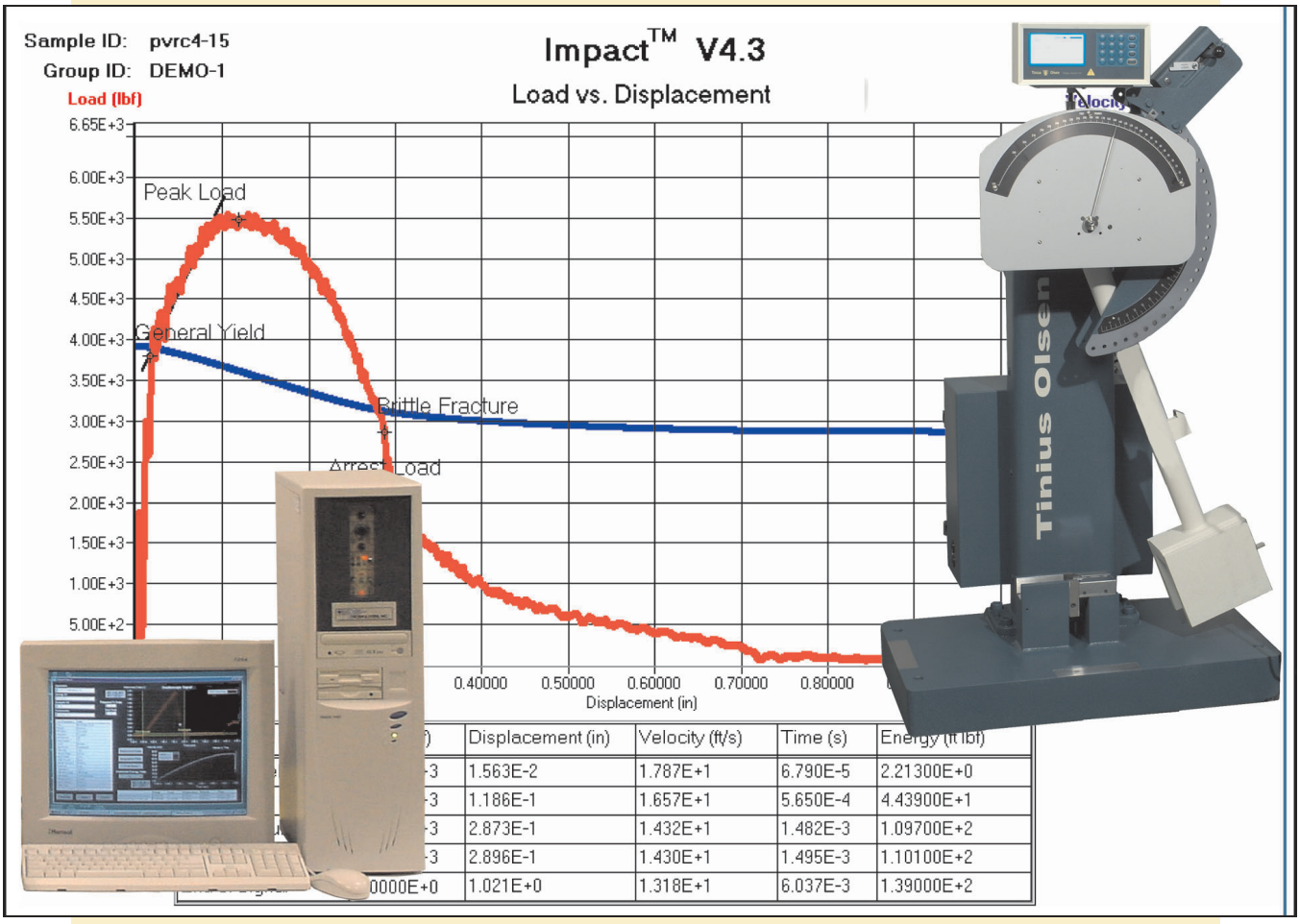
Tinius Olsen

Instrumented Impact Tester



	Displacement (in)	Velocity (ft/s)	Time (s)	Energy (ft lbf)
-3	1.563E-2	1.787E+1	6.790E-5	2.21300E+0
-3	1.186E-1	1.657E+1	5.650E-4	4.43900E+1
-3	2.873E-1	1.432E+1	1.482E-3	1.09700E+2
-3	2.896E-1	1.430E+1	1.495E-3	1.10100E+2
0000E+0	1.021E+0	1.318E+1	6.037E-3	1.39000E+2

Instrumented Impact Testers

The Tinius Olsen / MPM instrumented striker system is the most accurate dynamic force measurement system in the world. The most important advantage of instrumenting the striker with strain gages is that the applied force and the energy during impact can be measured. In the case of a drop tower machine, this is the only means for energy determination, but for a pendulum machine, the energy is determined by an optical encoder and also independently by the instrumented striker. In addition to energy measurement, additional data such as the characteristic loads, deflections, and energies can be obtained.

Accurate measurement of the force during impact is an especially challenging task due to the dynamic nature of the load and the short time period over which the impact occurs (typically 1 to 5 milliseconds). This is compounded by the requirement of at least 10,000 data points to accurately represent the applied force. This data size requirement and short test duration means that the storage of the force-time data must be precisely triggered and this is accomplished by continuously monitoring the load signal and saving data when a significant rise in load occurs. Rapid load change events, such as acceleration of the specimen up to the striker speed, and brittle crack propagation, require a system response capability of at least 50 kHz for conventional specimens and > 100 kHz for miniature specimens. The Tinius Olsen / MPM system satisfies all of these requirements.

The powerful Impact™ software displays the raw voltage time data along with the test parameters and allows up to 1,000,000 data points to be spread over any time range from a few microseconds to a few seconds. This is very important for brittle tests where many data points are required over a short time interval (~0.1 msec). A serious data acquisition limitation arises because the PC processor is too slow to acquire many data points over a short time interval, so we solved this problem by providing a 20 MHz oscilloscope card that stores the data directly, once the test is complete, data is downloaded from the board to the PC.

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. This curve can then be mathematically integrated to yield the velocity-time curve; this velocity-time curve can, in turn, be mathematically 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 resultant force - displacement data can itself be integrated to give the energy absorbed by the specimen in fracturing.

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 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 this region, a small amount of stable crack growth precedes rapid brittle fracture which in turn is seen on the force displacement curve as a precipitous force drop.

Data from instrumented 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.

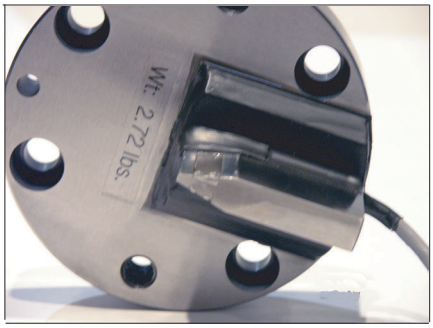


Fig 1. This shows an instrumented Charpy striker complete with strain gages.

Fig 2. Instrumented impact system computer running Impact 4.3 software, with oscilloscope data collection card.

Fig 3. Instrumented impact system with in-situ heating and cooling system.

Instrumented Impact Testers

Hardware

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

- strain gage amplifier (will be installed in test machine computer)
- instrumented striker with cable (sold separately)
- oscilloscope card installed in computer
- ImpactTM v4.3 software package
- system manual

The Tinius Olsen / MPM oscilloscope card has the following features:

- 12- bit 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 (10,000 to 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 also be provided.

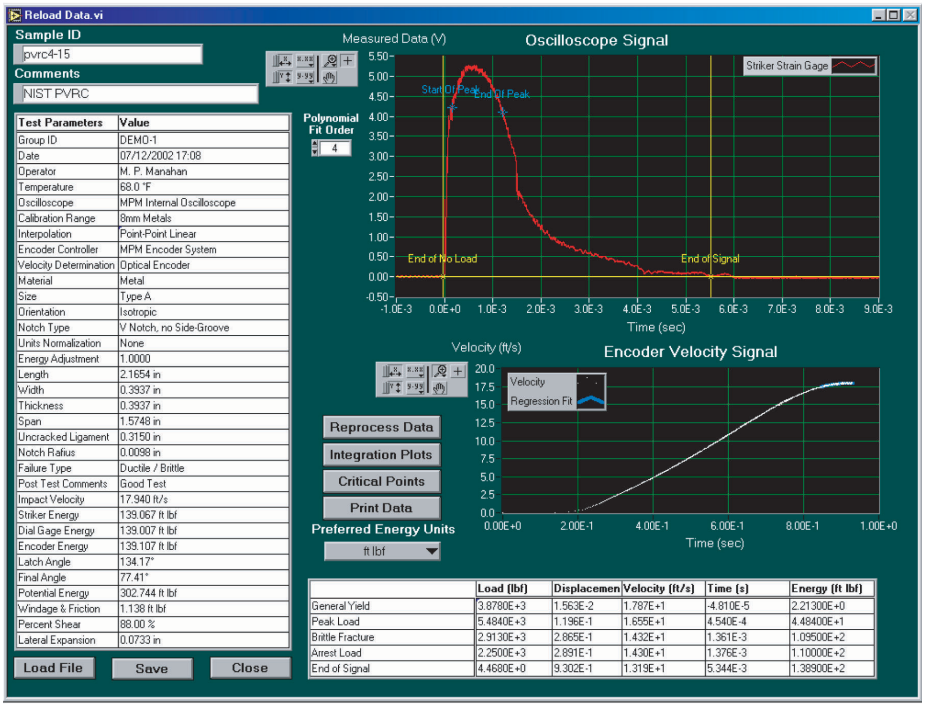
Software

Impact v4.3 software is the data acquisition and analysis software, operating under Microsoft Windows 2000™, that is power behind the system. The software acquires the instrumented signal and, optionally, the optical encoder energy and the dial energy (for test machines equipped with this hardware), analyses these data and provides a test report which summarizes the absorbed energy as well as important information from the test such as test temperature, specimen identification, etc.

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

general yield load (for metal Charpy specimens)
peak load
brittle fracture initiation load
brittle fracture arrest load
crack initiation energy
crack arrest energy
total absorbed energy

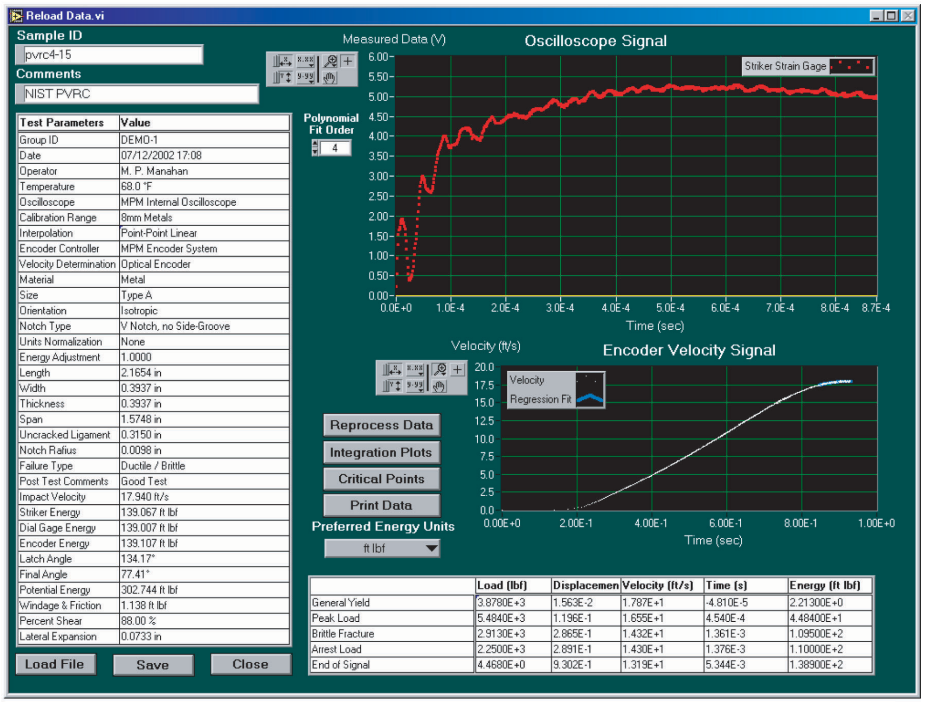
These data can be used to determine other useful quantities such as:
micro cleavage fracture stress (for metals)
fractures toughness
crack arrest toughness
definition of the intersection of the lower shelf and transition region (for materials which exhibit transitional fracture behavior)
definition of the onset of the upper shelf (for materials which exhibit transitional fracture behavior)



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

Fig. 4. This screen shows the raw voltage-time data which is displayed with the test parameters. This machine was equipped with a 20,000 count encoder, allowing the pendulum velocity to be measured.



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End of Signal	4.4680E+0	9.302E-1	1.319E+1	5.344E-3	1.38900E+2

Fig 5. This screen shows an expanded time axis on the previous screen. This uses a 10,000 point acquisition spread over 10msec. The MPM/Tinius Olsen system allows up to 1,000,000 data points to be spread over any time range from a few microseconds to several seconds.

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. In addition, the software includes a statistical process control model for tracking changes in key material variables.

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Another useful feature of the software is the Table function. With this function, users can define the test parameters to be included in a table and the order in which the parameters appear in the table. Users then simply point 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.

In summary, the Tinius Olsen / 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
- ImpactTM v4.3 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

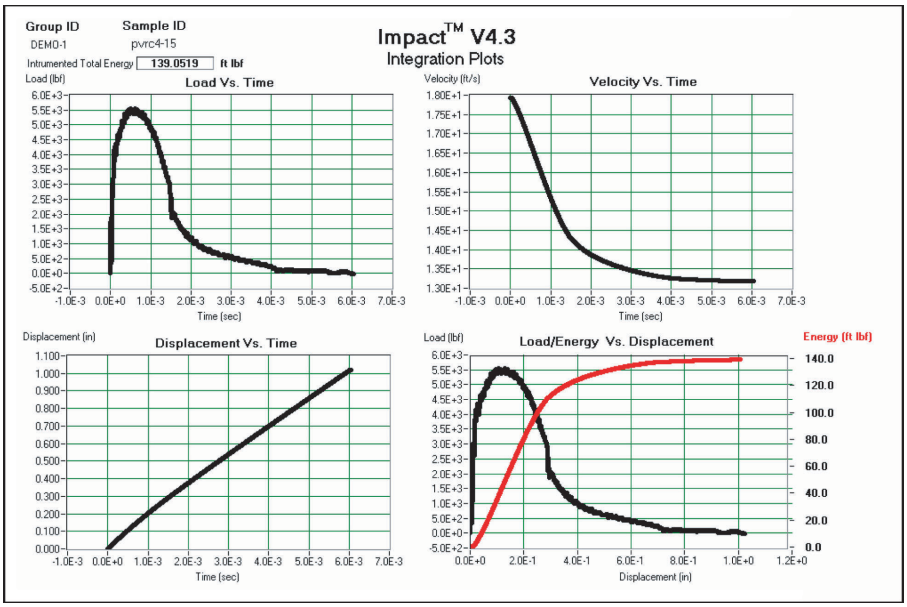
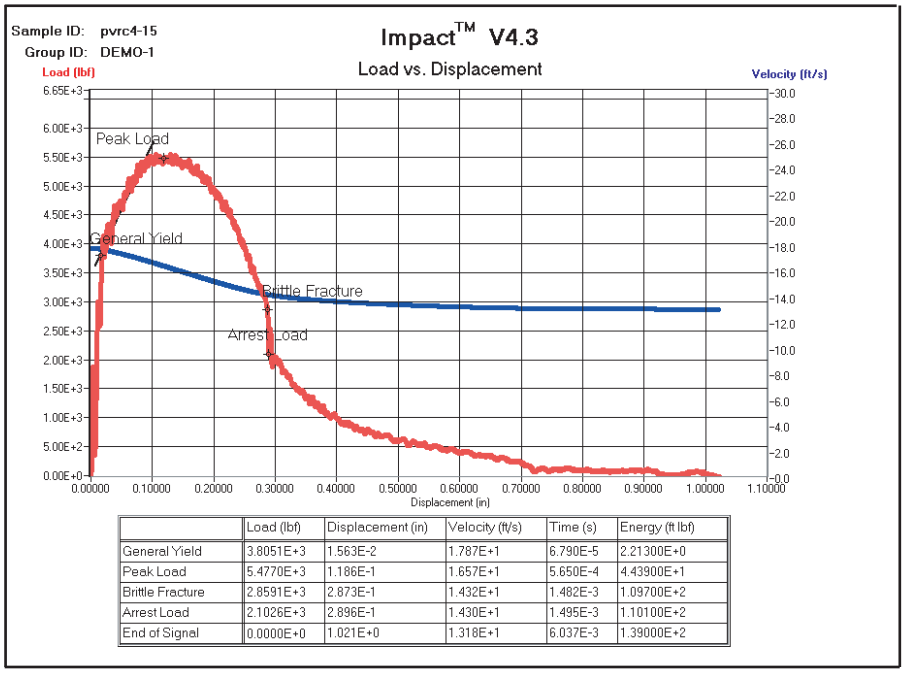


Fig 6. Graphs showing the integration plots on the data acquired.



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End of Signal	0.0000E+0	1.021E+0	1.318E+1	6.037E-3	1.39000E+2

Fig 7. This shows the characteristic load report with all the critical points calculated and shown.

Specifications subject to change without notice

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