Capabilities

of

MP Machinery

and

Testing, LLC

" … serving client needs through advanced technology… "

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USA
Web: www.MPMachineryandTesting.com

COMPANY BACKGROUND

MP Machinery and Testing, LLC (MPM) was incorporated in 2009 to offer materials testing products and services to industry and government. MPM also offers several specialized services such as nuclear surveillance capsule testing, neutron transport analyses, and in-service component failure analyses for the nuclear industry. The overall balance between products and services has historically been 50/50. MPM is considered a technological world leader in the impact testing and nuclear analysis areas.

MPM capabilities include the following:

Test equipment fabrication
Mechanical behavior testing
Quality Control test specimen fabrication
Fracture mechanics and flaw evaluation
Finite element analysis
Stress analysis
Failure analysis
In-service mechanical property testing
In-service component residual stress simulation
Material characterization
Reactor pressure vessel fabrication and analysis
License renewal & safety issue evaluation
Material corrosion testing and analysis
Irradiation services
Ex-vessel dosimetry analysis
Neutron transport and shield analysis
Monte Carlo simulation
Component surveillance

MPM has extensive in-house experimental and computing capabilities. These resources are used to solve industry problems and to develop and advance existing testing machines. MPM's advanced technology and meticulous attention to detail provide customers with the highest quality products and services at a price which is significantly below that of competitors.

MPM has adopted the phrase *"serving client needs through advanced technology"* as its corporate motto. This thought expresses MPM's focus on customer problems and the highly innovative spirit reflected in MPM problem solving. MPM is recognized as a leader in finding innovative solutions to very difficult problems. The breadth and depth of MPM experience is brought to bear on the difficult and challenging problems clients present.

MP Machinery & TESTING, LLC

SUMMARY OF TEST MACHINES

Impact Test Machines

- Charpy pendulum impact test machine with 400 ft-lb and 700 ft-lb capacities (ASTM E23)
- Automatic pendulum impact and drop tower test machines which run continuously in unattended mode
- Table top pendulum/drop tower impact test machines with 0.1 ft-lb to 100 ft-lb capacities for conventional and miniature test specimens
- Drop tower test machines for a wide variety of impact tests including ASTM E23, D3763, D256, D2444, and D6110

Impact Test Equipment

- Instrumented impact test systems for measurement of force-displacement during the impact test event
- In-situ heating and cooling systems for impact test machines
- Automatic test specimen transfer and alignment machines for impact test systems
- Fully automatic impact test equipment including: In-situ heating/cooling systems; specimen transfer systems; and specimen identification readers
- Instrumented striker calibration load frames

Test Equipment Refurbishment

- Existing drop towers and pendulum impact machine can be upgraded with the MPM state-of-the-art instrumented impact test system
- The in-situ heating/cooling and automatic specimen transfer system can be added to existing test equipment

Imaging Systems

- Image analysis systems for various measurements including percentage of shear fracture area

Shock Test Equipment

- Shock test machines for component qualification to various industry and military (MIL) standards

High Temperature Corrosion Equipment

- Reference electrodes for high temperature applications
- Corrosion crack growth monitoring systems
- Electrochemical corrosion potential monitoring systems

Electrochemistry Equipment

- Multi-purpose corrosion cell $(MC^2)^{TM}$ for all electrochemical experiments
- Dry reference electrodes for rapid field measurements

Shrink Test Equipment

- Shrink testers for characterization of shrink wrap

Photographs of several of MPM's test machines are provided on the following pages.

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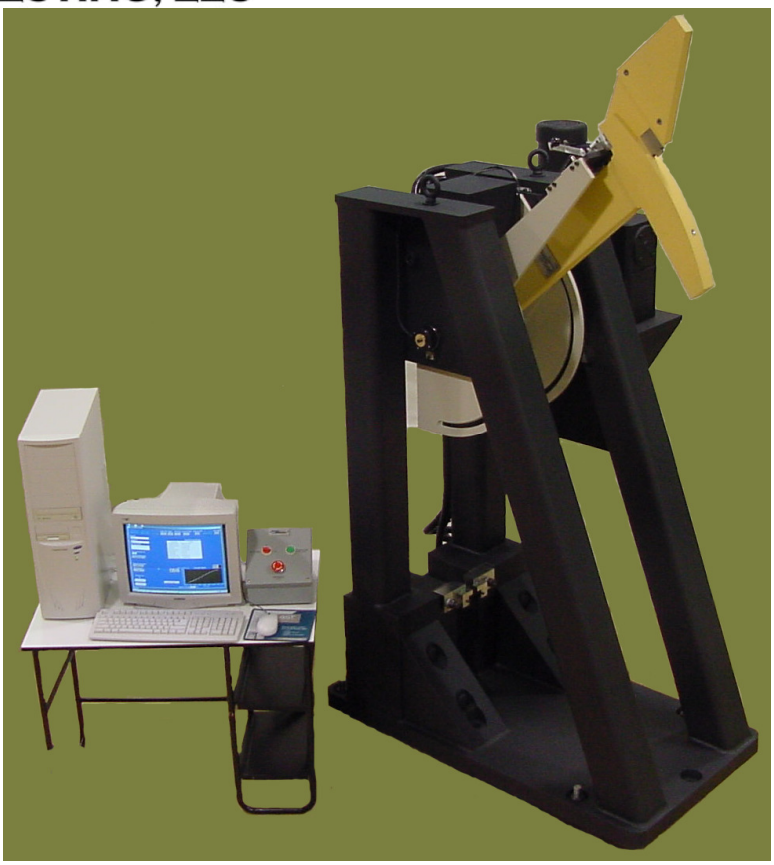
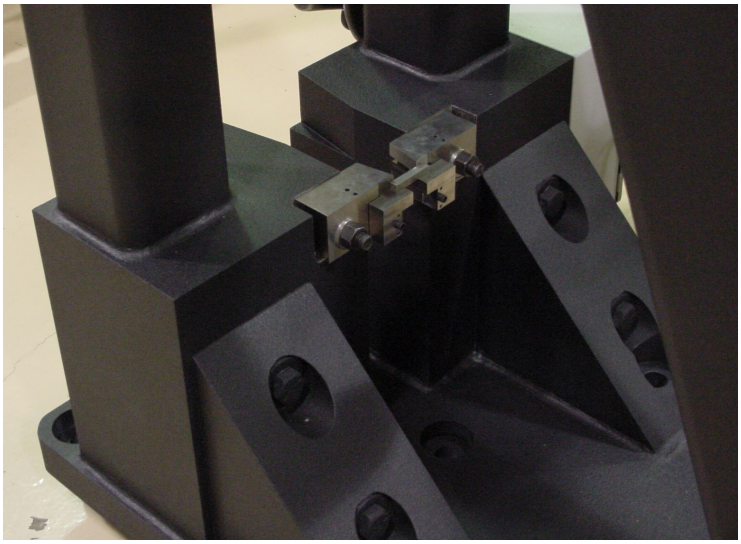


MPM pendulum impact test machine. The frame has been designed for up to 700 ft-lbs. Various test capacities from 100 to 700 ft-lbs are achieved by changing the pendulum.



Close up of test machine supports showing Charpy anvils and supports. The test machine base has been designed for Charpy, miniature Charpy, Izod, and tensile attachments.

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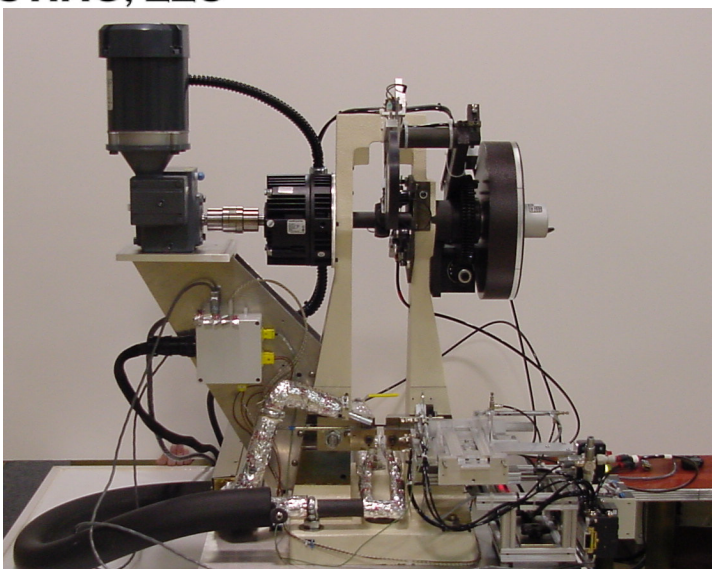
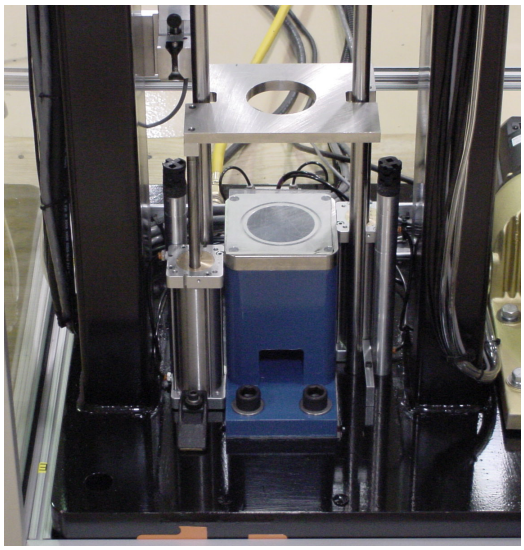


Table top test machine equipped with automatic hammer return, specimen transfer system, and in-situ heating and cooling system.

Tinius Olsen Model 84 Pendulum Impact Test Machine equipped with in-situ heating and cooling system, optical encoder, and motorized hammer return.

MP Machinery & TESTING, LLC

MPM drop tower test machine configured for ASTM D 3763 plastic puncture test.



Close up of test machine showing pneumatic test specimen support clamp.

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Refurbished drop tower equipped with state-of-the-art instrumented striker system.

Instrumented striker system includes strain gaged striker, computer, amplifier, fast acquisition board, manual, and Windows software.

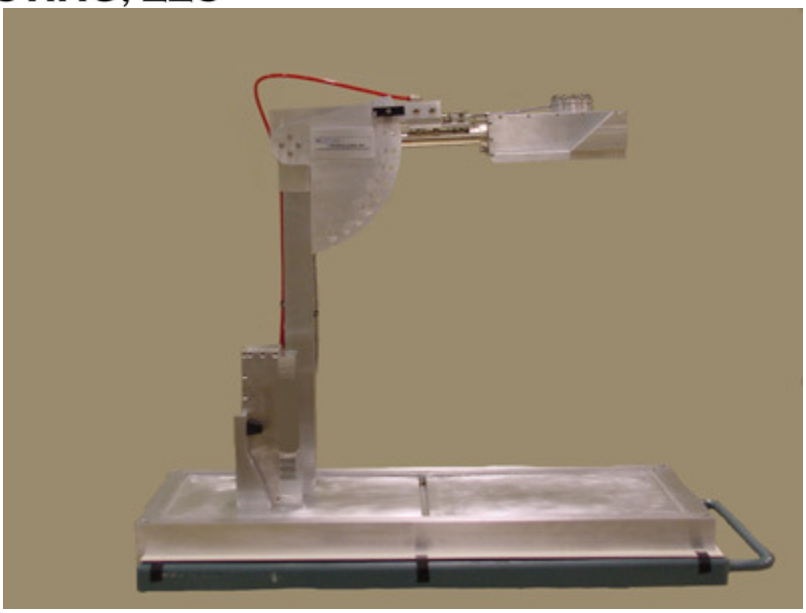

Table top test puncture test machine equipped with instrumented striker and pneumatic hammer release.

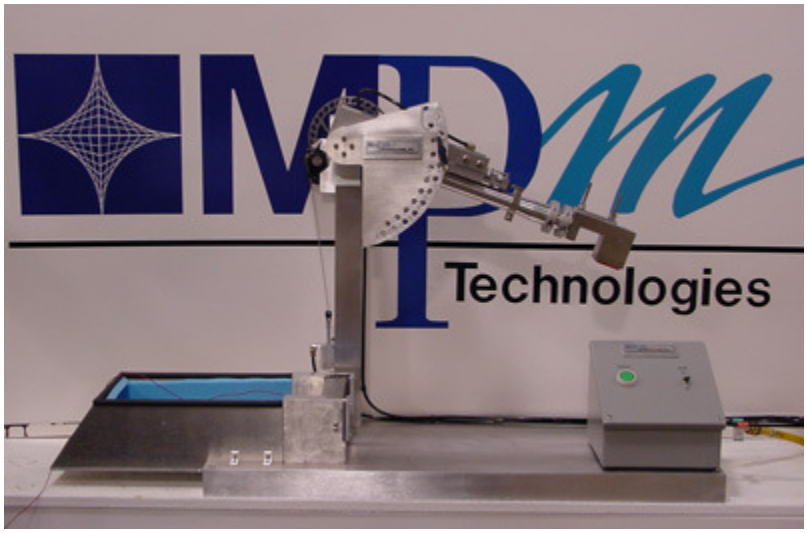

Table top shock test machine equipped with pneumatic hammer release and brake to prevent multiple impacts. System is capable of 3000 g half-sine pulses.

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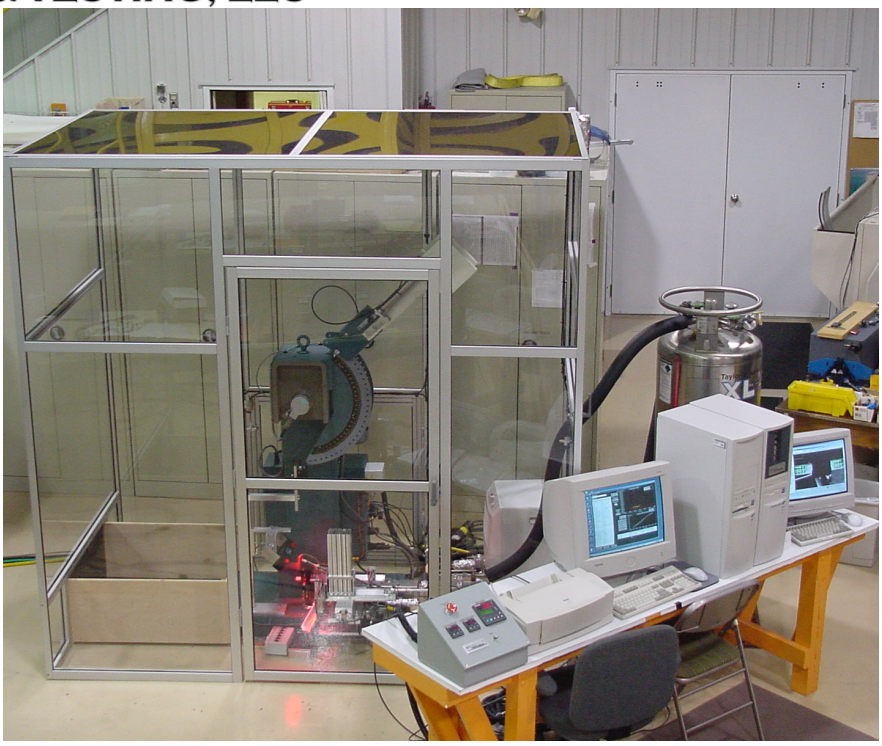
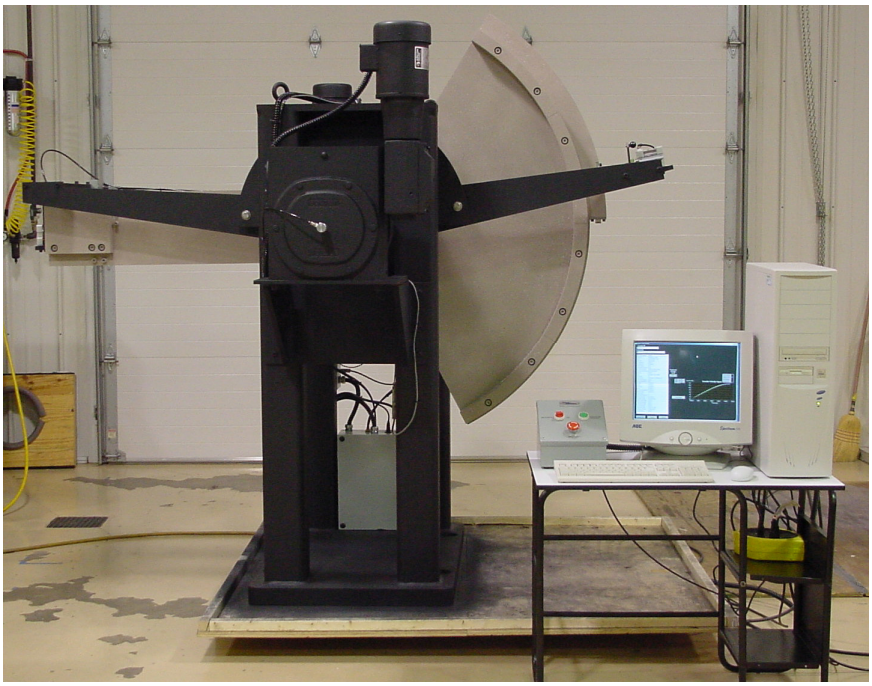
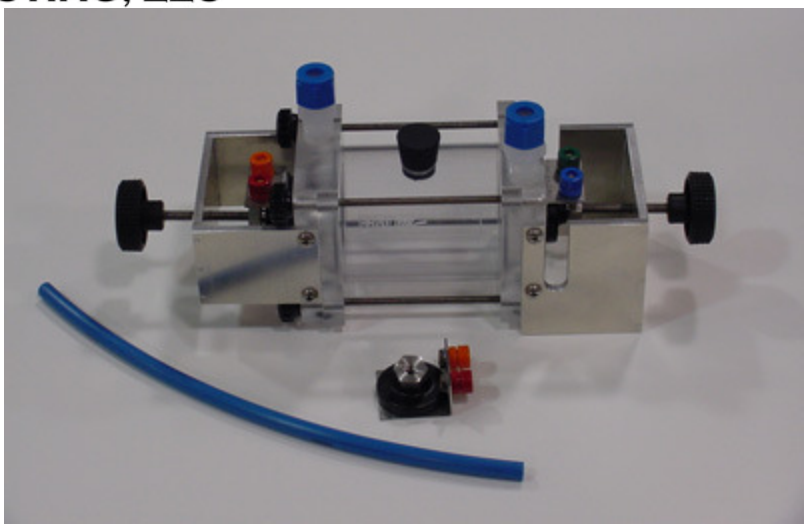


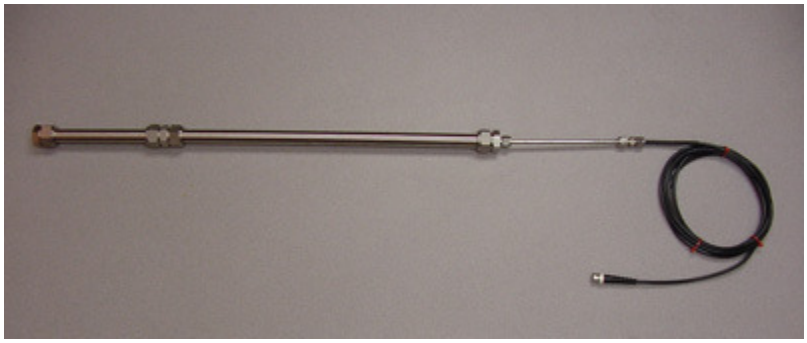
Automatic Charpy machine with Specimen Transfer System, In-Situ Heating/Cooling, Specimen ID Reader, and Computer Control System.



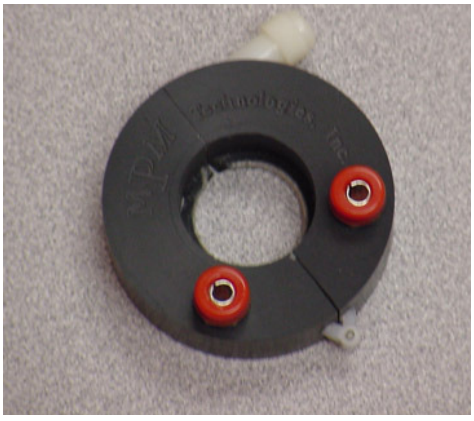
Double pendulum for dynamic Tear testing in accordance with ASTM E604 and Drop Weight Tear Testing in accordance with ASTM E436.



Multipurpose Corrosion Cell (MC^2) for electrochemical testing.



High temperature reference electrode for corrosion measurements in operating plants. The electrode is capable of long term operation at 300 C and higher at several thousand psig pressures.



Dry reference electrode for electrochemical measurement of components which would be damaged by exposure to a wet reference electrode.

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SUMMARY OF SERVICES AND CAPABILITIES

Pressure Vessel Technology

surveillance program management and optimization
P-T curve calculations
surveillance capsule re-insertion
dosimetry and neutron transport analysis
specimen reconstitution (e-beam, laser, arc-stud welding)
radiation damage modeling
elastic-plastic fracture mechanics assessment

Corrosion Testing

salt spray
polarization
galvanic corrosion
cyclic voltametry
electrochemical impedance spectroscopy
electrochemical noise

Stress-Corrosion Cracking

plant corrosion modeling
predictive calculation
in-plant monitoring
mitigation technology
laboratory experimentation

Finite Element Analysis

ABAQUS - non-linear analysis
WELD3 - weld process simulation
ALT3D - stress intensity factor calculation

Material Characterization

metallography
electron microscopy
electron microprobe
positron annihilation
secondary ion mass spectrometry
chemical analysis
thermal analysis
laser microscope profiling

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Mechanical Properties

fracture toughness
Charpy/Izod
tensile
indentation
creep rupture/creep crack growth
miniaturized specimen testing

Irradiation Services

neutron irradiation
gamma irradiation
hot cell machining and testing
neutron transport analysis
shielding analysis

Failure Analysis

root cause determination
preventive measures
material replacement

Mechanical Engineering Services

material, system, and equipment review to code requirements
develop repair/replacement procedures

Technology Analysis

technology watching
investment prioritization
technology scenarios

Quality Control Services

test machine installation in accordance with ASTM requirements
quality control Charpy specimen production

MP Machinery & TESTING, LLC

PARTIAL CLIENT LIST

Advance Pinnacle Technologies
Alcan
Albany Research Center
Allegheny Ludlum
Algeria – Centre de Recherche Nucleaire de Birine (CRNB)
American National Can
Ameren Corporation
Applied Research Laboratory
Armstrong World
ASRC Aerospace
Battelle
Battelle Geneva
Battelle Seminars Program
Benedict Engineering
Bombardier
Burlington Northern Santa Fe Railway (BNSF)
Cal-Rite
Canada – Atlantic Fabrication Center
Canada – Maritime Steel and Foundries Limited
Cannon Instrument Company
Carpenter Technology
Century Products
Coca-Cola Company
Columbia University
Consolidated Edison Company
Constellation Nuclear Corporation
Concurrent Technologies Corporation (CTC)
Dana Corporation
Delphi Harrison Thermal Systems
Delphi
Dofasco
Electric Power Research Institute (EPRI)
Electricite De France
Empire State Electric Energy Research Corporation (ESEERCO)
Emerson & Cuming
Emerging Power
Entergy
Extrude Hone
Fastenal
Florida International University
Florida Power & Light Company
FM Global
Foseco International
General Electric
General Public Utilities
Gilbert Commonwealth

Grant Prideco
Henkel Surface Technologies
Honeywell
Howmet
India – NMRL
International Atomic Energy Agency (IAEA)
Johns Manville
Kiefner and Associates
Kodak
Korea - Korea Research Institute
Korea – Gyeong Sang National University
Korea – Chung-Ju National University
Lincoln Electric
Los Alamos National Laboratory
Lone Star
Manufacturing Sciences Corporation
McDermott
Melcor
Metallurgical Technologies, Inc.
MPR Associates
Metallurgical Services Incorporated (MSI)
New York Power Authority
New York Times
Niagara Mohawk Power Corporation
Nissan Motors
National Institute for Standards and Technology (NIST)
Northeast Hub
Nova Chemicals
Nuclear Fuel Development Corporation
OECD Halden Reactor Project
Ohio State University
Ohio PUCO
Pennsylvania State University
Precision Components Corporation
Purdue University
REB Research & Consulting
Rexam Beverage Company
Rideoout Tool
Rohm and Haas
Sarnoff
Scott Forge
Schneider Engineers
Seattle University
Singapore - Singapore Polytechnic
SRI
State of PA - Ben Franklin Grant Office
Structural Integrity
Swing Perfect
TDA Research, Inc.
Textron Lycoming

Testing Institute of Alaska
Texas A&M
Tinius Olsen Test Machine Company
Triaxial Structures
University of Virginia
University of Delaware
University of Tulsa
Union Switch
US Air Force
Utah State Univeristy
Visteon
Westinghouse Electric Corporation
Worldwide

RESUME OF

Dr. MICHAEL P. MANAHAN, Sr.
President, MPM Technologies, Inc.

EDUCATION

Sc.D., Nuclear Materials Engineering, Massachusetts Institute of Technology, 1982
M.S., Nuclear Reactor Physics, Columbia University, 1978
B.S., Mathematics, Michigan State University, 1975
B.A., Physics, Michigan State University, 1975

QUALIFICATIONS

Dr. Manahan has a broad teaching and instruction experience that has spanned his 38 year professional career begining in 1975 where he was selected to be a math and physics course instructor during his undergraduate program. In 1981, he served as a nuclear engineering course instructor for Northeastern University.

EXPERIENCE

1996-present: President, MPM Technologies, Inc.
1987-present: President, MPM Research & Consulting
1992-1996: Adjunct Professor, Nuclear Engineering Department, Penn State University
1989-1992: Associate Professor, Nuclear Engineering Department, Penn State University
1985-1989: Senior Research Scientist, Applied Mechanics Department, Battelle
1982-1985: Principal Research Scientist, Nuclear Engineering Department, Battelle
1988-1989: Adjunct Associate Professor, Nuclear Engineering Program, Department of Mechanical Engineering, The Ohio State University
1985-1988: Adjunct Assistant Professor, Nuclear Engineering Program, Department of Mechanical Engineering, The Ohio State University
1981: Course Instructor, Northeastern University
1975-1978: Nuclear Engineer, Nuclear Licensing Engineer, Shielding Engineer, Burns and Roe, Inc.
1973-1975: Course Instructor, Michigan State University

SCIENTIFIC AND PROFESSIONAL RECOGNITION, AFFILIATIONS, AND ACTIVITIES

Honors

Member, M.I.T. Chapter Alpha Nu Sigma, National Honor Society, Nuclear Science and Engineering
Associate Member, Sigma Xi Honorary Scientific Research Society
Graduated Summa Cum Laude, Michigan State University
President of Pi Mu Epsilon, Mathematics Fraternity, 1974
Member of Honors College, Michigan State University
American Nuclear Society, Materials Science and Technology Division, Award for Best Paper, 1982
M.I.T. Nuclear Engineering Department Award for Outstanding Contribution Toward Public Understanding of Nuclear Power, 1981

Professional Affiliations

Member, American Nuclear Society, 1977-1984
Member, American Society of Mechanical Engineers, 1978-1983
Member, American Society for Testing and Materials, 1982-present
Member, American Concrete Institute, 1977-1980
Member, Battelle Public Speakers Bureau, 1982-1989
Member, Public Speakers Bureau on Energy Technology, Burns and Roe, Inc., 1977-1978
Member, M.I.T. Nuclear Reactor Laboratory Safety Committee, 1980-1982 President, Massachusetts Voice of Energy, 1980-1981
Chairman, Public Relations Committee, Society for the Advancement of Fission Energy, 1977-1978

Conference Chair

Structural Mechanics in Reactor Technology, Ninth Conference (SMIRT-9), 1987, Lausanne, Switzerland, chaired technical session entitled, Mechanical Properties of LWR Fuel Cladding".
Sixth ASTM-Euratom Symposium on Reactor Dosimetry, 1987, Jackson Hole, Wyoming, Chaired workshop entitled, "Detector Activities, Decay Data, and Uncertainties".

Professional Committees

International Group on Radiation Damage Modeling (IG-RDM)
American Society for Testing and Materials (ASTM), Committee E-10 (Subcommittee E10.05 on Radiation Metrology, and E10.02, Task Group E10.02.05 on Miniature Specimens)
American Society for Testing and Materials (ASTM), Committee E-8
American Society for Testing and Materials (ASTM), Committee E-28 (Subcommittee E28.07.08 Chairman - Miniature and Instrumented Charpy Testing)

Standards Work

American Society for Testing and Materials (ASTM), chairman of the committee responsible for the standard on miniature Charpy testing and instrumented impact testing

American Society for Testing and Materials (ASTM), responsible for standard on pressure vessel surveillance correlation monitor testing and analysis

Expert Opinion

Reed Report Study, member of expert panel to assess the impact of the Reed Report on the Perry Nuclear Plant

Future Energy Technology Research Study, member of expert panel to identify and prioritize long-range energy technology research relevant to Japan.

National Research Council Committee on Future Nuclear Power Development, worked with committee member using the Analytical Hierarchy Process to prioritize the utilities' choice of advanced reactor designs.

TEACHING AND RESEARCH EXPERIENCE

Teaching

Nuclear Physics
Reactor Physics
Nuclear Materials Engineering
Nuclear Fuels
Radiation Damage
Strength of Materials
Finite Element Analysis
Reactor Engineering
Physical Metallurgy

Research

Plant Component Assessment Technology. Dr. Manahan has developed a variety of technical approaches for characterizing the mechanical behavior state of in-service components. These approaches include: miniaturized specimen technology; in-field cutting techniques; laser weld specimen reconstitution; and a physically based material-specific modeling approach of material degradation. In addition, he has developed a balance-of-plant modeling technique, called Technology Application Optimization (TAO), which is used to determine which technologies should be applied to a given plant to ensure optimal economic benefit.

Radiation Damage in Materials. Dr. Manahan has developed an embrittlement model for Boiling Water Reactor (BWR) pressure vessels. He has developed a method for characterizing embrittlement of reactor pressure vessel steels on a plant-specific basis. He developed a miniature slow strain rate tensile test to characterize highly irradiated control rods. This test, in conjunction with microstructural data, demonstrated that intergranular fracture can occur in highly irradiated stainless steel in the absence of a

corrosive medium. His experience includes irradiation, testing, and analysis of BWR primary containment rubber seals. He managed a program to determine the effects of irradiation on fracture toughness of ASTM A212B steel. Dr. Manahan also worked on the national fusion first wall alloy development program at M.I.T. This research was conducted under a multi-disciplinary materials research project at M.I.T., for the Department of Energy, to develop superior fusion reactor first wall alloys using rapid solidification technology.

Pressure Vessel Technology. Dr. Manahan served as program manager for nuclear pressure vessel surveillance programs while employed at Battelle. He has managed and performed work on surveillance capsules for many utilities. His experience includes research and advancement in methods for Charpy testing, tensile testing, dosimetry analysis, neutron transport analysis, chemical analysis, specimen reconstitution, and P-T curve determination. He directed Battelle's participation in the Pool-Side Facility (PSF) dosimetry and mechanical behavior blind test sponsored by EPRI and NRC. He also managed a program for Niagara Mohawk to re-encapsulate miniature specimens and place the capsules, along with advanced dosimetry and temperature monitors, back into the reactor for life extension purposes. His current research efforts are focused on the development of physically based models to predict the Charpy 30 ft-lb transition and upper shelf energy drop as a function of neutron exposure. He is also researching irradiation enhanced creep in low melting point eutectic alloys.

Corrosion Engineering. Dr. Manahan worked on the stress corrosion cracking (SCC) analysis of the failed Point Beach control rods. He has performed a variety of tests related to SCC study including: fracture surface investigation; microstructural analysis; miniaturized CERT testing; and grain boundary susceptibility testing. In addition, he developed a patentable SCC sensor which can be used in nuclear power plant monitoring. He also performed physical and mechanical testing and analysis of steam generator corrosion products. Further, he developed an advanced zircoloy corrosion model for normal operation and accident conditions.

Advanced Radiation Field Measurement Technology. Dr. Manahan has performed research in the development of radiation field characterization technology. He designed and installed an advanced dosimetry and temperature monitoring package in a nuclear reactor for plant life-extension data development. The package included spectral radiometric monitors, solid-state-track recorders (SSTRs), meltwires, and SSTR temperature monitors. Dr. Manahan has also been involved in adapting SSTR counting hardware used in medical irradiations to measure track densities for nuclear reactor applications. His current research efforts are focused on using metal scrapings taken from in-service components as spectral dosimeters.

Radiation Transport Analysis. Dr. Manahan is responsible for the continued development and implementation of advanced neutron transport analysis methods. He managed the development of Battelle's three-dimensional flux synthesis approach and developed a technique for estimating the flux in Zircaloy-2 pressure tubes in cases where the Mn-54 activity cannot be detected by using instrumental gamma-ray spectroscopy. He was also

involved in the development of a calculative procedure for estimating the neutron flux at the pressure vessel wall of a nuclear reactor when part-length burnable poisons are used in the peripheral assemblies. He led Battelle's participation in an EPRI-sponsored research program to benchmark the results from dosimetry measurements made both in- - and ex-vessel at the ANO-1 Plant. He has developed advanced three-dimensional neutron field characterization techniques for analyzing advanced reactor cavity dosimetry for St. Lucie Unit-1 and Turkey Point Unit-3. He recently upgraded MPM's neutron transport models to include the latest cross section libraries. The current MPM transport model meets or exceed the requirements of the NRCs Draft Guide DG-1053.

Miniaturized Specimen Technology. Dr. Manahan pioneered this new field and he is responsible for the coordination, management and marketing of multi disciplinary research programs related to Miniaturized Specimen Technology. Dr. Manahan developed a Miniaturized Disk Bend Test (MDBT) capable of determining postirradiation mechanical behavior information from disk-shaped specimens no larger than those used for transmission electron microscopy. He also developed a finite element frictional contact boundary condition model which was implemented in the MDBT test methodology to allow the extraction of mechanical behavior information from experimental data. Several additional research programs to determine mechanical behavior information using miniaturized specimens have been completed. Successful miniature specimen benchmark experiments have been performed on a variety of materials to determine tensile behavior, creep-crack-growth behavior and Charpy impact properties. Several innovative miniature tests, including fracture toughness and dynamic-crack arrest toughness, are under development and modifications to existing tests are being made so that the technology can be applied directly to in-service components for residual life assessment. He also developed unique experimental procedures to test nuclear steam generator rust flakes. A variety of tests were performed on the flakes including mechanical behavior, thermal expansion, thermal conductivity, and swelling.

Advanced Crack/Strain Gage Technology. Dr. Manahan developed an advanced technique using physical vapor deposition (PVD) and photo-lithography for David Taylor Naval Shipyard to apply a crack gage to side-grooved specimens for dynamic crack extension measurements. He also developed a unique passive strain gage for the Japanese to measure maximum accumulated plastic strain on the cover head of a nuclear shipping cask after dynamic loading at terminal velocity to simulate an air crash.

Computer Code Development and Accident Analysis. Dr. Manahan participated in the development and upgrading of the MARCH (Meltdown Accident Response CHaracteristics) computer code. He developed a new zirconium-water reaction model for MARCH incorporating latest reaction rate constants, hydrogen blanketing effects, and turbulence. He coordinated the development of a more mechanistic fuel relocation and collapse model for incorporation into MARCH.

Strategic Planning and Technology Management. Dr. Manahan has developed a strategic planning and implementation approach which is based on the Analytical Hierarchy Process (AHP). This approach was used to prioritize Battelle's materials technology

internal research and development program. Dr. Manahan was task leader on the NRC Severe Accident Research Program (SARP) to prioritize severe accident technical issues. He modified the Analytical Hierarchy Process to account for the impact of phenomenological uncertainty on the overall plant risk uncertainty. He has developed a course designed to train senior managers to use computer-based tools in decision making. He has also developed a technique which combines AHP and desirability analysis to determine the optimum combination of material constituents to achieve prescribed in-service performance objectives. Dr. Manahan has developed two other computer based tools for technology management. *TrendSearch* is a global technology watching tool and IPValue can be used to value intellectual property.

Failure Analysis. Dr. Manahan has participated in and led failure analysis research for several industrial clients. His experience includes research to determine the cause and nature of cracking in Inconel gas tungsten arc welds at the Davis-Besse Nuclear Power Station. He also led a research program to determine the cause of BWR drywell head seal failure.

Mechanical Behavior of Polymers. Dr. Manahan recently managed a program to evaluate the performance of BWR drywell head seal rubber gaskets after irradiation, aging, and loss-of-coolant accident loading. He also developed a unique test to screen gas valve rubber diaphragms to determine those which will stick after relatively long downtimes. He recently developed a nondestructive test capable of determining uniaxial stress-strain and creep response. Other work included a technique for automating the measurement of ply interface coordinates in tire cross-sections.

Reactor Engineering

Dr. Manahan was previously employed in the Liquid Material Fast Breeder Reactor Division of Burns and Roe, Inc. During employment with Burns and Roe, he held the positions of Nuclear Engineer, Nuclear Licensing Engineer, and Shielding Engineer. As Nuclear Engineer, he was Clinch River Breeder Reactor (CRBR) Project Coordinator for the design of features to mitigate the consequences of a hypothetical core disruptive accident. As Nuclear Licensing Engineer, he was responsible for the licensing of cell liners and catch pans for the CRBR and for answering various NRC questions relating to structural integrity. As Shielding Engineer, he performed a variety of shielding analyses for the CRBR.

MANAGEMENT TRAINING COURSES TAUGHT

Research & Development Prioritization, Columbus, Ohio, 1988

Research & Development Prioritization, Patterson New Jersey, 1988
Technology Management Seminar, London, 1988
Technology Management Seminar, Paris, 1988
Technology Management Seminar, Milan, 1988
Technology Acquisition and Management, Brussels, 1989
Technology Acquisition and Management, Stockholm, 1989
Technology Management, London, 1990
Technology Management, Dusseldorf, 1990
Technology Watching and Commercialization, London, 1990

PUBLICATIONS

Refereed Journal/Special Technical Publication Articles

Siewert, T.A., Manahan, M.P., McCowan, C.N., Holt, J.M., Marsh, F.J., and Ruth, E.A., **"The History and Importance of Impact Testing,"** *Pendulum Impact Testing: A Century of Progress*, *STP 1380,* T.A. Siewert and M.P. Manahan, Sr., Eds., American Society for Testing and Materials, West Conshohocken, PA, 2000.

Manahan, M. P., Sr., and Stonesifer, R. B., **"The Difference Between Total Absorbed Energy Measured Using An Instrumented Striker and That Obtained Using an Optical Encoder,"** *Pendulum Impact Testing: A Century of Progress*, *STP 1380,* T.A. Siewert and M.P. Manahan, Sr., Eds., American Society for Testing and Materials, West Conshohocken, PA, 2000.

Manahan, M. P., Sr., Martin, F. J., and Stonesifer, R. B., **"Results of the ASTM Instrumented/Miniaturized Round Robin Test Program,"** *Pendulum Impact Testing: A Century of Progress*, *STP 1380,* T.A. Siewert and M.P. Manahan, Sr., Eds., American Society for Testing and Materials, West Conshohocken, PA, 2000.

Manahan, M. P., Sr., **"In-situ Heating and Cooling of Charpy Test Specimens,"** *Pendulum Impact Testing: A Century of Progress*, *STP 1380,* T.A. Siewert and M.P. Manahan, Sr., Eds., American Society for Testing and Materials, West Conshohocken, PA, 2000.

Manahan, M.P., **"Miniaturized Charpy Test for Reactor Pressure Vessel Embrittlement Characterization,"** *Effects of Radiation on Materials: 18th International Symposium, ASTM STP 1325,* R.K. Nanstad, M.L. Hamilton, F.A. Garner, and A.S. Kumar, Eds., American Society for Testing and Materials, 1999.

Manahan, M.P., Cruz, C.A., and Yohn, H.E., **"Instrumented Impact Testing of Plastics,"** *Limitations of Test Methods for Plastics, ASTM STP 1369,* J.S. Peraro, Ed., American Society for Testing and Materials, West Conshohocken, Pa, 1999.

MacDonald, D.D., Liu, C., and Manahan, M.P., Sr., **"Electrochemical Noise Measurements on Carbon and Stainless Steels in High Subcritical and Supercritical Aqueous Environments,"** *Electrochemical Noise Measurements for Corrosion Applications, ASTM STP 1277,* Jeffery R. Kearns, John R. Scully, Pierre R. Roberge, David L. Reichert, and John L. Dawson, Eds., American Society for Testing and Materials, 1996, pp.247-265.

Manahan, M.P., and Stonesifer, R.B., **"Miniature Charpy Design Optimization for Reactor Pressure Vessel Surveillance Applications,"** *Evaluating Material Properties by Dynamic Testing,* ESIS 20 (Edited by E. van Walle), Mechanical Engineering Publications, London, pp. 125-147, 1996.

Manahan, M.P., **"Plane-strain Fracture Toughness Determination using Stress Field Modified Miniature Specimens,"** *Evaluating Material Properties by Dynamic Testing,* ESIS 20 (Edited by E. van Walle), Mechanical Engineering Publications, London, pp. 177-195, 1996.

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CODE DEVELOPMENT ACTIVITIES

Impact v3.0™	Acquires load-time data from an instrumented Charpy impact test machine
USE™	Calculates the lowest allowable upper shelf energy based on ASME, Appendix X elastic-plastic fracture mechanics rules
WITHDRAW™	Optimizes pressure vessel surveillance capsule withdrawal schedule subject to user specified risk criteria
SCENARIO™	Cross impact analysis package for assessing the future economic and technological conditions
SAM McFRAC™	Statistical analysis package for analyzing fracture data and fitting Charpy curves
BOUNDCON™	Finite element boundary condition analysis code for use with ABAQUS
ZRWATER™	Zircaloy oxidation code for severe accident analysis
PTCODE™	Nuclear reactor pressure - temperature operating parameter analysis code

JCODE™	J-Integral fracture mechanics analysis code
SMART-PAKT™	Eigenvector Code for research prioritization
TREND SEARCH™	Literature and patent data base analysis code for finding key technologies and assessing competitor strategy
JKFRAC™	J_{IC} and K_{IC} test data analysis and plotting package
TENSILE™	Tensile data analysis package
IPVALUE™	Valuation of intangible assets