equipment

Most drop tower testing machines are provided with an instrumented striker system. For pendulum machines, the energy can be obtained using an optical encoder, and an instrumented striker system is added to provide more data such as load-deflection. In the case of a drop tower, the only method for obtaining load, deflection, and energy is the instrumented striker technology. The MPM instrumented striker system is described below, and instrumented data are provided which illustrate pendulum testing. In addition, a description of the MPM In-Situ Heating and Cooling system option is also provided.

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## Instrumented Striker System

Figure 1 shows a typical MPM drop tower. The example tower shown in Figure 1 is equipped with an instrumented striker with a hemispherical tip and specimen support for ASTM D 3763 testing. A data acquisition computer is needed to record the instrumented striker voltage-time signal and the velocity at impact. MPM will install the instrumented striker hardware and software in the drop tower data acquisition computer and will calibrate the striker. The MPM supplied computer has the following specifications:

- Computer with Pentium processor
- 21 inch flat panel color monitor
- Window operating system
- Keyboard and mouse
- MPM hardware (described below) will be installed in the computer

A photograph of the data acquisition computer is given in Figure 2. For the drop tower system, the encoder hardware is not included (only for pendulum machines). The drop tower system will include the strain gage amplifier, a fast acquisition oscilloscope board, and the data acquisition software. The amplifier is an excellent research laboratory tool. The amplifier provides autobalance, amplifier range selection over several decades, and shunt calibration for periodic calibration checking.

The MPM instrumented striker system is the most accurate dynamic force measurement system in the world. Instrumenting the striker with strain gages so that the applied force can be measured during impact has several advantages, the most important of which is that energy can be determined on a drop tower test machine. Further, additional data (i.e., data in addition to absorbed energy) can be obtained. Knowing the mass of the striker and using a special strain gage system, the force-time curve can be measured and converted to an acceleration-time curve, which can be numerically integrated to give the velocity-time curve. The velocity-time curve can, in turn, be numerically integrated to give the striker displacement-time curve. These numerical integrations permit a force-displacement curve to be constructed. Since the work (or energy) of a system is the area under the force-displacement curve, the force-displacement data can be integrated to give the energy absorbed by the specimen in fracturing.

Accurate measurement of the force during impact is a challenging task because of the dynamic nature of the measured signal and the short time period over which the impact occurs (typically 1 to 5 milliseconds for steel specimens). The dynamic character of the force signal requires the acquisition of at least ~10,000 data points per millisecond to accurately represent the applied force. Because of the data size requirement and short test duration, the storage of the force-time data must be precisely triggered. This is accomplished by continuously monitoring the load signal and saving data when a significant rise in the load occurs. Rapid load change events, such as acceleration of the specimen up to the speed of the striker and brittle crack propagation, require a system response capability of at least 50 kHz for conventional specimens and at least 100 kHz for miniature specimens. The MPM instrumented system meets these requirements.

The Impact™ v6.3 test screen is shown in Figures 3 and 4. As shown in the Figures, the raw voltage-time data are displayed along with the test parameters. The data in these figures were obtained using a pendulum test machine equipped with a 20,000 count encoder and therefore the velocity of the pendulum at impact was measured using this system. This feature is not available on drop tower test machines. For drop tower machines, MPM uses a light beam to measure the striker speed at impact. A repeat of the screen of Figure 3 is shown in Figure 4 with the data in point-plot mode with the time axis expanded. This test was conducted with a 10,000 point acquisition spread over 10 msec. Notice that there are barely sufficient points to fully characterize the dynamic portions of the test signal. Therefore, the MPM system allows up to 1,000,000 data points to be spread over any time range of interest. This is very important for brittle tests where many data points are required over a short time interval (~0.1 msec). Test systems from other manufacturers do not include an oscilloscope board and acquire the data at

the speed of the PC processor. Therefore, this is a serious limitation because the processor is too slow to acquire many data points over a short interval. MPM has solved this problem by providing a 20 MHz oscilloscope card which stores the data directly on the card. The data are downloaded from the board to the PC after the test is completed. Thus, with the 1,000,000 point technology, it is easy to ensure that 10,000 points per millisecond are acquired since most tests are completed within 10 milliseconds.

Example output reports for a Charpy test on a drop tower system are shown in Figures 5 through 7. The four critical (or characteristic) load points are the general yield load (applicable to metals), peak load, brittle fracture load, and brittle fracture arrest load. The general yield load corresponds to yielding across the entire uncracked ligament. For Charpy tests in the transition region, the peak load occurs shortly after the formation of a sharp crack along the entire notch surface and is an indicator of crack formation in the test specimen. In the transition region, a small amount of stable crack growth precedes rapid brittle fracture. Rapid brittle fracture is evidenced on the force-displacement curve as a precipitous force drop. Additional test examples for ASTM D3763 testing are shown in Figures 8 through 13.

Data from instrumented Charpy tests have been used to measure the conventional impact test parameters (41 J transition temperature and upper shelf energy), and these data have also been used to develop useful engineering correlations. In terms of structural integrity assurance, the most important of these are static and dynamic fracture toughness correlations. The development of such correlations seems reasonable given that the state of stress in the notched bar specimen at the time of crack initiation is plane strain, which is the same state of stress present in relatively thick fracture toughness specimens. Also, several researchers have shown that the bend bar geometry is the best of all geometries in terms of retaining crack tip (or notch) field constraint during extensive plasticity. The availability of accurate instrumented striker data in the future is expected to lead to valid and useful fracture toughness correlations. MPM is working on development of fracture toughness models and it is expected that software add-ons will be offered in the future.

The MPM instrumented impact test system includes the following hardware and software:

- Dynamic stain gage amplifier (will be installed in test machine computer)
- instrumented striker with cable
- oscilloscope card installed in computer
- Impact™ v6.3 software package
- system manual

The MPM oscilloscope card has the following features:

- precise acquisition capability (reduces uncertainty to less than 2 mV on the 10 V full scale which is below the calibration load cell accuracy of 0.1% full scale.)
- allows any number of data points per test up to 1,000,000 points (50,000 points are more than adequate for most tests)

- separate arming of the card

The standard card is single channel, but a dual channel scope can be provided for additional cost.

Impact™ v6.3 has been developed to operate under Microsoft Windows 10. The acquisition portion of the program is used to acquire the instrumented signal and, optionally, to acquire the optical encoder energy and the dial energy for test machines equipped with this hardware. A test report, which summarizes the absorbed energy as well as important information from the test such as test temperature, specimen identification, etc., is available and can be printed to provide immediate documentation of the test results.

The post-test analysis portion of the program provides data in addition to absorbed energy that can be used to characterize the impact behavior of materials and to estimate the plane strain fracture toughness of the material. The following data can be obtained using the analysis program:

- general yield load (for Charpy specimens fabricated from metals)
- peak load
- brittle fracture initiation load
- brittle fracture arrest load
- crack initiation energy
- crack arrest energy
- total absorbed energy

These data can be used to determine other useful quantities such as:

- micro cleavage fracture stress (for metals)
- fractures toughness
- crack arrest toughness
- definition of the intersection of the lower shelf and transition region for materials which exhibit transitional fracture behavior
- definition of the onset of the upper shelf for materials which exhibit transitional fracture behavior

The software includes several other analysis features as well. The data can be read back into the program at any time to perform additional analysis, change units, or print out test reports. The units (English or metric) can be changed at any time and the change is applied universally throughout the program. This is very convenient for publication preparation. The software includes a statistics algorithm for summarizing results from many tests. In addition, the software includes a statistical process control model for tracking changes in key variables.

Another useful feature of the software is the Table function. The user can define test parameters to be included in a table and can specify the order in which the parameters are displayed in the table. The user then simply points to a folder and the software will automatically open each file (can be for hundreds or thousands of tests), extracts the data, and

constructs the data table (all of the post-test analysis options work this way). The table can be printed or exported to various spreadsheet programs. The software also allows the data files to be organized by groups.

Another feature of the software gives the user the option to combine any number of tests onto the same graph along with a table giving the average of key test parameters. The option is given to plot the average graph alone, the individual graphs, or both the individual graphs with the average graph. An important feature for plastics testing allows the user to request that the software automatically determine the local peak load and energy due to cracking prior to peak load.

In summary, the MPM instrumented striker software incorporates the following features:

- data acquisition and analysis program provides flexible data analysis capability
- test parameters can be easily changed to accommodate testing requirements
- virtual digital voltmeter for easy load cell balance verification and shunt calibration check
- the optical encoder and instrumented striker energy, percent shear, and lateral expansion data can be stored in the instrumented data file
- ASCII data file storage format makes specialized post-test analysis and plotting easy
- Impact™ v6.3 supports the MPM oscilloscope card, Nicolet scope, and Tektronix scope (the widest range of features and functionality is obtained with the MPM PC card)
- characteristic loads (general yield load, peak load, brittle fracture load, and crack arrest load), energies, and displacements are reported along with total energy absorbed by the specimen
- users manual and extensive built-in program help

**Compatibility of Data Acquisition System with Strikers Fabricated by Others**

Several customers have been so pleased with the MPM instrumented system and software, that they have decided to use the MPM system with existing hardware. The MPM data acquisition system is fully compatible with existing instrumented systems. Therefore, the MPM data acquisition system can replace old systems.

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## In-Situ Heating and Cooling System

The MPM system heats and cools the test specimen right on the test machine. This technology enables thermal conditioning of the test specimen up to the instant of impact. The system has been designed to hold the specimen temperature to within ± 1 C up to the instant of

impact. It is important to note that this temperature tolerance applies at -190 C (liquid nitrogen temperature) and from -100 C to 300 C.

The features of the system are given below:

- test specimen temperatures from -100 C to 300 C
  (higher temperatures are available upon request)
- hardware includes:
  - modified test specimen supports
  - temperature control console with four thermocouple readouts
  - flow channel and nozzle to direct fluid flow to specimen fracture process zone
  - contact thermocouple and mounting bracket for in-situ temperature measurement (if the specimen transfer system is ordered at the same time, MPM will provide the bracket on the specimen transfer system)
  - INSITU ™ v2.0 software for calculation of support set point temperature
  - user manual
- Customer Requirements:
  - liquid nitrogen supply
  - shop air or inert gas for elevated temperature tests

An option for computer control of the In-situ system is available

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## High Energy Capacity Test Machines

MPM offers high energy capacity drop towers for various testing applications such as drop weight tear test (E 436), dynamic tear (E 604), and drop weight NDT testing (E 208). These machines vary in energy capacity and therefore are quoted on a case-by-case basis. Figure 14 shows and NDT drop weight test machine. In addition, MPM builds custom machines to satisfy a wide variety of impact testing requirements. Figure 15 show a high capacity (10,000 ft-lb) machine that was designed to test concrete highway abutments. Figure 16 shows an instrumented dynamic tear test machine.

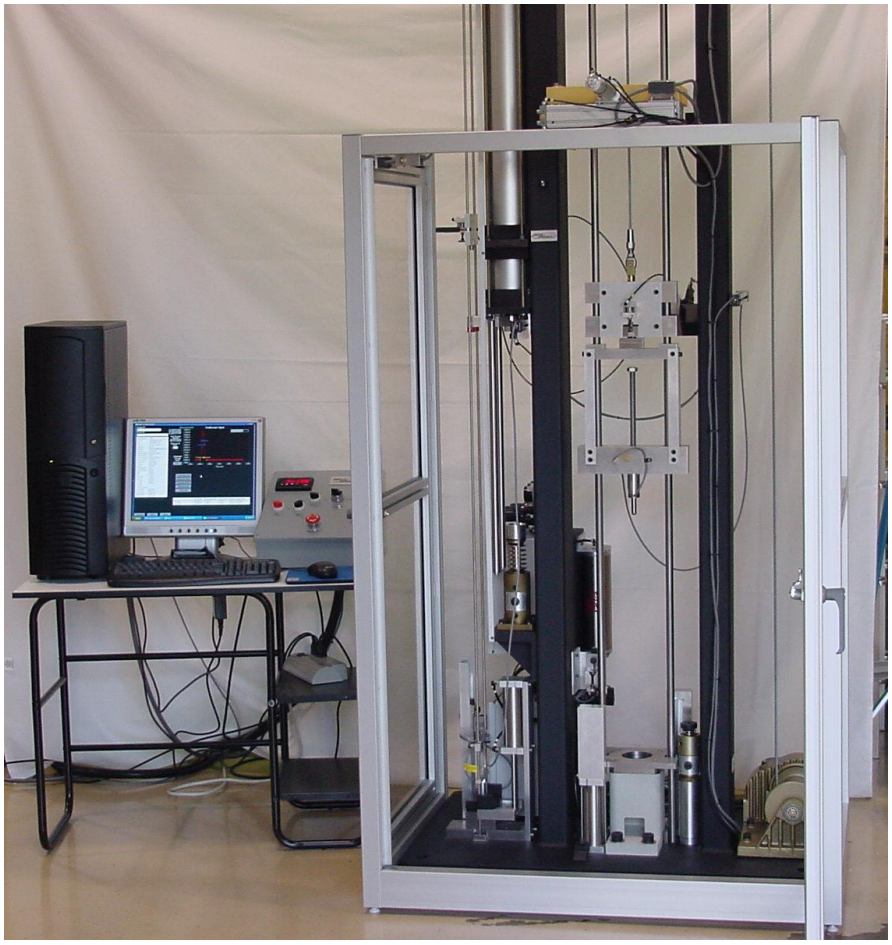
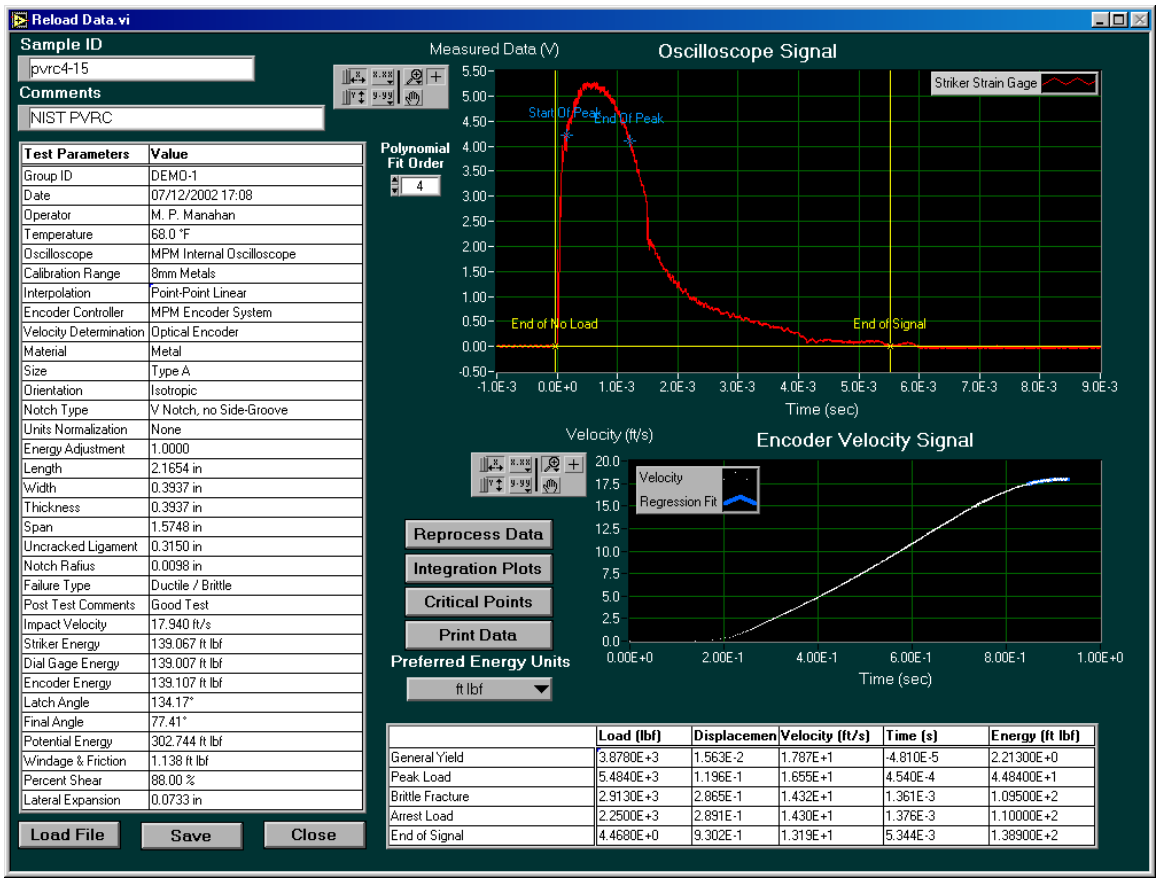


**Figure 1 MPM 9800 drop tower system equipped for ASTM D3763 punch penetration test for plastics and a second tower for hail simulation. The photograph shows the safety enclosure, drop height positioning system, safety plate, increased velocity system, pneumatic release, manual control handset, and control consolette. The rail cart release is interlocked with the door. The entire test can be controlled manually or by computer. When the test machine is configured for other test geometries, the base and tups are replaced with those specified for the desired test.**

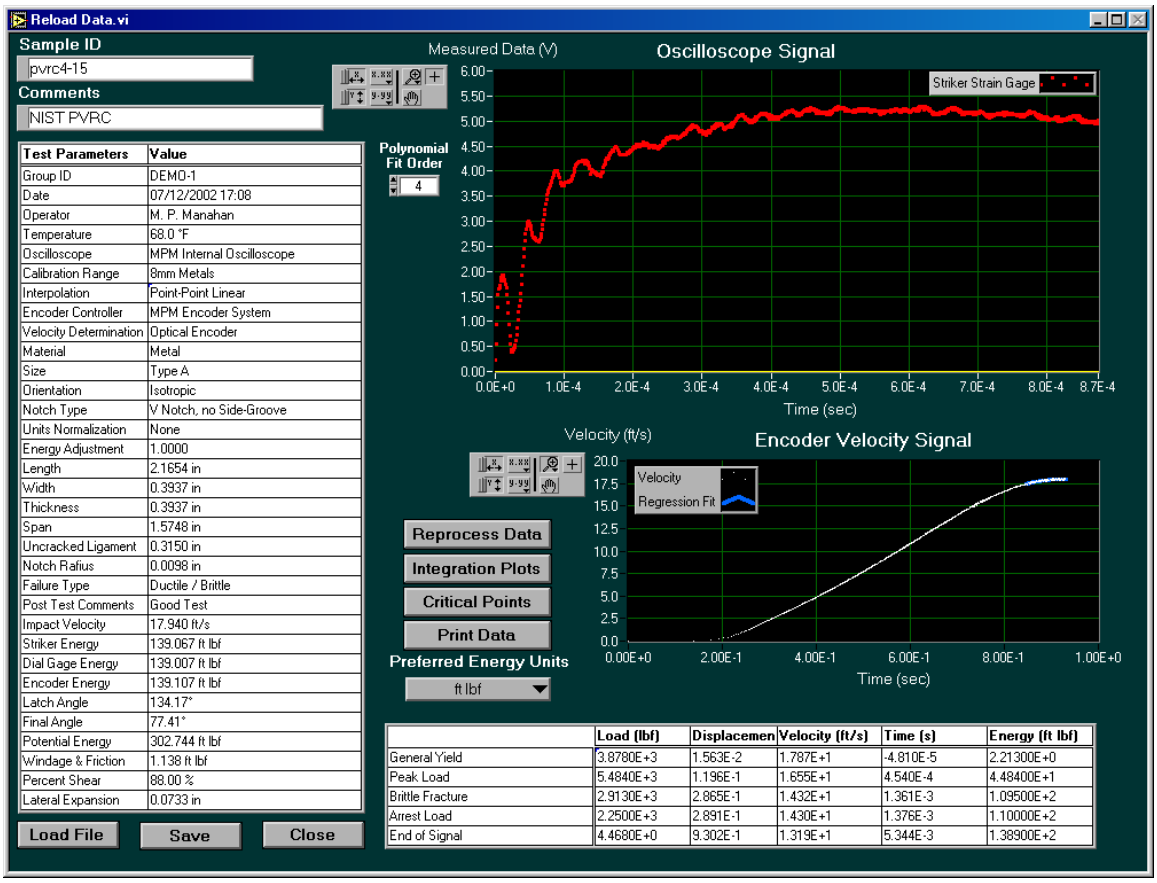
**Figure 2** **Data acquisition computer with 12 bit fast acquisition board, encoder board, encoder hardware, and strain gage amplifier. The amplifier provides autobalance, amplifier range selection, and shunt calibration for periodic calibration checking. The amplifier is capable of a wide range of amplification settings for the research environment needs.**




| Test Parameters | Value |
|---|---|
| Group ID | DEMO-1 |
| Date | 07/12/2002 17:08 |
| Operator | M. P. Manahan |
| Temperature | 68.0 °F |
| Oscilloscope | MPM Internal Oscilloscope |
| Calibration Range | 8mm Metals |
| Interpolation | Point-Point Linear |
| Encoder Controller | MPM Encoder System |
| Velocity Determination | Optical Encoder |
| Material | Metal |
| Size | Type A |
| Orientation | Isotropic |
| Notch Type | V Notch, no Side-Groove |
| Units Normalization | None |
| Energy Adjustment | 1.0000 |
| Length | 2.1654 in |
| Width | 0.3937 in |
| Thickness | 0.3937 in |
| Span | 1.5748 in |
| Uncracked Ligament | 0.3150 in |
| Notch Rafius | 0.0098 in |
| Failure Type | Ductile / Brittle |
| Post Test Comments | Good Test |
| Impact Velocity | 17.940 ft/s |
| Striker Energy | 139.067 ft lbf |
| Dial Gage Energy | 139.007 ft lbf |
| Encoder Energy | 139.107 ft lbf |
| Latch Angle | 134.17° |
| Final Angle | 77.41° |
| Potential Energy | 302.744 ft lbf |
| Windage & Friction | 1.138 ft lbf |
| Percent Shear | 88.00 % |
| Lateral Expansion | 0.0733 in |

| | Load (lbf) | Displacemen | Velocity (ft/s) | Time (s) | Energy (ft lbf) |
|---|---|---|---|---|---|
| General Yield | 3.8780E+3 | 1.563E-2 | 1.787E+1 | -4.810E-5 | 2.21300E+0 |
| Peak Load | 5.4840E+3 | 1.196E-1 | 1.655E+1 | 4.540E-4 | 4.48400E+1 |
| Brittle Fracture | 2.9130E+3 | 2.865E-1 | 1.432E+1 | 1.361E-3 | 1.09500E+2 |
| Arrest Load | 2.2500E+3 | 2.891E-1 | 1.430E+1 | 1.376E-3 | 1.10000E+2 |
| End of Signal | 4.4680E+0 | 9.302E-1 | 1.319E+1 | 5.344E-3 | 1.38900E+2 |

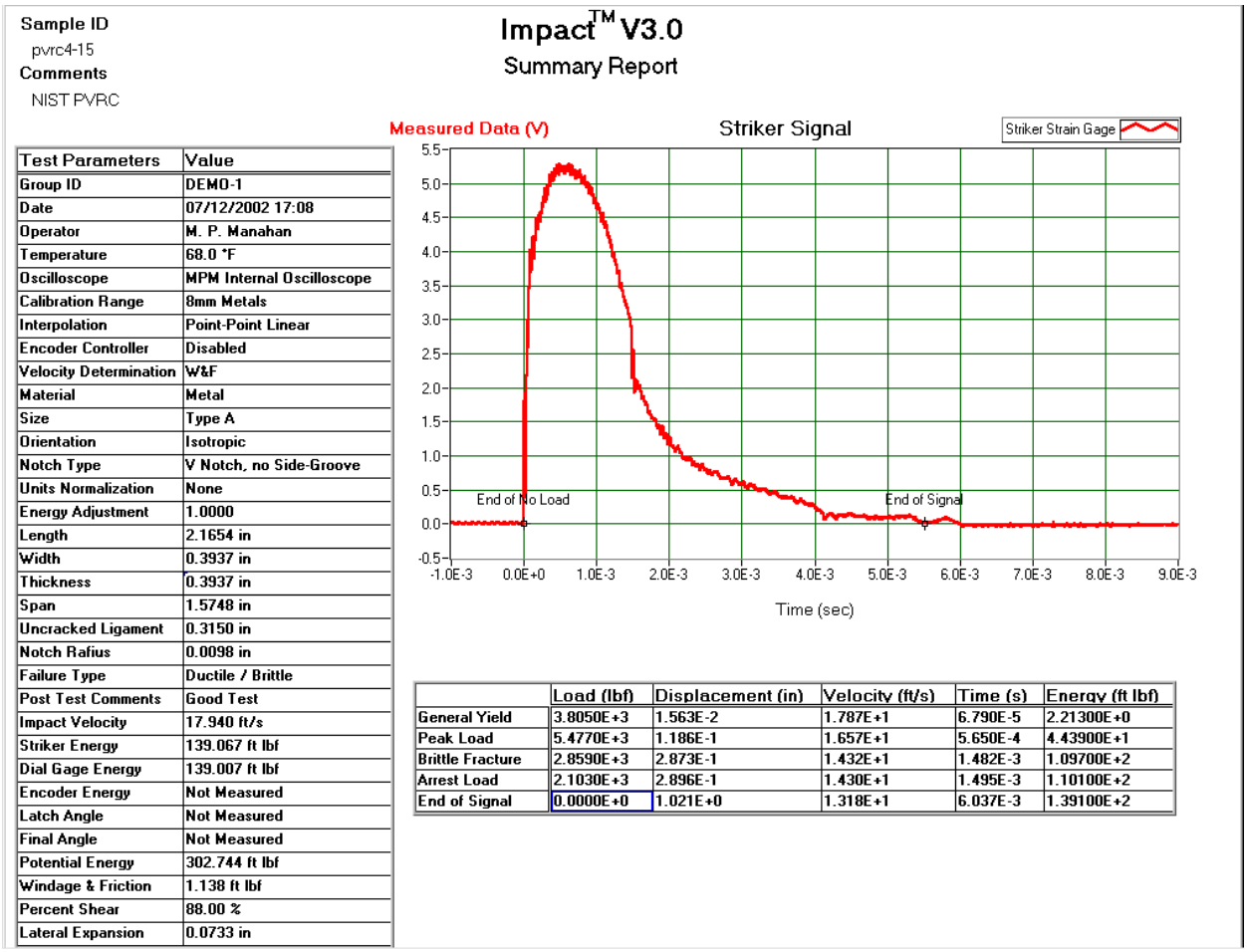
**Figure 3** **Data acquisition screen for test conducted on a pendulum impact machine. The raw voltage-time data are displayed along with the test parameters. This test machine was equipped with a 20,000 count encoder and therefore the velocity of the pendulum was measured. This feature is not available on drop tower test machines.**




| Test Parameters | Value |
|---|---|
| Group ID | DEMO-1 |
| Date | 07/12/2002 17:08 |
| Operator | M. P. Manahan |
| Temperature | 68.0 °F |
| Oscilloscope | MPM Internal Oscilloscope |
| Calibration Range | 8mm Metals |
| Interpolation | Point-Point Linear |
| Encoder Controller | MPM Encoder System |
| Velocity Determination | Optical Encoder |
| Material | Metal |
| Size | Type A |
| Orientation | Isotropic |
| Notch Type | V Notch, no Side-Groove |
| Units Normalization | None |
| Energy Adjustment | 1.0000 |
| Length | 2.1654 in |
| Width | 0.3937 in |
| Thickness | 0.3937 in |
| Span | 1.5748 in |
| Uncracked Ligament | 0.3150 in |
| Notch Ratius | 0.0098 in |
| Failure Type | Ductile / Brittle |
| Post Test Comments | Good Test |
| Impact Velocity | 17.940 ft/s |
| Striker Energy | 139.067 ft lbf |
| Dial Gage Energy | 139.007 ft lbf |
| Encoder Energy | 139.107 ft lbf |
| Latch Angle | 134.17° |
| Final Angle | 77.41° |
| Potential Energy | 302.744 ft lbf |
| Windage & Friction | 1.138 ft lbf |
| Percent Shear | 88.00 % |
| Lateral Expansion | 0.0733 in |

| | Load (lbf) | Displacemen | Velocity (ft/s) | Time (s) | Energy (ft lbf) |
|---|---|---|---|---|---|
| General Yield | 3.8780E+3 | 1.563E-2 | 1.787E+1 | -4.810E-5 | 2.21300E+0 |
| Peak Load | 5.4840E+3 | 1.196E-1 | 1.655E+1 | 4.540E-4 | 4.48400E+1 |
| Brittle Fracture | 2.9130E+3 | 2.865E-1 | 1.432E+1 | 1.361E-3 | 1.09500E+2 |
| Arrest Load | 2.2500E+3 | 2.891E-1 | 1.430E+1 | 1.376E-3 | 1.10000E+2 |
| End of Signal | 4.4680E+0 | 9.302E-1 | 1.319E+1 | 5.344E-3 | 1.38900E+2 |

**Figure 4** **Repeat of the screen of Figure 3 above demonstrating the data in point-plot mode with the time axis expanded. This test was conducted with a 10,000 point acquisition spread over 10 msec. Notice that there are sufficient points to fully characterize the dynamic portions of the test signal. The MPM system allows up to 1,000,000 data points to be spread over any time range from a few microseconds to 20 seconds. This is very important for brittle tests where many data points are required over a short time interval (~0.1 msec).**



Sample ID
pvrc4-15
Comments
NIST PVRC

Impact™ V3.0
Summary Report

| Test Parameters | Value |
|---|---|
| Group ID | DEMO-1 |
| Date | 07/12/2002 17:08 |
| Operator | M. P. Manahan |
| Temperature | 68.0 °F |
| Oscilloscope | MPM Internal Oscilloscope |
| Calibration Range | 8mm Metals |
| Interpolation | Point-Point Linear |
| Encoder Controller | Disabled |
| Velocity Determination | W&F |
| Material | Metal |
| Size | Type A |
| Orientation | Isotropic |
| Notch Type | V Notch, no Side-Groove |
| Units Normalization | None |
| Energy Adjustment | 1.0000 |
| Length | 2.1654 in |
| Width | 0.3937 in |
| Thickness | 0.3937 in |
| Span | 1.5748 in |
| Uncracked Ligament | 0.3150 in |
| Notch Rafius | 0.0098 in |
| Failure Type | Ductile / Brittle |
| Post Test Comments | Good Test |
| Impact Velocity | 17.940 ft/s |
| Striker Energy | 139.067 ft lbf |
| Dial Gage Energy | 139.007 ft lbf |
| Encoder Energy | Not Measured |
| Latch Angle | Not Measured |
| Final Angle | Not Measured |
| Potential Energy | 302.744 ft lbf |
| Windage & Friction | 1.138 ft lbf |
| Percent Shear | 88.00 % |
| Lateral Expansion | 0.0733 in |

Measured Data (V)

Striker Signal

Striker Strain Gage



| | Load (lbf) | Displacement (in) | Velocity (ft/s) | Time (s) | Energy (ft lbf) |
|---|---|---|---|---|---|
| General Yield | 3.8050E+3 | 1.563E-2 | 1.787E+1 | 6.790E-5 | 2.21300E+0 |
| Peak Load | 5.4770E+3 | 1.186E-1 | 1.657E+1 | 5.650E-4 | 4.43900E+1 |
| Brittle Fracture | 2.8590E+3 | 2.873E-1 | 1.432E+1 | 1.482E-3 | 1.09700E+2 |
| Arrest Load | 2.1030E+3 | 2.896E-1 | 1.430E+1 | 1.495E-3 | 1.10100E+2 |
| End of Signal | 0.0000E+0 | 1.021E+0 | 1.318E+1 | 6.037E-3 | 1.39100E+2 |

**Figure 5** **Typical output report (see Figures 6 and 7 for other reports) for a Charpy test on a drop tower test machine. The raw voltage-time signal is displayed along with test parameters and characteristic load data.**

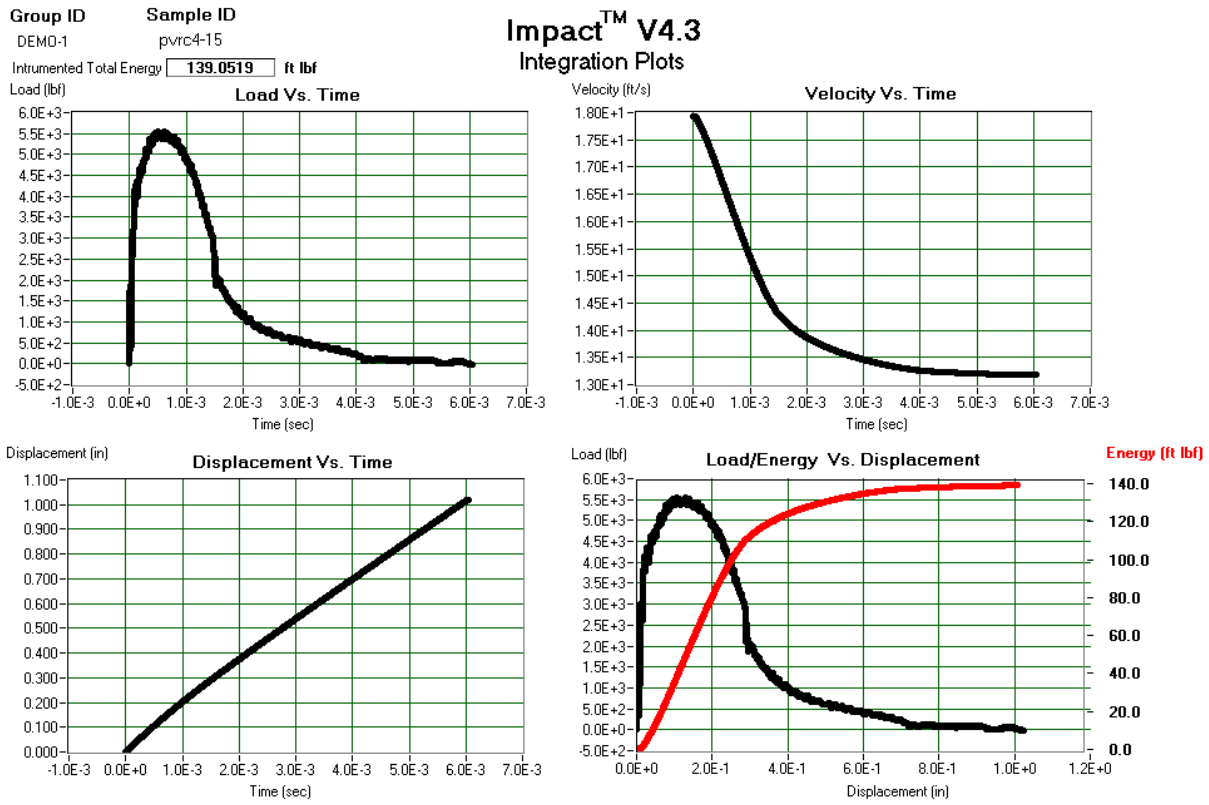
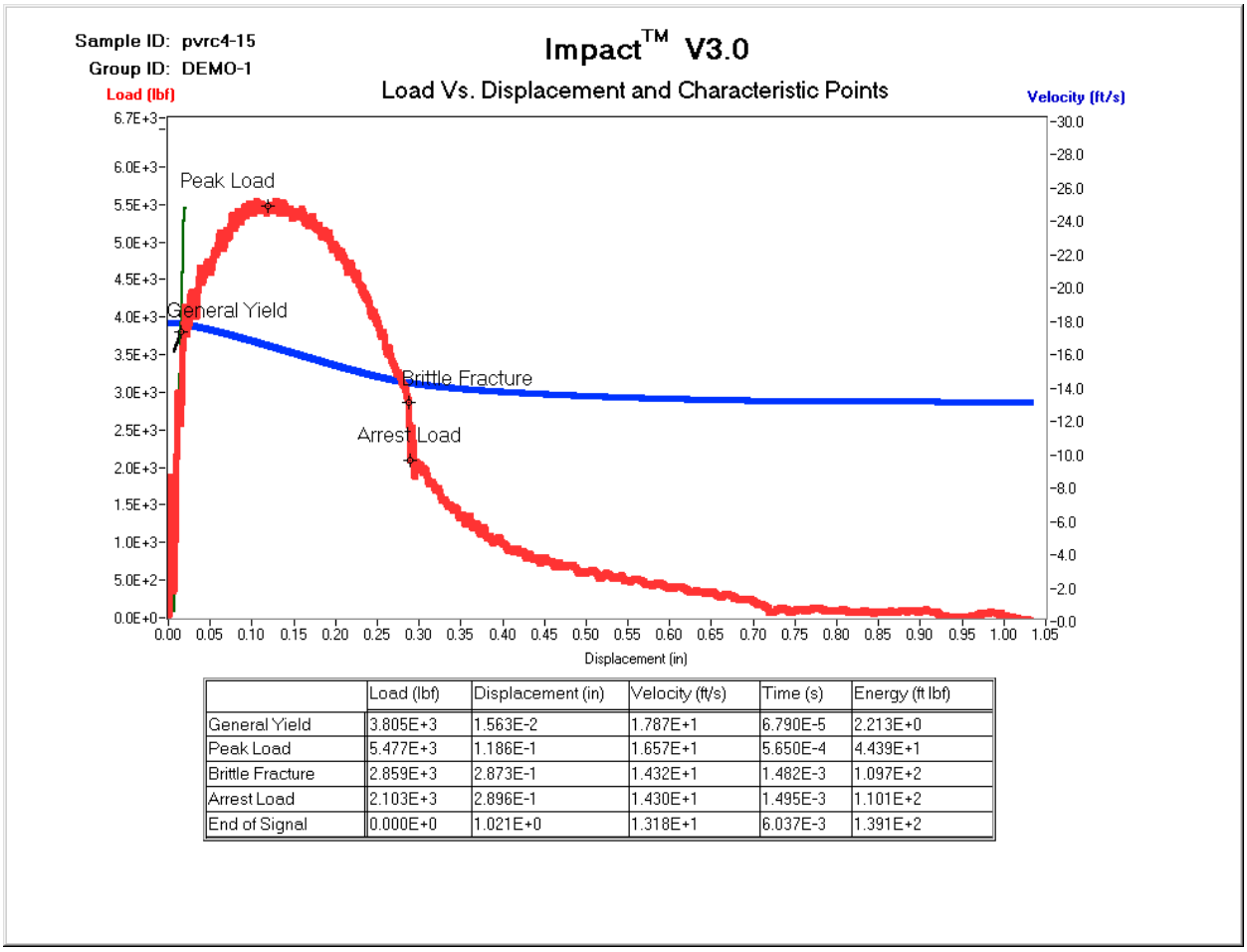
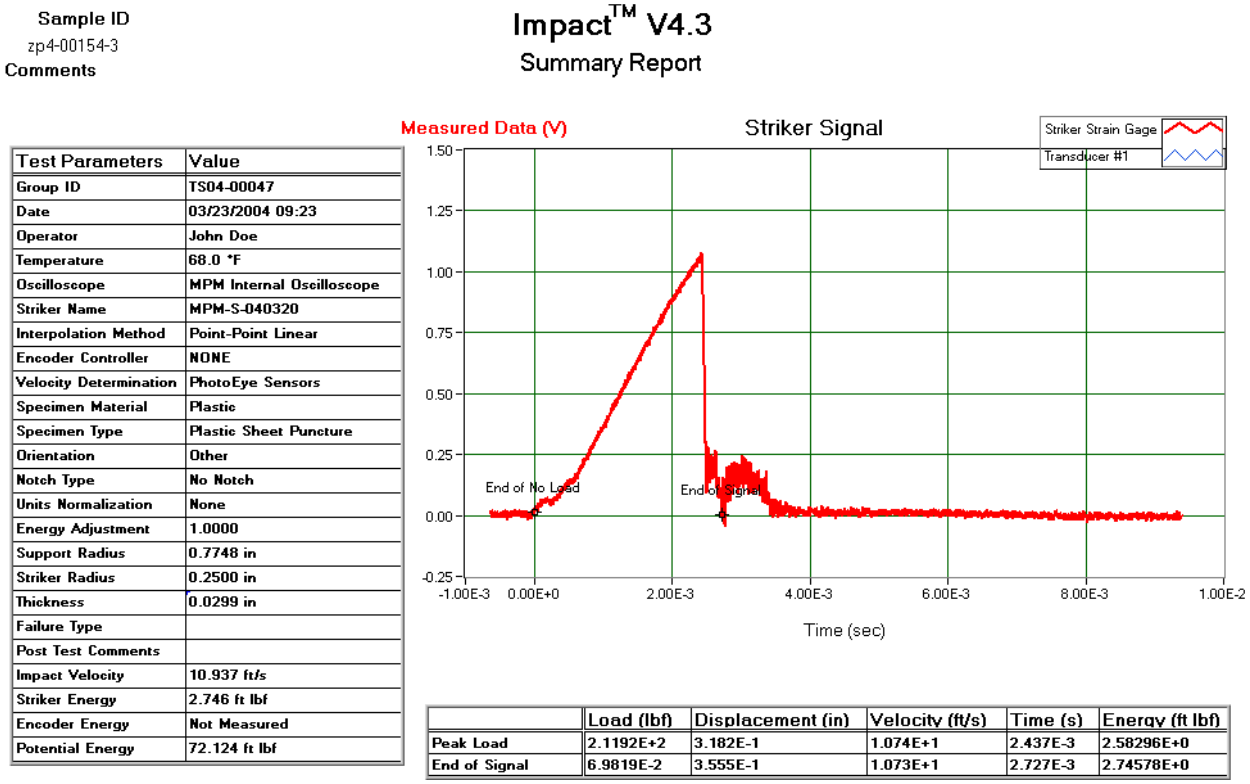



**Figure 6** **Typical output report (see Figures 5 and 7 for other reports) for a Charpy test on a drop tower test machine. The raw voltage-time signal has been converted to the force-time signal through the striker calibration. The calibration is typically performed statically using 20 points which are fit to give the force-striker voltage relationship. The force-time curve is integrated to give the velocity-time curve. The velocity-time curve is integrated to give the striker displacement-time curve. Finally, the force-displacement curve is integrated to give the energy absorbed by the test specimen.**




| | Load (lbf) | Displacement (in) | Velocity (ft/s) | Time (s) | Energy (ft lbf) |
|---|---|---|---|---|---|
| General Yield | 3.805E+3 | 1.563E-2 | 1.787E+1 | 6.790E-5 | 2.213E+0 |
| Peak Load | 5.477E+3 | 1.186E-1 | 1.657E+1 | 5.650E-4 | 4.439E+1 |
| Brittle Fracture | 2.859E+3 | 2.873E-1 | 1.432E+1 | 1.482E-3 | 1.097E+2 |
| Arrest Load | 2.103E+3 | 2.896E-1 | 1.430E+1 | 1.495E-3 | 1.101E+2 |
| End of Signal | 0.000E+0 | 1.021E+0 | 1.318E+1 | 6.037E-3 | 1.391E+2 |

**Figure 7** **Typical output report (see Figures 5 and 6 for other reports) for a Charpy test on a drop tower test machine. This plot displays the force-displacement plot and the velocity-displacement plot. The table summarizes the characteristic load data. The software contains an algorithm to automatically determine whether the curve is lower shelf, transition region, or upper shelf. The characteristic loads are automatically determined. In addition, the user can move the cursors to define the points.**



Sample ID
zp4-00154-3
Comments

Impact™ V4.3
Summary Report

| Test Parameters | Value |
|---|---|
| Group ID | TS04-00047 |
| Date | 03/23/2004 09:23 |
| Operator | John Doe |
| Temperature | 68.0 °F |
| Oscilloscope | MPM Internal Oscilloscope |
| Striker Name | MPM-S-040320 |
| Interpolation Method | Point-Point Linear |
| Encoder Controller | NONE |
| Velocity Determination | PhotoEye Sensors |
| Specimen Material | Plastic |
| Specimen Type | Plastic Sheet Puncture |
| Orientation | Other |
| Notch Type | No Notch |
| Units Normalization | None |
| Energy Adjustment | 1.0000 |
| Support Radius | 0.7748 in |
| Striker Radius | 0.2500 in |
| Thickness | 0.0299 in |
| Failure Type | |
| Post Test Comments | |
| Impact Velocity | 10.937 ft/s |
| Striker Energy | 2.746 ft lbf |
| Encoder Energy | Not Measured |
| Potential Energy | 72.124 ft lbf |

Measured Data (V)

Striker Signal

Striker Strain Gage
Transducer #1

1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25

End of No Load
End of Signal

-1.00E-3 0.00E+0 2.00E-3 4.00E-3 6.00E-3 8.00E-3 1.00E-2

Time (sec)

| | Load (lbf) | Displacement (in) | Velocity (ft/s) | Time (s) | Energy (ft lbf) |
|---|---|---|---|---|---|
| Peak Load | 2.1192E+2 | 3.182E-1 | 1.074E+1 | 2.437E-3 | 2.58296E+0 |
| End of Signal | 6.9819E-2 | 3.555E-1 | 1.073E+1 | 2.727E-3 | 2.74578E+0 |

**Figure 8 Typical voltage-time output report for an ASTM D3763 test conducted on a drop tower. This specimen exhibits brittle fracture behavior.**

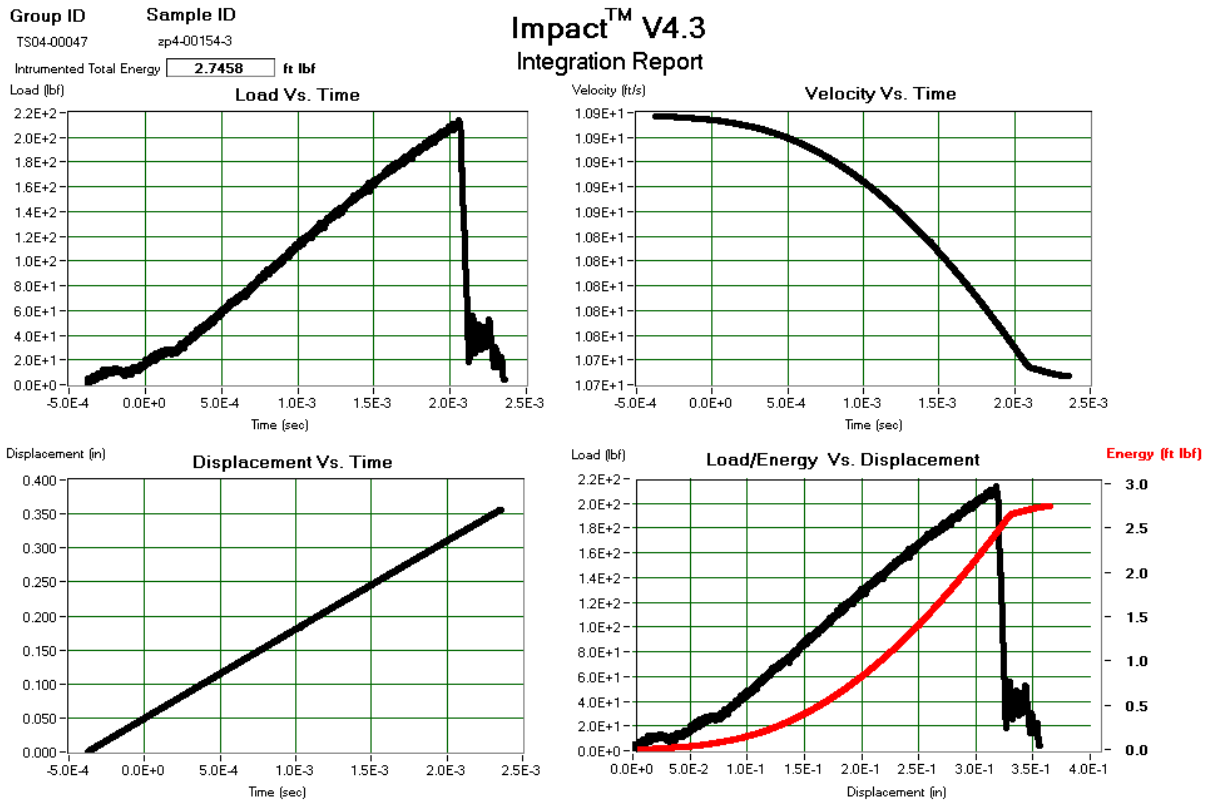
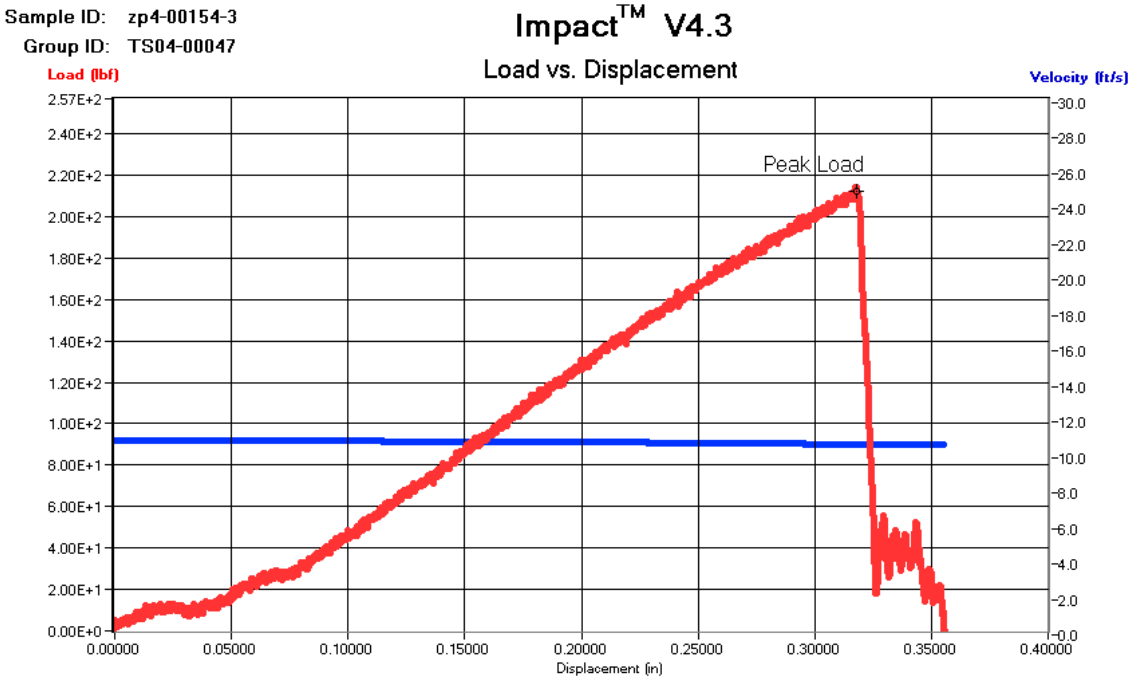
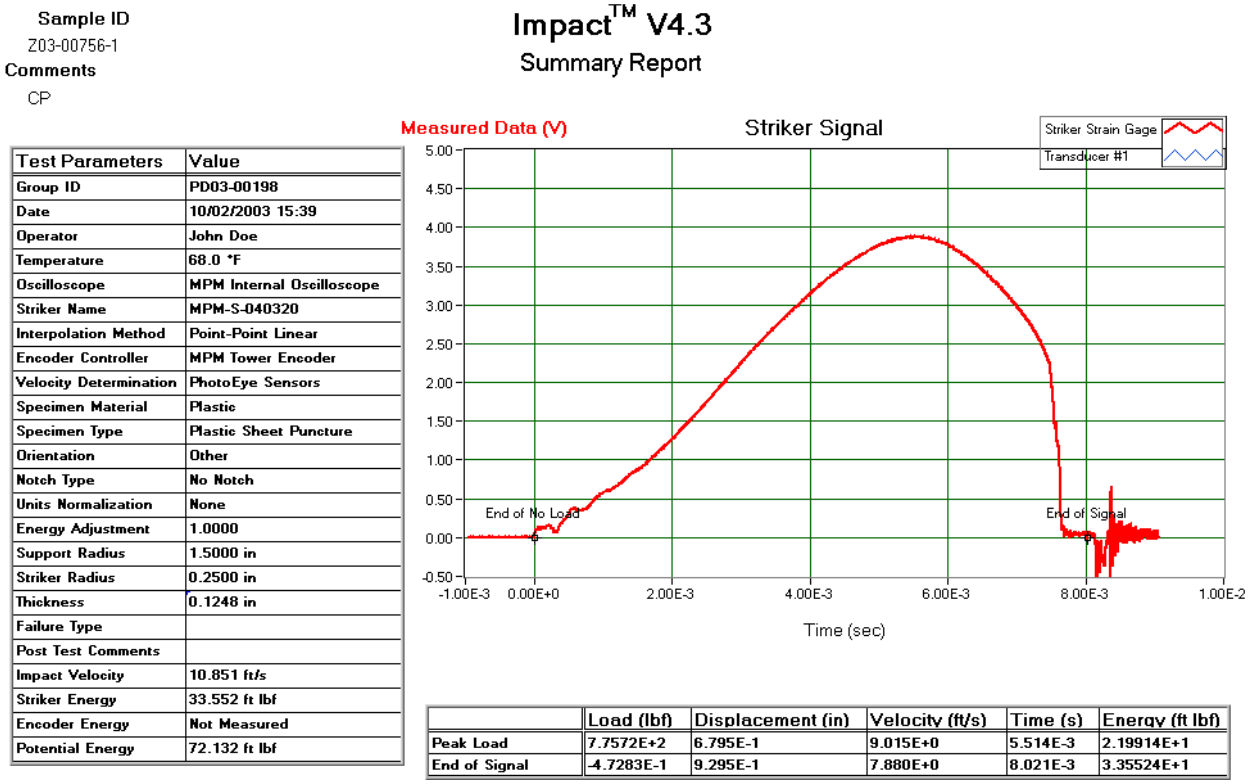



**Figure 9** **Typical integration steps output report for an ASTM D3763 test conducted on a drop tower. This specimen exhibits brittle fracture behavior.**




| | Load (lbf) | Displacement (in) | Velocity (ft/s) | Time (s) | Energy (ft lbf) |
|---|---|---|---|---|---|
| Peak Load | 2.1191E+2 | 3.182E-1 | 1.074E+1 | 2.437E-3 | 2.58296E+0 |
| End of Signal | 6.9819E-2 | 3.555E-1 | 1.073E+1 | 2.727E-3 | 2.74578E+0 |

**Figure 10 Typical critical points output report for an ASTM D3763 test conducted on a drop tower. This specimen exhibits brittle fracture behavior.**




| Test Parameters | Value |
|---|---|
| Group ID | PD03-00198 |
| Date | 10/02/2003 15:39 |
| Operator | John Doe |
| Temperature | 68.0 °F |
| Oscilloscope | MPM Internal Oscilloscope |
| Striker Name | MPM-S-040320 |
| Interpolation Method | Point-Point Linear |
| Encoder Controller | MPM Tower Encoder |
| Velocity Determination | PhotoEye Sensors |
| Specimen Material | Plastic |
| Specimen Type | Plastic Sheet Puncture |
| Orientation | Other |
| Notch Type | No Notch |
| Units Normalization | None |
| Energy Adjustment | 1.0000 |
| Support Radius | 1.5000 in |
| Striker Radius | 0.2500 in |
| Thickness | 0.1248 in |
| Failure Type | |
| Post Test Comments | |
| Impact Velocity | 10.851 ft/s |
| Striker Energy | 33.552 ft lbf |
| Encoder Energy | Not Measured |
| Potential Energy | 72.132 ft lbf |

| | Load (lbf) | Displacement (in) | Velocity (ft/s) | Time (s) | Energy (ft lbf) |
|---|---|---|---|---|---|
| Peak Load | 7.7572E+2 | 6.795E-1 | 9.015E+0 | 5.514E-3 | 2.19914E+1 |
| End of Signal | -4.7283E-1 | 9.295E-1 | 7.880E+0 | 8.021E-3 | 3.35524E+1 |

**Figure 11 Typical voltage-time output report for an ASTM D3763 test conducted on a drop tower. This specimen exhibits ductile fracture behavior.**

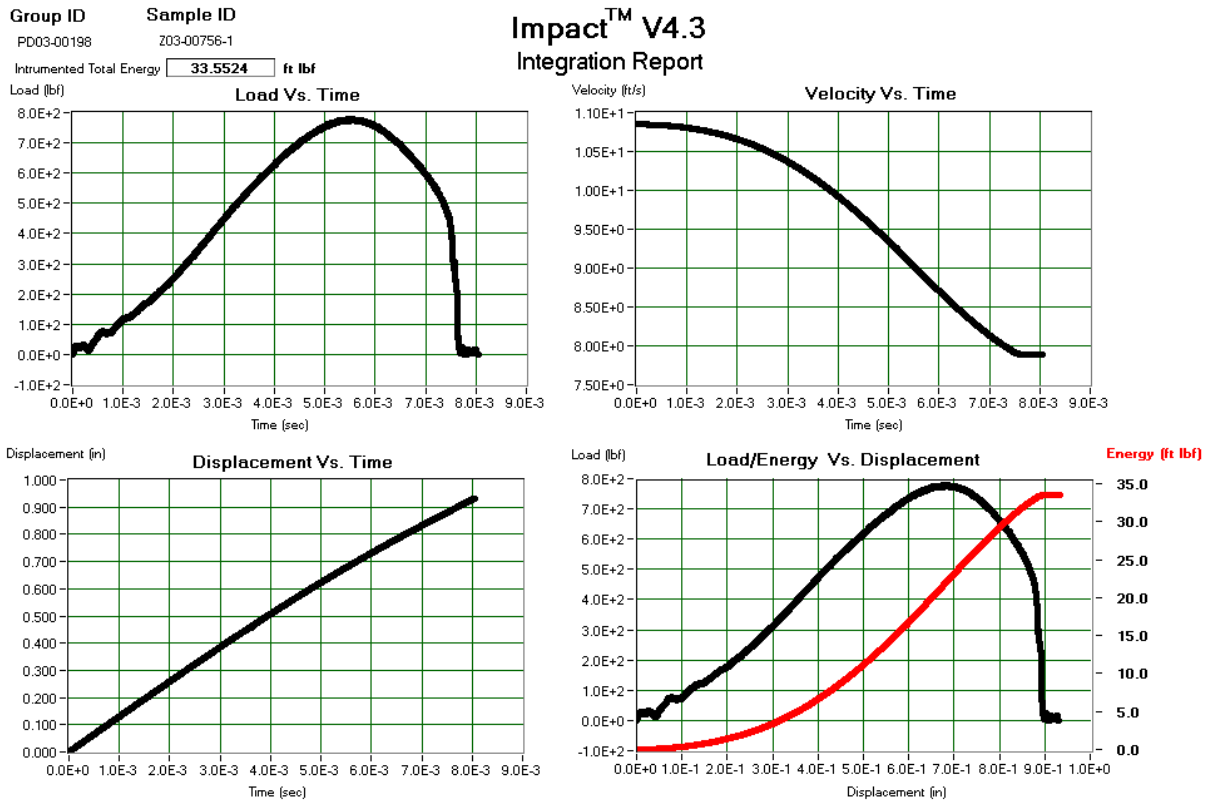
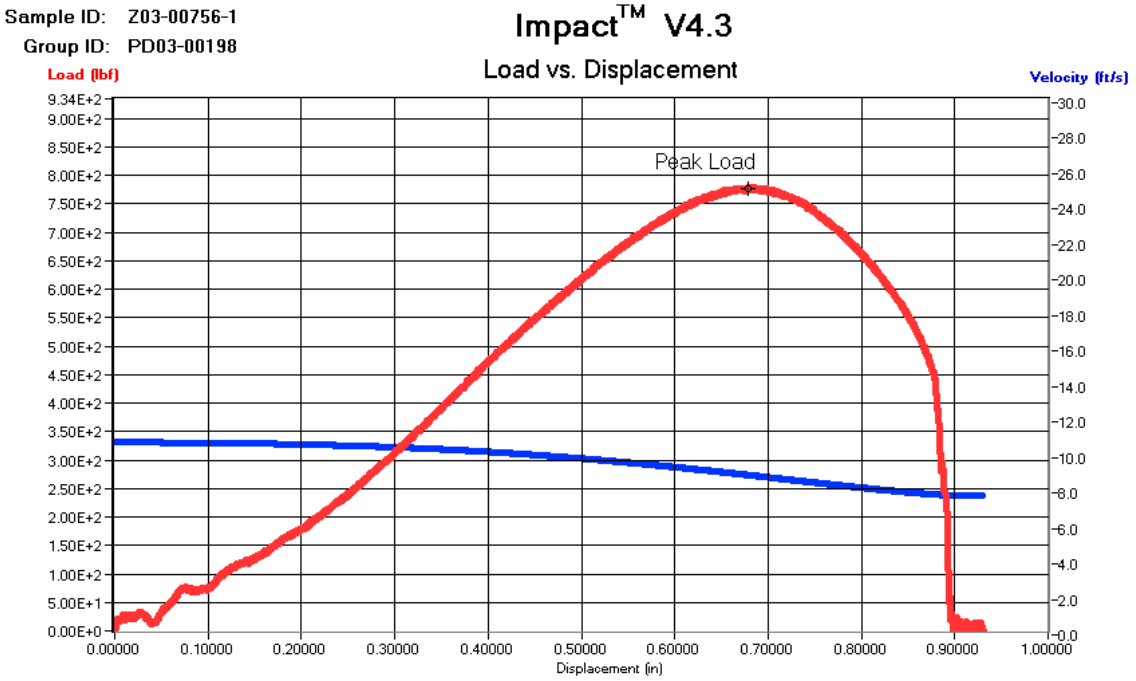



**Figure 12 Typical integration steps output report for an ASTM D3763 test conducted on a drop tower. This specimen exhibits ductile fracture behavior.**




| | Load (lbf) | Displacement (in) | Velocity (ft/s) | Time (s) | Energy (ft lbf) |
|---|---|---|---|---|---|
| Peak Load | 7.7570E+2 | 6.790E-1 | 9.018E+0 | 5.509E-3 | 2.19564E+1 |
| End of Signal | -4.7283E-1 | 9.295E-1 | 7.880E+0 | 8.021E-3 | 3.35524E+1 |

**Figure 13 Typical critical points output report for an ASTM D3763 test conducted on a drop tower. This specimen exhibits ductile fracture behavior.**

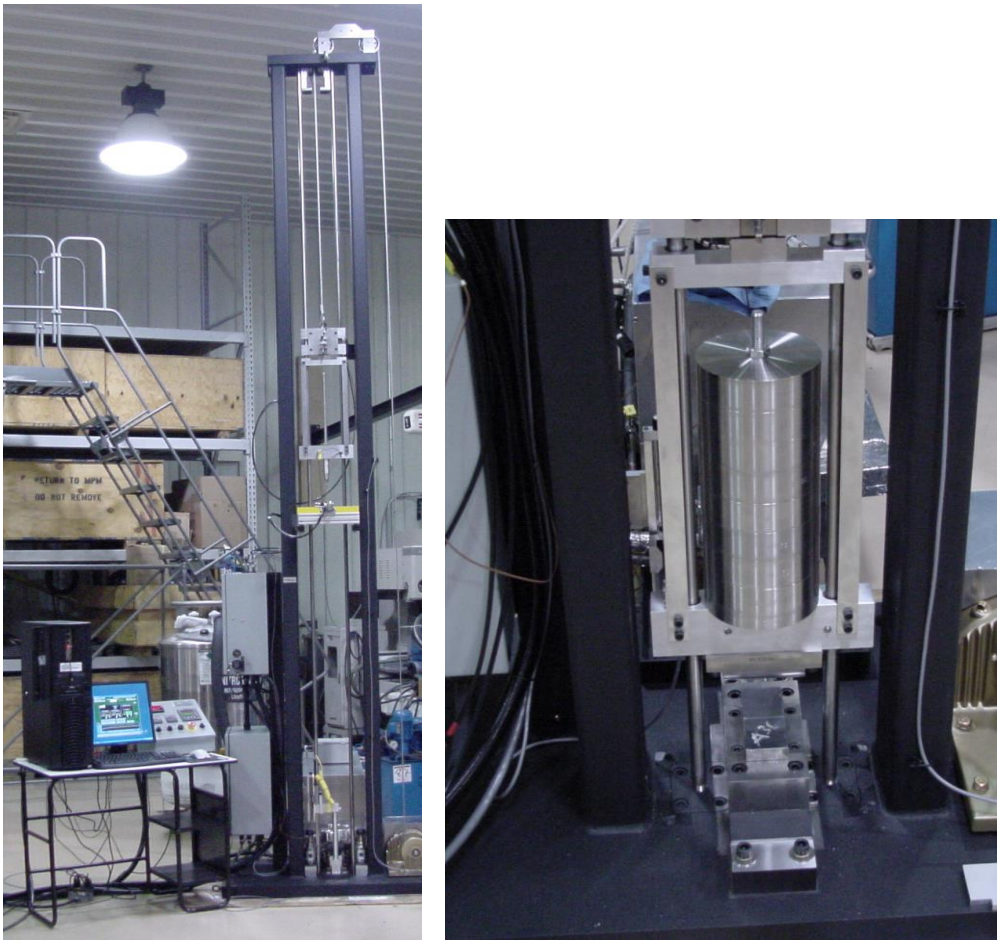


**Figure 14** **ASTM E 208 NDT Drop Tower with motorized return and computer control system (left) showing close of add-on weights for various energy capacities.**

**Figure 15** **High energy capacity (10,000 ft-lbs) drop tower for impact testing of concrete highway abutments.**

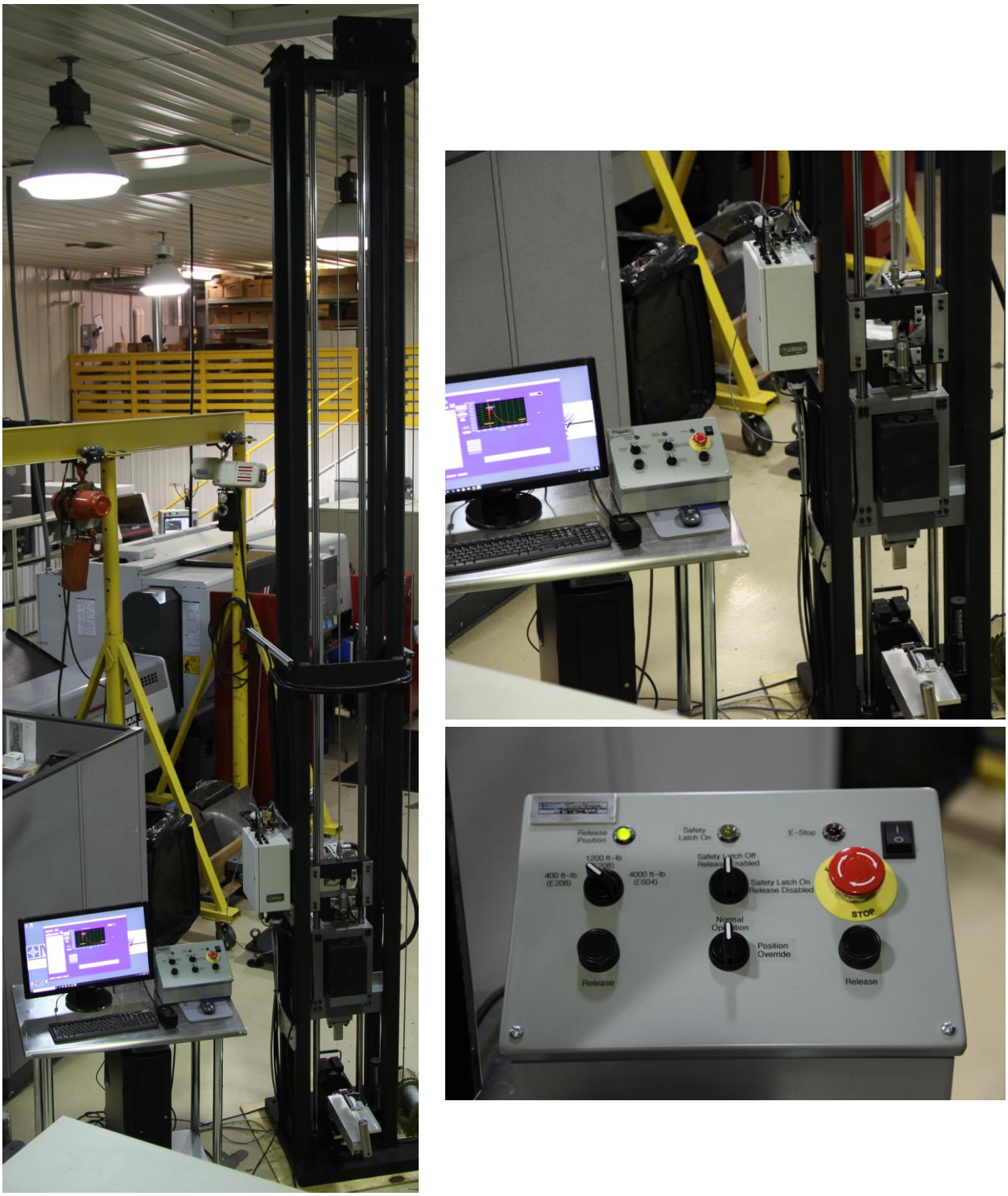



**Figure 16** **4000 ft-lb dynamic tear drop tower with instrumented striker and kinetic energy measurement systems.**