



Steve MacInnis, P.Eng.

- 36 years of mechanical, vehicle, oil and gas, and civil engineering experience
- 18 years of dedicated failure analysis and vehicle accident reconstruction expertise
- Specialized expertise in tires failures, occupant dynamics, computer simulations, and mine truck fires
- Court qualified at all levels in Alberta, British Columbia, and Saskatchewan

EDUCATION

Bachelor of Engineering (High Distinction), Carleton University, Ottawa **1974**

Major - Civil Engineering **Minor** - Materials Engineering

- courses included vehicle dynamics, surveying and highway design

Post-graduate courses in statistics and geology

Certified ATS Instructor, Tire Industry Association

PROFESSIONAL ASSOCIATIONS & MEMBERSHIPS

Association of Professional Engineers, Geologists & Geophysicists of Alberta (APEGGA)

Association of Professional Engineers and Geoscientists of British Columbia (APEGBC)

Society of Automotive Engineers (SAE)

Tire Industry Association

Wheel and Tire Council, SEMA

Association for the Advancement of Automotive Medicine (AAAM)

Canadian Association of Technical Accident Investigators & Reconstructionists

WORK HISTORY

SAMAC ENGINEERING LTD. (Calgary) **1992 to date**

Failure analysis engineering specialist and president. Personally responsible for 2000+ failure analyses and vehicle accident reconstructions. Technically review and approve staff engineering analyses, including biomechanical, civil, and metallurgical analyses.

SHELL CANADA LIMITED (Halifax & Calgary) **1981-1991**

Offshore drilling engineer & supervisor

Arctic and Offshore project engineer and coordinator

ENERGY, MINES AND RESOURCES (Ottawa) **1976-1981**

Regulatory offshore drilling and project engineer

OGILVIE & ASSOCIATES (Calgary) Structural design engineer **1975**

IMPERIAL OIL (Calgary) Facilities project engineer **1974-1975**

TECHNICAL TRAINING

Numerous technical courses have been attended since 1974. The list below relates only to accident reconstruction and failure analysis courses attended since 1992.

Automotive Tire Service – Instructor’s Course, Denver, 2009

A 3 day hands-on to become an instructor able to train and certify tire shop staff in vehicle/tire operations. This includes vehicle lifting procedures, mounting and demounting tires, diagnosing and repairing tires, and the installation and servicing of new Tire Pressure Monitoring Systems. Course presented by the Tire Industry Association.

Advanced PC-Crash Simulations and Animations, Toronto, 2009

A 2 day study of the advanced features of PC-Crash version 8.1. PC-Crash is the premier simulation and animation program for vehicle accident reconstruction. Course included the collision theories, kinematic path backwards, loading surveys, contouring bitmaps, animations, loading FCE and DFF vehicles, rollovers, the ellipsoid and mesh multibody models, and trailers.

Tire Technology Seminar, Akron, 2008

A comprehensive short course on tire and wheel engineering, regulations, compounding, manufacturing, testing, traction, service issues, and tire/vehicle mechanics. Included examination of ongoing tire testing, hands-on mounting and demounting of tires, and pressure testing of a passenger tire until it failed (exploded). (2½ days)

Pedestrian Collision Investigation Course, Calgary, 2007

A detailed mathematical and practical review of the available methods used to analyze collisions involving pedestrians or bicyclists struck by cars, vans, and trucks. Full scale testing and reconstructions of different types of impacts to validate formulae. (5 days)

The Tire as a Vehicle Component, Detroit, 2007

Tire design and manufacturing course by the Society of Automotive Engineers (SAE). Topics included rolling resistance, braking, camber thrust, ply steer, spring behaviour, and tire properties versus vehicle response (stopping, ride, handling, etc). (1 day)

Tire and Wheel Safety Issues, Detroit, 2007

An SAE technical course on tire and wheel safety which included analysis of tire construction and failure modes, tire grip, hydroplaning, brake performance, burst pressures, wheel issues, oversteering/loss of control, and rollover thresholds. (1 day)

Commercial Vehicle Braking Systems, Detroit, 2007

An SAE technical course on the design and operation of commercial air brake systems for large trucks, including brake component and system designs, braking performance and distribution, tractor/trailer compatibility, maintenance issues, vehicle dynamics, anti-lock brakes, electronic traction control, brake testing and related regulations. (3 days)

CDR Operator and Analyst Courses, Calgary, 2006

A 5 day course in downloading and analyzing event data recorders from GM, Ford, and now Chrysler vehicles using specialized equipment. Depending on the manufacturer and type of vehicle, available data may include accelerations, speeds, braking, engine speeds, and numerous other sets of data pre and post impact.

Tire Retread Plant Operations, Calgary, 2006

Review and analysis of retread plant operations including tire inspection, preparation, retreading, marking and analysis of typical failure modes. (1/2 day)

Prisoner Transport Vehicles, Tennessee and Pennsylvania, 2006

Review of prisoner transport design and operational requirements with van cell manufacturers (Havis-Shields and Bob Barker Company), a commercial prisoner transport firm (TransCor), and large prisons in Nashville and Philadelphia. (4 days)

Commercial Vehicle Collision Reconstruction, Calgary, 2005

A course teaching the techniques to analyze accidents involving tractor-trailers and other large vehicles. Topics included braking capability, analysis of scene markings, vehicle pre and post impact movements, and rollover reconstruction. Full scale brake testing of different vehicle types, including tractor-trailers and buses. (5 days)

Low Speed Collisions and EDR data, Edmonton, 2004

A 1 day accident reconstruction review including the analysis of low speed collisions and potential data recorded within vehicle event data recorders during low speed events.

Investigating Vehicle Fires, Calgary, 2001

A detailed course reviewing the procedures used to examine burned vehicles and how to determine the cause and origin of the fire. Extensive hands-on origin and cause investigations of burned vehicles. (3 days)

HiLo Seminar, Vancouver, 1997

A 5 day course on the analysis of low speed collisions, the use of the PC Crash simulation and animation program, and full scale high-speed crash tests to validate the computer simulations.

EDC Computer Simulations, Los Angeles, 1995

Use of the EDSMAC computer simulation program based on U.S. National Highway Traffic Safety Association's SMAC and CRASH3 programs. This was the major computer program used by reconstructionists for many years until PC Crash was developed. (5 days)

Fraud Fire Seminar, Calgary, 1993

A 3 day course on developing the skills to analyze the cause and origin of fires, particularly fraud related investigations such as arson.

Traffic Accident Reconstruction (1&2), Chicago, 1992

In-depth courses at Northwestern University covering numerous technical topics, such as derivation of formulae used in accident reconstruction, conservation of momentum and energy, occupant kinematics, pedestrian collisions, motorcycle collisions, tractor-trailer accidents, perception reaction times, and vehicle dynamics. (3 weeks)

Traffic Accident Investigation, Chicago, 1992

A Northwestern University course on scene investigation techniques including interpreting road markings, lamp examination, tire failures and photogrammetry. (correspondence)

CONFERENCES & MEETINGS

Numerous conferences and meetings have been attended since 1974. The list below relates only to the accident reconstruction and failure analysis conferences and meetings attended since 1992.

SEMA & AAPEX Shows, Los Vegas, 2008 & 2009

These two events for the automotive specialty products industry and aftermarket component manufacturers are attended only by pre-qualified industry personnel. The shows had over 4000 exhibitors and 120,000 attendees. Of particular interest were the 300 exhibitors specifically focussed on wheels and tires. (3 days)

International Tire Exhibition and Conference, Akron, 2008

Attended this exhibition and conference, including purchasing applicable tire engineering papers, while on the University of Akron tire mechanics course. (3 days)

SAE International Congress & Exposition, Detroit, 2007, 2002, 2001, & 1996

Have attended the annual conference and trade show for the Society of Automotive Engineers (SAE) four times. I attend all or part of the vehicle accident reconstruction sessions presenting peer reviewed papers on the latest international engineering research. Also attended papers in other engineering areas such as braking systems, occupant safety, vehicle design parameters, and biomechanics. The conference bookstore enables all the several hundred new technical papers published each year to be reviewed. (4 days)

CATAIR Annual Conference, 2007 & 1995

Have twice attended the annual conference of the Canadian Association of Technical Accident Investigators & Reconstructionists. This conference is primarily attended by police officers and includes review and training in accident reconstruction topics such as collision analysis, pole impacts, perception-reaction times, and event data recorders. Full scale crash and yaw tests are also performed, documented and analyzed. (4 days)

American Correctional Association Winter Conference, Nashville, 2006

Attended conference and trade show for correctional facilities as part an investigation into the methods required to securely and safely transport prisoners by vehicle. (2 days)

ABA Emerging Issues in Motor Vehicle Product Liability Litigation, Phoenix, 2005

Attended 3 days of legal and technical presentations on U.S. product liability claims against vehicle manufacturers, including the latest in vehicle accident reconstruction.

CATAIR Fall Lecture, Red Deer, 2001

A 1 day technical review of current accident reconstruction topics for Alberta members of the Canadian Association of Technical Accident Investigators & Reconstructionists.

SAE TopTec on Accident Reconstruction – State of the Art, Los Angeles, 1999

AAAM 39th Annual Conference, Chicago, 1995

37th STAPP Car Crash Conference (3days), San Antonio, 1993

Child Occupant Protection Symposium, San Antonio, 1993

Canadian Multi-Disciplinary Road Safety Conference VIII, Saskatoon, 1993

RESEARCH AND TESTING (since 1992)

Torque Variations in Wheel Nuts, 2007 ongoing

A study to determine the relationship between the torque required to back-off wheel lug nuts on a vehicle versus the original torque value used to install the wheel.

High Speed Yaw Research, 2007 & 2008

Lead engineer for a series of 21 high speed yaw tests (90 km/h) in partnership with the Calgary Police Service. Three different vehicles were tested with each being equipped with a 5th wheel speed sensor, VC3000 accelerometer, and a DAQ computer. Yaw marks were surveyed and photographed. Data was used for peer reviewed SAE paper on accurate measurement of yaw marks, analysis methodology, and analyzing vehicle speeds and movements during yaw via computer simulation.

Fire Causation due to Sawdust Ignition, 2006

Full scale testing to determine the likelihood of sawdust igniting after removal from a stained and finished wood floor. A data acquisition system was designed and built to digitally record the entire exemplar event over an 18 hr period using multiple video cameras and temperature sensors.

Cargo Net Testing, 2005 ongoing

Review and approve ongoing full scale tests of prototype cargo nets at SAMAC's testing facility. Designed for use in pickups, technical reports are prepared confirming whether nets meet certification requirements and to determine breaking strength of net.

Non-OEM Seat & Seatbelt Installations, 2002 ongoing

Design, manufacture and install a large test frame and hydraulic system to record seatbelt and seat tests via a data acquisition system. Typically used to design and test the installation of non-OEM seats and seatbelts in work vehicles. SAMAC also certifies installation to be in compliance with CMVSS 207(1), 210(7) & (8).

Maneuvering Capability of an Overloaded Vehicle, 2002

Testing of a 1998 Honda Prelude at Race City Speedway to objectively compare the vehicle's maneuvering capability with normal occupant loading versus being loaded beyond its Gross Vehicle Weight Rating (GVWR).

Low Speed Impacts and Acceleration Testing, 1996 ongoing

Lead engineer or technical reviewer of numerous low speed vehicle tests undertaken at SAMAC. Includes instrumented front to rear impacts to match vehicle damages sustained by incident vehicles and video analysis of low speed vehicle accelerations.

Mine Haul Truck Hydraulic Control Systems, Las Vegas, 2001

Testing, with manufacturer, of hydraulic control systems for brake, steering, and dump systems (up to 3000 psi and 300 gpm) for mine haul trucks. These are very large dump trucks weighing up 600 tons.

I have also researched and designed deep water drilling risers; tested offshore drilling unit anchor chains; and analyzed subsea hydraulic control systems.

PUBLICATIONS (focus on failure analysis)

Variability of Yaw Calculations from Field Testing, SAE 2009-01-0103, 2009

Co-author of a peer reviewed paper published by the Society of Automotive Engineers (SAE). Based on two years of high speed vehicle testing, the paper discusses, among others, the accuracy of the yaw formula at higher speeds, the optimal chord length to be used, and use of the centre of gravity method (see Research and Testing).

Factors Affecting the Accuracy of Nonmetric Analytical 3-D Photogrammetry Using Photodeler, SAE 1999-01-0451, 1999

Co-author of a Society of Automotive Engineers paper on the accuracy of 3D photogrammetry as a tool for use in vehicle accident reconstruction.

Low Speed Collisions - Analysis of Collision Severity, 1996

Lead author for article published in The Barrister (ACTLA). Also technical reviewer for a second article by Dennis Chimich on the Biomechanics of Low Speed Impacts.

Review of Ocean Ranger Recommendations, Calgary, 1992

An internal report prepared for National Energy Board engineering staff regarding the implementation status of the safety and technical recommendations from the sinking of the Ocean Ranger off of Newfoundland in February 1982.

Analysis of Blowout Preventer (BOP) Control Systems – Uniacke G-72, 1984

An internal Shell Canada report analyzing the failure of the BOP's to seal the wellbore during a loss of well control on Uniacke G-72, an offshore well off of Sable Island. This included a detailed analysis of the hydraulic control system design and operation.

PRESENTATIONS (focus on failure analysis)

Preventing Large Unit Fire Losses and Operator Safety, 2003

Invited speaker to Arch Coal's Black Thunder Mine in Gillette, Wyoming (the largest surface coal mine in North America) to address fire safety on mine haul trucks.

Forensic Investigation of Large Unit Losses, 2002

Invited speaker and moderator of the manufacturing session at the Enhanced Fire Protection Symposium for Large-Scale Mining Equipment in Edmonton. Session attended by surface mining firms, suppliers, and insurers from across North America.

Haul Truck and Shovel Fires - Problems & Solutions, 2001

Organized and chaired industry meeting in Fort McMurray attended by all major projects and equipment suppliers to discuss the solutions to haul truck and shovel fires.

High Speed Impacts & Pedestrian Collision Testing, 2000

Organizer and lead presenter for a 1/2 day seminar on low speed collisions, biomechanics, industrial failure analysis, and high speed collision analysis. Included 2 vehicle high speed collisions and a pedestrian collision. Approximately 170 attendees.

Low Speed Collision Analysis, Biomechanics and Testing, 1997

Organizer and lead presenter for a 1 day seminar in Calgary on low speed collisions, including collision analysis, biomechanics of injury. Approximately 60 attendees.

The Low-Speed Package, 1995

Invited speaker to an Insurance Institute of Alberta seminar. Presented session on low speed analysis techniques and supported the biomechanical session. (about 50 attendees)

Engineering Investigation of Personal Injury Accidents, 1995

Review the issues and approaches to investigate and analyze personal injury accidents with the personal injury sub-sections of the Calgary and Edmonton Bar Associations.

Investigation of a Ladder Fall, Vancouver, 1994

Lead expert on a ladder fall where extensive on-scene testing and mathematical analysis provided the basis for a verbal presentation to the Canadian Society of Forensic Scientists.

Over 100 additional accident reconstruction and failure analysis presentations have been provided to legal firms, insurance companies, and schools across Western Canada.

TRIAL EXPERIENCE

Opinion evidence as an expert has been provided 41 times in civil and criminal trials (qualifications always accepted). Of the 39 trials involving vehicle accident reconstruction and mechanical failure issues, 33 were in Alberta Queen's Bench, Provincial Court, and small claims court. The other 6 vehicle related trials were in the Supreme and Provincial Courts of British Columbia, and the Court of Queen's Bench of Saskatchewan.

On vehicle related files I have been qualified to provide data and opinion evidence regarding:

- impact locations and speed,
- vehicle dynamics,
- event data recorder analysis,
- mechanical failure causation,
- brake design, operation, & analysis
- fire cause and origin,
- sightlines,
- potential to avoid,
- occupant kinematics and dynamics,
- seatbelt use & effectiveness,
- perception-reaction times
- driver identification,
- prisoner transportation safety,
- collision analysis computer programs (SLAM, CRASH3),
- collision simulation programs (EDSMAC, PC-CRASH), and
- collision animations (PC-CRASH).

Collision simulations and animations have been presented several times to courts in both Alberta and British Columbia.

Expert evidence has also been provided in 2 other trials, one related to a worker falling off a ladder and the other to a person jumping off a climbing wall.

AREAS OF EXPERTISE

Motor Vehicle Accident Reconstruction

Files worked on include analysis of impact speeds, pre and post impact movements, visibility, potential to avoid, and mechanical failures. Typical types of MVA investigations and analyses undertaken include:

- a) High speed highway collisions where vehicles collide either in a head-on, offset head-on or intersection related impact.
- b) Rollovers, other single vehicle losses of control, and impacts with roadside objects.
- c) Accidents involving pedestrians and bicycles struck by all types of vehicles including cars, vans, pickups and commercial vehicles.
- d) Motorcycle collisions and losses of control, including impacts with trucks, passenger vehicles and motorcycles.
- e) Very large or heavy vehicle collisions involving vehicles such as loaded super B-trains, busses, road maintenance equipment, etc.
- f) Low speed collisions, typically rear-end impacts and side-swipes, which occur on city streets, in alleys and in parking lots.
- g) Accidents involving vehicles not licensed for highway use. Includes quads, farm equipment, drilling equipment, snowmobiles, and trains.

Data used in an analysis is based on information gathered from personal inspection of vehicles and locations, documented data from SAMAC personnel and others, police scene data, or facts assumed from witness statements. Analysis techniques include computer simulations, computerized calculations, analysis of vehicle event data recorders ("*black boxes*"), preparing scale scene and analysis drawings, night visibility studies, vehicle testing, video re-enactments, Monte Carlo probability studies, animations, photogrammetry, and microscopic examinations. Library resources are used to provide historical research data and to confirm technical methods. The technical analyses provide the basis to form conclusions and opinions regarding how the incident occurred and what technical factors caused or contributed to the accident or the injuries sustained.

Restraint System Use & Effectiveness and Occupant Kinematics

Carrying on from a vehicle accident reconstruction, I am also often requested to address seatbelt/restraint use and effectiveness. Issues include intrusion into the occupant compartment, occupant ejections, effect of seatbelts not being available or in use, and other occupants being unrestrained. As well, I am routinely involved in issues of air bag effectiveness, deploying too early, or failing to deploy. This type of investigation will involve analyzing collision severity and direction, interior inspection of the incident vehicle(s) and use of other documented data to determine remaining survival space for the occupants, whether available seatbelts had been in use, possible ejection paths, and interior occupant impacts. Additionally, vehicle motions during the collision sequence are analyzed, any recorded restraint system data is accessed and, if required, medical data is reviewed documenting the injuries sustained. Exemplar vehicles and occupants can also be used to determine available survival space and limits of occupant motion. Use of these results enables technical opinions to be formed regarding restraint use and effectiveness.

Occupant kinematics is the science of analyzing how occupants move in a vehicle and whether they would have struck the interior during the incident whether restrained or not. This enables engineering analyses to be carried out to determine issues such as whether unrestrained occupants in a vehicle could have switched positions during a collision sequence or who was driving when the occupants were ejected.

Vehicle Component Failures

When wheels fall off, brakes fail, tires blow out, or other vehicle mechanical issues arise, I am typically requested to analyze whether the failure occurred before or after the incident, what caused the failure, if the failure caused or contributed to the accident, whether the driver could have maintained control of the vehicle, and whether the failure could have been prevented. Specialized areas of expertise, through both experience and education, are failures of tires and wheels.

Personal Injury and Commercial Failure Investigations

Numerous incidents occur where engineering principles can be used to analyze incidents that have led to an injury. My experience includes many common situations such as:

- Slip and fall accidents, including testing of coefficient of friction v. standards.
- Swimming pool/slide/diving boards for proper installation, standards, and warnings.
- Recreation equipment injuries including playground equipment, toboggans, sleds, water ski tow mounts, school kiln, and gymnastic equipment.
- Civil engineering analyses, e.g. steps, retaining walls, roof leaks & handicap access.
- Approval of civil engineering failure & design check reports on major failures.
- Management of building reconstruction (architect, civil, mechanical & electrical)
- Automatic door testing and analysis.
- Ladder functionality after fall related injuries, including on-scene testing, design verification, use, materials analysis, and ladder stability.
- Analysis of bicycle falls and cause of component failure.

Mechanical Failure Analysis and Fires/Explosions

Numerous failures of mechanical equipment in commercial and industrial operations have been investigated. As well, analysis of the cause and origin of fires and explosions has included investigation of small residential fires and explosions, vehicle fires, and industrial fires and explosions. These latter investigations are generally linked to a mechanical or electrical failure or design issue such that the origin of fire can be fairly easily determined but the cause of the loss requires detailed engineering analysis.

Investigations have been carried out on large and small mechanical equipment, vehicles, oil and gas equipment, buildings, propane tanks, and mining equipment. Specific examples include several ultra-large mine haul truck fires (Canada & U.S.A.), a large natural gas liquids straddle plant, pipe failure in a high rise building leading to extensive water damage, fire detection and suppression system failures, a sour gas well blowout, failure of oil and gas wellhead systems, a large underwater control system failure off Sable Island, and repair of damages to a large production battery.

Specific work performed typically includes some or all of the following:

- Detailed examination and documentation of scenes to determine the origin of the loss and the extent of damage.
- Review of operating & maintenance records, review of construction drawings, and detailed analysis to determine the cause of the loss.
- Evaluation of the requirement to replace or repair damaged equipment.
- Determining repair scope and assessing if plant betterment included in repairs.
- Monitoring of the repair contractor's cost and schedule, including review of invoices.

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