

Exponent®
Engineering & Scientific Consulting

Steven MacLean, Ph.D., P.E.

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Professional Profile

Dr. MacLean is the practice director and a principal engineer in Exponent's Polymers & Chemistry practice. Combining his degrees in polymer science and mechanical engineering with his industrial experiences, he routinely assists clients on complex issues related to the design, development, durability, failure analysis, and intellectual property of end-use applications manufactured from polymeric materials, with an emphasis on load-bearing components and structures.

Dr. MacLean has investigated various polymer failure mechanisms including stress overload, creep rupture, fatigue, environmental stress cracking, delamination, dielectric breakdown, and weathering. For over 30 years, he has evaluated the formulation-structure-property relationships and the suitability of thermoplastics, thermosets, rubbers, elastomers, and polymer composites used in a variety of industries including automotive, sporting goods, medical and drug delivery device, consumer products, oil and gas, alternative energy, electrical, fluid handling, and construction. Dr. MacLean also assists clients in assessing risk in all stages of product life, including product qualification, reliability testing, quality control, and long-term field performance, and he routinely conveys his findings to entities including technical decision makers, government regulators, arbitrators, and juries.

Polymers and composites failure analysis

Dr. MacLean is a recognized expert in the field of failure analysis, having performed hundreds of root-cause investigations related to component parts manufactured from polymeric materials. For regulated products, he is well versed in product assessment and recall frameworks established by the U.S. Food and Drug Administration (FDA), the Consumer Product Safety Commission (CPSC), the National Highway Traffic Safety Administration (NHTSA), and the National Transportation Safety Board (NTSB). He is familiar with the processes of each federal agency regarding the investigation, analysis, and remedies of underperforming products and components.

Dr. MacLean is also familiar with testing and material standards published by ASTM International, the International Organization for Standardization (ISO), Underwriters Laboratories (UL), the International Electrotechnical Commission (IEC), the Society of Automotive Engineers (SAE), and others. He leverages his Six Sigma skills and failure modes and effects analysis (FMEA) training when assessing product manufacturing processes and field performance issues.

Intellectual property for polymeric finished goods

Dr. MacLean has extensive experience in intellectual property matters involving polymers, specializing in patent infringement and validity assessments as well as trade secret and inventorship disputes. He also routinely assists clients with claim construction and Markman hearing preparation for complex IP matters. Dr. MacLean has provided testimony across a wide range of venues, including federal district courts,

international arbitration panels, the International Trade Commission (ITC), and the Patent Trial and Appeal Board (PTAB).

Product manufacturing

Over the past 30 years, Dr. MacLean has worked on a variety of finished goods produced from polymer and composite manufacturing processes including injection molding, compression molding, blow molding, press blow molding, blown film, rotational molding, extrusion, fiber spinning, thermoforming, calendaring, and laminating. In addition, he has investigated material systems that include secondary operations such as metallic plating, coatings, adhesives, paints, and welding.

Industry experience

Before joining Exponent, Dr. MacLean worked in industry at General Electric Aerospace, General Electric Plastics, and SABIC, where he held several technical and leadership positions of increasing responsibility. His responsibilities included product development, material formulation, processing and selection, testing for high-demand applications, product safety and compliance assessments, failure analysis, and intellectual property analysis.

Academic Credentials & Professional Honors

Ph.D., Materials Science, University of Rochester, 2007

M.S., Materials Science and Engineering, Rochester Institute of Technology, 2001

M.E., Mechanical Engineering, Rensselaer Polytechnic Institute, 1997

B.S., Mechanical Engineering, Rensselaer Polytechnic Institute, 1993

Tau Beta Pi

Pi Tau Sigma

Society of Plastics Engineers ANTEC Best Paper Award

Licenses and Certifications

Professional Engineer Mechanical, Arizona, #80192

Professional Engineer, Maryland, #41592

Professional Engineer, New York, #79001

Professional Engineer, Pennsylvania, #PE097089

Six Sigma Black Belt Certification (CSSBB)

Academic Appointments

Worcester Polytechnic Institute Department of Mechanical & Materials Engineering, Adjunct Professor, 2025

Prior Experience

Director, Global Agency Relations & Product Safety, SABIC Innovative Plastics, 2007-2011

Global Technical Manager, General Electric Plastics, 2003-2007

Six Sigma Black Belt, General Electric Plastics, 2001-2003

Senior Application Development Engineer, General Electric Plastics, 1998-2001

Plastic Design and Analysis Leader, General Electric Plastics, 1996-1998

Edison Engineer, Lockheed Martin Corporation, (Formerly General Electric Aerospace), 1994-1996

Professional Affiliations

Society of Plastics Engineers (SPE) Senior Member

SPE Medical Plastics Division Member

ASTM D20 Plastics Committee Member

Plastic Pipe Institute (PPI) Member

Publications

Vytiniotis A, MacLean S, Sykora, D. Laboratory testing and engineering analysis of an underground stormwater detention system. Proceedings, Geo-Congress, 2020.

Lyons C, Farzana A, MacLean S, Siskey R, Donthu, S. Environmental stress cracking failure of amorphous polymer materials. Society of Plastics Engineers - ANTEC, March 2019.

Ansari F, Lyons C, MacLean S, Siskey R, Donthu, S. Mechanical characterization and fractography of PC, ABS and PMMA - a comparison of tensile, impact and ESC fracture surfaces. Society of Plastics Engineers - ANTEC, May 2017.

Benight S, MacLean S, Garcia M, Moll, J. Microscopy of intentionally oxidized polypropylene-based mesh material. Society of Plastics Engineers - ANTEC, May 2016.

MacLean S, Lee C, Ledwith P, Moll J. Fractographic examination and tensile property evaluation of 3D printed acrylonitrile butadiene styrene (ABS). Society of Plastics Engineers - ANTEC, March 2015.

MacLean S, et al. Comparison of mass transit material flammability requirements and trends for aircraft and train applications in Europe and North America. Proceedings, Society of Plastics Engineers - ANTEC, April 2012.

MacLean S, et al. Comparison of mass transit material flammability requirements and trends for aircraft and train applications in Europe and North America. Proceedings, EUROTEC, 2011.

MacLean S, et al. Root cause investigation of cracked polycarbonate blender jars. Society of Plastics Engineers - ANTEC, May 2010.

MacLean S. Plastics, electronics and the environment: How new global regulations affect material choices. Kunststoffe International, September 2008,; 97-100.

MacLean S. Plastics, electronics and the environment: How new global regulations affect material choices. Telepati Aylik Telekom, March 2008; 74-77.

MacLean S, et al. Monolayer barrier for small engine fuel tanks. Plastics Technology Online June 2007.

MacLean S. Environmental effects of poly(phenylene ether) blends due to long-term exposure to potable hot water. Ph.D. Dissertation, University of Rochester, 2007.

Case R, Korzen A, MacLean S. The effects of recycling and heat history for select high polymers. Society of Plastics Engineers - ANTEC, May 2001.

Adedeji A, MacLean S, Torrey B, Baccaro L, Zuber P. Poly(phenylene ether) engineering thermoplastic provides creep resistance, toughness and fire resistance required for high performance pallets. Society of Plastics Engineers – ANTEC, May 2000.

Presentations

Budiansky A, MacLean S, Jing B, Fox R, Kreder M, Moll J. Microtomy of Extra-Large Polymer Samples. International Applications & Technologies Conference and Exposition – IMAT, October 2023.

Vytiniotis, A, MacLean, SB. Buried Plastic Reservoirs and Tanks - Out of Sight; But Are They Out of Mind? American Society of Civil Engineers, Continuing education for licensed professional engineers, 2018.

MacLean S, Moll J. The importance of polymer structure-property relationships in preventing failure in medical devices. Medical Grade Polymers Conference, Woburn, MA, 2015.

MacLean S. Fundamentals of plastics fractography. ANTEC, Cincinnati, OH, 2013.

MacLean S. Challenges associated with replacing metal with plastic. Material Science and Technology Conference, Pittsburgh, PA, 2012.

MacLean S, et al. Fractography of unfilled thermoplastic materials subjected to common mechanical failure modes. Material Science and Technology Conference, Pittsburgh, PA, 2012.

MacLean S. Common analytical techniques for failure analysis - A Resin Manufacturer's Perspective. ANTEC, Boston, MA, 2011.

MacLean S, et al. Plastic failure analysis and prevention expert panel. ANTEC, Boston, MA, 2011.

MacLean S. Root cause investigation of cracked polycarbonate blender jars. ANTEC, Orlando, FL, 2010.

MacLean S. Diffusion of potable hot water in poly(phenylene ether) blends. American Chemical Society Conference, Binghamton, NY, 2006.

MacLean S. Changes in polycarbonate and ABS mechanical properties due to multiple heat histories. Society of Plastics Engineers ANTEC, Dallas, TX, 2001 (with Korzen).

MacLean S. Yield Improvement for gas assist panels using statistical methods. Society for the Plastics Industry Conference, Vancouver, BC, 2000.

MacLean S. Design methodologies for metal to plastic conversion. General Electric Plastics Innovation Seminar, Columbus OH, 2000.

MacLean S. Fundamentals of polymer science. General Electric Plastics Customer Design Workshop, Pittsfield, MA, 1998, 1999.

MacLean S. Designing for injection molded parts. General Electric Plastics Customer Design Workshop, Pittsfield, MA, 1998, 1999.

MacLean S. Mechanical behavior of polymeric materials. General Electric Plastics Engineering Workshop, Pittsfield, MA, 1997.

Project Experience

Polymers and composites failure analysis

Photovoltaic Wire Harness

- Investigated exposed wire conductor occurring throughout numerous solar farms due to in situ shrinkback of cross-linked polyethylene (XLPE) wire insulation material.
- Analyzed all potential factors across the supply chain, including incoming raw materials, wire extrusion process, harness manufacturing process, and field installation conditions, to assess the root cause of the observed shrinkback mechanism.

Pipeline Leakage

- Investigated the root cause of through-wall pinhole formation in a buried high-density polyethylene (HDPE) oil and gas pipeline.
- Evaluated numerous factors including raw material quality, pipe and connector manufacturing processes, pipe fusion process, installation conditions, and site operating conditions.
- Determined that persistent static discharge conditions led to dielectric strength breakdown of the pipe material over time.

Gas Pipeline Explosion

- Investigated the root cause of a municipal gas delivery pipeline leak that led to a roadway explosion.
- Performed multiple field and laboratory inspections of subject and sister pipe sections from the incident pipeline.
- Tested and analyzed the subject pipe, including butt weld sections to assess the integrity of fused joints.

Active Head Restraints

- Investigated the root cause of headrest assemblies molded from polycarbonate/ABS materials that were inadvertently deploying in the field.
- Analyzed observed failure mechanism, specifications of component parts, design verification testing per FMVSS 202, and warranty returns to assess risks associated with a deployment event.

Unintended Acceleration Investigations

- Evaluated the specification and performance of several polymeric materials used in throttle and cruise control system components related to allegations of unintended acceleration of passenger vehicles.

Water Filtration System

- Investigated the uncontrolled water release events associated with premature cracking of polypropylene water filtration systems installed in residential homes.
- Analyzed and tested the interaction between water treatment media and the housing material to determine degradation mechanism and underlying root cause.

Beverage Container Assessments

- Analyzed the closure designs and sealing mechanisms of several beverage containers to assess the potential for lid/container separation under various simulated end-use conditions.

Polymeric products performance and manufacturing

Implantable Pelvic and Hernia Mesh

- Investigated the specification and use of fiber spun polypropylene for knitted implantable mesh devices that address pelvic organ prolapse or hernia issues.
- Evaluated long-term test data to assess the material’s ability to withstand in vivo environmental conditions.

Implantable Port Catheters

- Investigated the specification and use of polyurethane and polydimethylsiloxane polymers for implantable catheters used for long-term drug delivery.
- Evaluated the design history files, biocompatibility and performance per applicable ISO test standards and FDA guidelines, as well as 510(k) submissions.

Sleep Apnea Tongue Retractors

- Assessed the mechanical performance of implantable tongue retractor devices made from polydimethylsiloxane used to alleviate sleep apnea conditions.
- Studied and characterized the fatigue behavior of the material via simulated end-use conditions.

High-Performance Window Glazing

- Investigated the suitability of numerous glass/polymer laminate structures for use in bullet resistant glazing per UL standards as well as tornado- and hurricane-rated glazing applications per FEMA guidelines.

Automotive Fuel Sensors

- Assessed the historical use and state-of-the-art related to polyoxymethylene materials specified for use in fuel sensor and fuel sender components in passenger vehicles.

Product recalls consulting

Recreational Vehicle Brake Pistons

- Investigated the failure mechanism and potential safety hazards associated with the material specifications, design, and end-use performance of phenolic brake pistons used in recreational vehicle caliper braking systems.

Baby Bottle Delamination

- Investigated the failure mechanism and potential safety hazards associated with the delamination of polyolefin materials from the outer surfaces of baby bottles.

High-Pressure Plumbing System

- Investigated the failure mechanism and potential safety hazards associated with pressure-assist toilet flushing systems manufactured from a glass fiber reinforced polypropylene composite material.

Beverage Maker Machines

- Investigated the failure mechanisms and potential safety hazards of several types of hot and cold beverage dispensing machines.
- Failure modes ranged from material compatibility issues between dispensing liquids and construction materials to premature degradation of seals, gaskets, and O-rings used in pressurized devices.

Intellectual property for polymeric finished goods

Plastic Food Packaging

- Performed non-infringement and invalidity assessments on a series of claims from a family of patents pertaining to the design of tamper-resistant and tamper-evident single-use food packaging containers thermoformed from polyethylene terephthalate (PET).

Luxury Vinyl Tile Flooring

- Performed infringement and validity assessments pertaining to the design of interlocking floor tiles made from multiple layers of extruded polyvinyl chloride (PVC) materials.

Reflective Laminate Insulation

- Performed non-infringement and invalidity assessments on insulation products used in residential, industrial, and commercial buildings made from multiple layers of polyester, polyethylene, aluminum foil manufactured from a blown film process.

Testosterone Delivery Device

- Performed non-infringement and invalidity assessments related to the design and functionality of an ANDA Hatch-Waxman testosterone applicator device made from polypropylene and polydimethylsiloxane materials.

Antifungal Applicator

- Performed non-infringement and invalidity assessments related to the design and functionality of an ANDA Hatch-Waxman antifungal applicator device to treat tinea unguium made from solid and fibrous polymeric materials.

Fracking Pump Header Ring

- Performed infringement and validity assessments on a series of claims from a family of patents pertaining to high-pressure header rings used in fracking pump packing assemblies. Header rings consisted of nitrile rubber compounds reinforced with aromatic polyamide fabric.
- Provided Markman hearing support and analysis on secondary considerations for non-obviousness.

Downhole Drilling Stators

- Performed trade secret and patent analyses on commercialized and experimental grades of nitrile-isoprene rubber formulations used in the manufacturing of stator liners for downhole drilling equipment.

Underground Stormwater Chambers

- Performed infringement and validity assessments related to the design and functionality of underground stormwater chambers manufactured from proprietary formulations of polyolefin materials.

Cured-in-place Piping

- Performed non-infringement and invalidity assessments on a series of claims from a family of patents pertaining to a complex material system comprising a multi-layer polymer film and a release coating used to construct cured-in-place (CIP) piping liners.