ANALYSIS OF THE EFFECTIVENESS OF
SNOWMOBILE TRACTION PRODUCTS
IN
ENHANCEMENT OF SNOWMOBILE SAFETY

WINTER 96-97

CONDUCTED BY/
WRITTEN BY:

RICHARD S. HERMANCE
Accident Reconstruction Expert
Collision Research Ltd.
P.O. Box 281
Tillson, New York 12486
(914)658-9042

FINDINGS

Based on this writer's conducting of the study herein referenced; knowledge, training and experienced gained through being a snowmobiler for over 20 years; knowledge, training and experienced gained through being an accredited accident reconstruction expert in the field of scientific snowmobile accident reconstruction; knowledge, training and experience in conducting previous braking studies as well as overseeing braking studies while in the process of teaching snowmobile accident reconstruction courses to law enforcement personnel in many parts of the country; standard and commonly accepted laws of physics; standard and commonly accepted principles of scientific snowmobile accident reconstruction; the following conclusions and interpretations are drawn, and are so drawn to within a reasonable degree of scientific and professional certainty:

1. That it is a regular and foreseeable part of snowmobiling in general that a snowmobile operator will from time to time encounter un-warned of and unforeseen circumstances involving ice.

2. That a snowmobile without properly designed and installed traction studs and carbides basically has no ability to afford the operator any adequate magnitude of maintaining vehicle control on icy surfaces.

3. That from time to time, and in the course of normal snowmobiling, operators will be confronted with rapidly changing surfaces and conditions which will result in the necessity to be able to turn on paved surfaces. Without good carbides, the skis of the snowmobile alone may not afford an adequate level of steering force in these conditions.

4. That the use of properly designed and installed traction studs and carbides significantly enhances the ability of an operator to be able to control his snowmobile on icy or paved surfaces. This control is in the form of turning and stopping. It is certainly unsafe to ride a machine on an icy surface that does not have a reasonable balance of carbided skis and studded track, both properly designed and installed.

5. That the usage of properly designed and installed traction studs and carbides significantly enhances the level of snowmobile safety relative to stopping and turning under the average and normal snowmobiling conditions afforded to both the snowmobile operator, his passenger, and any other traffic or pedestrians in an area effected by the operation of said snowmobile.

6. That in this writer's opinion, the banning of properly designed and installed traction studs, under normal snowmobiling circumstances, would certainly create a question as to liability for crashes which occur that would most likely have been prevented by the enhancements afforded by these traction products in steering, stopping and general control.

7. The best answers that can be given at this point to the questions generated at the beginning of this report are as follows:

   A. **How effective are traction products?** Basically, on icy surfaces, properly designed and installed traction products are extremely effective and are a significant enhancement to the overall level of snowmobile safety for all involved.

   B. **Under what conditions are traction products most effective?** On icy surfaces as well as paved surfaces that snowmobiles from time to time have to traverse.

   C. **Does the use of traction products enhance safety?** Certainly, and without question. As described above, snowmobiles are designed to be driven on the snow but in the real world, snowmobilers are frequently faced with conditions where they have to traverse icy surfaces.

   D. **Should traction products be required?** This question is best answered by knowing the conditions that the snowmobile will be operated in. For someone with a special application whereby they will most likely never run into icy or paved conditions, it would not be cost effective or fruitful to require this person to have traction products on the machine. It may be a good idea to investigate the feasibility of the tracks being pre-drilled for studs by the manufacturer so if a person does make the decision they want a studded track, they can do it relatively easily.

   E. **Should traction products be banned?** Certainly not. As an expert, and as the person who has conducted the above study, it is readily apparent that the banning of studded tracks and ski carbides significantly reduces the level of snowmobile safety and can certainly result in the occurrence of accidents which could otherwise be prevented. Any snowmobile operator should have the opportunity to decide on his own if he wants to use traction studs or carbides on his snowmobile. I further feel that people who purchase snowmobiles should be made aware, either through their dealer or the safety courses they take in their given jurisdictions, of the advantages, dynamics, and significant enhancements provided by properly designed and installed snowmobile traction products so they can make an informed decision as how to set their own machines up.

The following study was done at the request of S.E.S.R.A to get a real world and documented analysis of the effects of traction products on the overall issue of snowmobile safety. S.E.S.R.A. had absolutely no influence on either the manner in which this study was conducted, or the opinions derived by this author through the study conducted.

Mr. Hermance has extensive experience in the field of scientific automobile accident reconstruction and cause analysis. Mr. Hermance has testified as an expert in his field on many occasions in the high courts for both the prosecution and defense in criminal matters as well as civil litigation. Mr. Hermance was one of the first 19 accident reconstruction experts in the nation to successfully complete the professional exam for accident reconstruction and become accredited and certified as an accident reconstruction expert by the National Accreditation Commission for Traffic Accident Reconstruction. Mr. Hermance has been featured on television and radio shows for his knowledge of the events surrounding motor vehicle accidents. In addition, Mr. Hermance has been a guest speaker at seminars and dinners sponsored by the legal profession, law enforcement agencies, and insurance claims professions. Mr. Hermance frequently performs research and technical testing of equipment and methods related to the profession of automobile accident reconstruction. Over the last couple of years, Mr. Hermance has done extensive testing with regard to the dynamic properties of snowmobiles and in the various areas of the reconstruction of snowmobile accidents.. Mr. Hermance also has extensive expertise in the various types of interaction between snowmobile riders, snowmobile drivers, snowmobiles, and the environment in which snowmobiles are driven. He has performed accident reconstruction and analysis for a wide variety of clients, including but not limited to the following: United States Department of Justice; Federal Bureau of Investigation; New York State Police; New York City Metropolitan Transit Authority; New York State Office of Parks, Recreation, and Historic Preservation; Unites States Air Force; Legal Division, State of Alaska; Erie County Department of Law; New York State Thruway Authority; New York State Police Forensic Laboratory; Arctic Cat Corporation; District Attorney's Offices of New York Counties of Orange, Dutchess, Ulster, Monroe, Hamilton, Queens; District Attorney's Office, City of Philadelphia, Pennsylvania; Florida State Prosecutor's Office; Rhode Island Transit Authority; Wisconsin Department of Natural Resources; Wisconsin Attorney General's Office; Texaco Oil Company; J. B. Hunt Transport, Inc.; Peter Pan Bus Lines; Federal Express; Anheuser-Busch, Inc.; ABC Eyewitness News; Budget Rent-a-Car; Avis Car Rentals; TRUCK I Transport, Co.; Delaware Department of Justice; Other Accident Reconstruction Firms; Numerous Personal Injury Law Firms; Numerous Defense Law Firms; Numerous General Practice Law Firms; Insurance Claims Offices; Many Municipal Police Departments.

EDUCATIONAL ACHIEVEMENTS

- Certified and accredited as an expert in Traffic Accident Reconstruction by the National Accreditation Commission for Traffic Accident Reconstruction.
- Certified Snowmobile Safety Instructor, State of New York
- Technical Advisor & Design of Technical Portions of New York State's Adult Snowmobile Education Program in Conjunction with the NY State Department of Parks, Recreation & Historical Preservation
- Adjunct Faculty, Traffic Dept., Institute of Police Technology & Management, University of North Florida
- Graduate, Traffic Accident Reconstruction Program, Institute of Police Technology and Management, University of North Florida
- Graduate, Computer Simulated Accident Reconstruction, The Traffic Institute, Northwestern University
- Graduate, Motorcycle Accident Reconstruction and Investigation, Institute of Police Management, University of North Florida
- Graduate, Injury and Crash Biomechanics, Texas A & M University
- Graduate, Commercial Vehicle Accident Reconstruction and Investigation, Institute of Police Technology and Management, University of North Florida
- Graduate, Seat Belt and Child Restraint Injury Reconstruction, Institute of Police Technology and Management, University of North Florida
- Graduate, Pedestrian/Bicycle Accident Reconstruction Program, Texas A & M University
- Associate's Degree, Engineering Technology, Ulster County Community College, New York
- Associate's Degree, Criminal Justice, Ulster County Community College, New York

PROFESSIONAL ORGANIZATIONS

Member of the following; International Association of Accident Reconstruction Specialists; National Forensic Center; New York State Snowmobile Safety Coordinating Group; International Association of Snowmobile Administrators; National Association of Traffic Accident Reconstructionists and Investigators; Research/Testing and Evaluation Committee, National Assoc. of Traffic Accident Reconstructionists and Investigators; National Association of Professional Accident Reconstructionists; Maryland Association of Accident Reconstructionists; American Society of Law Enforcement Trainers; Society of Automotive Engineers; Institute of Electrical and Electronic Engineers.

- Past Member, Board of Directors, National Assoc. of Traffic Accident Reconstructionists & Investigators
- Committee Member, Ethics, National Association of Traffic Accident Reconstructionists & Investigators
- Board Certified Forensic Examiner, The American Board of Forensic Examiners
- "Diplomate", The American Board of Forensic Examiners
- "Fellow of the College", The American Board of Forensic Examiners

PROFESSIONAL EXPERIENCE

- Reconstructed approximately 2,200 motor vehicle accidents.
- Consultant as an Accident Reconstruction Expert for the past fourteen years.
- Consultant to the State of New York Office of Parks, Recreation & Historical Preservation on the design and preparation of "The New York State Trail Design Manual".
- Dynamic Testing Research Project for the Snowmobile Education Research Association. Project involves testing and evaluation for the industry of snowmobile dynamics relative to the variations in the machine set-up, usage of various models of traction product installation and usage, and relevance to issues of snowmobile safety and accident prevention.
- Given expert testimony in many grand jury inquiries as a private consultant in scientific automobile accident reconstruction and analysis nationwide.
- Given expert testimony for the prosecution and defense in both criminal and civil matters.
- For both criminal and civil matters, has been retained by counsel for both prosecution and defense who shared equally in the payment of our fee and accepted our technical report and expertise.
- Has designed and implemented several software systems dealing with the mechanics of vehicle collisions and other technical aspects of motor vehicle accident reconstruction.
- Retired Police Officer, Town of Rosendale Police Department, Rosendale, New York. 1973-1983.
- Has previous law enforcement training and experience as an investigator in charge of many fatal and serious injury motor vehicle accident investigations.
- Has performed diversified realistic testing of friction coefficient and deceleration properties associated with all types of vehicles including passenger cars, tractor trailers, snowmobiles, motorcycles, motor homes, three and four wheeled ATV'S, recreational camping trailers, etc..
- Has performed extensive testing of snowmobile deceleration and acceleration factors as well as various other types of handling characteristics of all types of snowmobiles ranging from the smallest to the 900 cc hyper sleds.
- Has experience with aerial photography and application to photogrammetry.
- Has designed and implemented numerous computerized court room demonstrative devices.
- Has in possession and is able to use inertial based test equipment for realistic testing of roadway friction coefficient, superelevation, grades, etc..
- Has been an active and avid snowmobiler for over 20 years.

PROFESSIONAL DEVELOPMENT

- Guest Speaker, "Snowmobile Accident Reconstruction, Trail Design, Risk Management & Safety", International Association of Snowmobile Administrators Congress, Prince Edward Island, Canada (1994)
- Guest Speaker, "Putting Safety On Track", Snowmobile Safety and Trail Infrastructure, Ontario Snowmobile Safety Committee, Markham, Toronto, Canada (1994)
- Guest Lecturer, "Accident Reconstruction Related to Seat Belt and Occupant Motion Cases". American Association of Judges, Spring Educational Seminar, Atlantic City, New Jersey (March 1997)
- Guest Speaker, "Traction Products in Snowmobile Safety", Minnesota Snowmobile Advisory Council, White Bear Lake, Minnesota. (April 1997)
- Special Problems in Reconstruction of Light Rail and Commercial Vehicle Cases, Maryland Association of Accident Reconstruction Specialists, Ocean City, Maryland (1988)
- Guest Lecturer, "New York State Snowmobile Law Enforcement Seminar", "New York State Office of Parks, Recreation and Historical Preservation". Topic: Snowmobile Accident Reconstruction. (1993)
- Guest Lecturer, Accident Reconstruction Seminar, Budget Rent-A-Car, Boston, (May, 1994)
- Accident Reconstruction and Analysis Training Seminar, National Association of Traffic Accident Reconstructionists and Investigators, King of Prussia, Pennsylvania (1987)
- Professional Accident Reconstruction Training Seminar, National Association of Traffic Accident Reconstructionists and Investigators, Atlantic City, New Jersey (1988)
- Guest Speaker, "Seat Belts & Restraint Systems", Defendants Round Table, Mineola, NY (June 1996)
- Guest Speaker, Making The Most Of The Accident Reconstruction Expert", American Trial Lawyers Association, Motor Vehicle Section Seminar. Sheridan Towers, Boston, MA (July 1996)
- Guest Speaker, "Anatomy of a Trial", Bard College, Annandale-on-Hudson, New York (1988)
- Guest Lecturer, "The Nuts, Bolts, and Law of the Seat Belt Defense", New York Trial Lawyers' Institute, Manhattan, New York (April, 1990)
- Guest Speaker, Insurance Claims Association Monthly Dinner, Poughkeepsie, NY (1988)
- Guest Lecturer, "New Jersey Special Investigations Association" Seminar on "Insurance Fraud". Topic: Accident Reconstruction and Damage Analysis (1993)
- Guest Lecturer, Accident Reconstruction Seminar, NJ Manufacturers Ins. Co., Trenton, NJ (Nov. 1990)
- Society of Automotive Engineers Technical Seminar: Comparison Studies between Skid and Yaw Marks, Effects of Change in Angular Velocity of a Vehicle on the Change in Velocity Experienced by Occupants within the Vehicle. Detroit, Michigan (1989)
- Society of Automotive Engineers Technical Seminar: Nighttime Photography, Driver Perception and Response Time, Motorcycle and Semi-Truck Accident Reconstruction, Avoidability Analysis, Steeping Situations, Measurement of Vehicle Damage Profile, Relationship of Vehicle Deceleration to Coefficient of Friction, Comparison of Single Image Photogrammetry Methods. Detroit, Michigan (1989)
- Society of Automotive Engineers Technical Seminar: Application and Misapplication of Computer Programs for Accident Reconstruction, Three Dimensional Computerized Photogrammetry and its Application to Accident Reconstruction, Further Validation of EDCRASH using the RICSAC Staged Collisions, the Comparison of NHSTA Crash Date with CRASH3 Stiffness Coefficients, SMAC-88, Comparison of the IMPAC Collision Algorithm with Reference Cases. Detroit, Michigan (1989)
- Society of Automotive Engineers Technical Seminar: Video Animation in Understanding Vehicle Dynamics, Vehicle Collision Animation Employing Computer Graphics, Response of Halogen Light Filaments in Collision, Dynamics of Rollover Accidents, Elements of Seat Belt Technology and Performance, Investigation, Analysis, and Reconstruction of Railroad Crossing Accidents. Detroit, Michigan (1989)
- Guest Speaker, "Seat Belts & Restraint Systems", Plaintiff's and Defendant's Counsel Committees on Insurance, Negligence & Compensation of the Suffolk County Bar Assoc., Hauppauge, NY (Nov. 1996)
- Guest Lecturer, "Accident Reconstruction Related to Seat Belt and Occupant Motion Cases". American Association of Judges, Spring Educational Seminar, Atlantic City, New Jersey (March 1997)
- Advanced courses in Engineering, Mathematics, Physics, Chemistry, Software Design, and Graphics
- CRASH3 Accident Reconstruction Software
- EDVAP Series of Accident Reconstruction Software
- EDVAP Single and Articulated Vehicle Trajectory Simulation
- Fotogram Photogrammetry, General Motors Corporation
- Occupant Trajectory, Crash Kinematics and Injury Simulation

- Reconstruction of Human Structural Damage Resultant of Collisions Involving Occupant Interaction with the Interior and Exterior of Vehicles in Conjunction with Forensic Pathological Analysis
- Critical Speed Analysis and Dynamics of Vehicles Rounding Curves
- Driver Perception/Reaction Time, Human Factors and Nighttime Visibility Issues
- Impact Conditions and their Relationship to the Physical Laws of Linear Momentum and Kinetic Energy Dissipation
- Impact Forces in Centric, Parallel, and Collinear Collisions
- Analysis of Weight Shift and its Effects on Large Commercial Vehicle Deceleration and Handling
- Video Reconstruction and Animation
- Crush Deformation and Structural Analysis
- Highway Safety, Design and Maintenance, Deceleration and Dynamics Testing of Three and Four Wheeled ATV's and Snowmobiles

PUBLICATIONS

→ "Presenting Energy Dissipation Analysis in the Court Room Environment"
Accident Reconstruction Journal, September/October 1990.

→ Author, "Snowmobile Accident Reconstruction; A Technical and Legal Guide"
Published by Lawyers & Judges Publishing Co. 1995

→ "Snowmobile Accident Reconstruction Part I"
Law and Order Magazine, March 1994

→ "Snowmobile Accident Reconstruction Part II"
Law and Order Magazine, April 1994

→ "Snowmobile Accident Reconstruction and Safety"
Accident Reconstruction Journal, 1994.

AWARDS

- New York State Office of Parks, Recreation & Historical Preservation

"Outstanding Commitment and unparalleled expertise in the field of Snowmobile Accident Reconstruction and valuable contribution to the Snowmobile Law Enforcement". December 1993.

- New York Society of Forensic Sciences at Lehman College
  "For the advancement of knowledge to the Forensic Sciences". April 1994

Assisting this Author in the riding phase of the testing process was Test Rider Paul Costa. Mr. Costa has extensive experience in riding snowmobiles and has both attended and assisted Mr. Hermance with the teaching of the New York State Snowmobile Law Enforcement Accident Reconstruction Program. Mr. Costa did much of the test riding involved with the preparation of the book, authored by Mr. Hermance, as well as the field testing down in the accident reconstruction schools.

SCOPE & BASIS FOR RESEARCH PROJECT

Just about at the inception of snowmobiles gaining popularity back in the early 70's, both snowmobile riders, mechanics, and racers realized that traction products such as studs and carbides were needed and/or helpful on sleds under many conditions.

Over the past 25 years or so, the traction products industry has provided an excellent and wide array of products that assist a snowmobile operator in handling his/her machine. In general, snowmobiles are designed to be ridden on the snow, and the interaction between the ski and the snow surface is what basically provides the steering and turning force for the snowmobile. In addition, the track lugs on the snowmobile track are what usually provide for the stopping and acceleration traction of a snowmobile being operated on the snow. However, in the analysis of snowmobile safety, we have to look at the **REAL WORLD**, and not simply the theoretical world. In essence, if snowmobiles were always ridden on soft packed and powdered snow, or even on powdery groomed trails, traction products would not have a significant enhancement to the issue of snowmobile safety. However, in the **REAL WORLD**, and this writer has experienced this throughout the US and Canada, snowmobiles are quite frequently required to travel over ice and hard packed ice/snow mixtures on plowed and/or scraped roadways. In the best cases, the rider knows that he is on these surfaces and can attempt to control his/her machine appropriately, although sometimes proper control on the ice is not possible without the use of traction products. The stand-out issue here is when a snowmobile, for a variety of reasons that will be discussed later in this report, comes upon unexpected icy conditions. These unexpected situations are usually not the result of any type of inattentiveness by the operator, but usually exist as a function of the rapidly changing conditions of various snowmobile trails and usable roadways. Even the most experienced snowmobile operator can get into trouble very quickly when riding a machine with no studs or carbides when unexpected ice is encountered.

Recently, the state of Minnesota has banned the use of traction products on some of the trails in their system. Other states and jurisdictions are looking at doing the same thing. As this writer understands it, the ideas behind these limitations are as follows:

- **That traction products cause extensive wear and tear on bridge surfaces.**
- **That traction products cause excessive wear on paved surfaces.**
- **That traction products brake off and leave debris on roadways.**
- **That traction products are not needed as they are geared only for performance in racing.**

QUESTIONS TO BE ADDRESSED BY RESEARCH PROJECT

Although a significant amount of data has been generated in this study, the main questions that will hopefully be answered by this study are as follows:

1. **How effective are traction products?**
2. **Under what conditions are traction products most effective?**
3. **Does the use of traction products enhance safety?**
4. **Should traction products be required?**
5. **Should traction products be banned?**

TESTING METHODOLOGY

As is common knowledge in the profession of accident reconstruction, skid tests are a very well documented and acceptable way of estimating effective drag factor on various surfaces then and there existing. For the testing done relative to this study, the author used a Vericom VC2000 Digital Decelerometer which measures fore-aft accelerations resulting in memory data acquisition easily stored and then transferred to most types of PC computers for analysis and output. The test method used was to put the decelerometer in the "braking" mode and accelerate the machine to speed. When the speed of the machine is leveled off, the snowmobile brake was applied. The accelerometer senses the inertial imbalance gained through the beginning of the braking phase and triggers the accelerometer. The accelerometer records the acceleration history of the snowmobile until it comes to a complete stop. The stopping distances, as indicated on the VC2000, were then checked with a roll-a-tape for reasonable accuracy. One of the main reasons the Vericom was chosen for this assignment is that this author feels it is the best tool for the job, since it triggers on inertial imbalance. The decision on what snowmobiles to use was made by analyzing various weights, acceleration rates, and popularity. It was felt that the most popular class is that of the 500cc to 600cc range. For purposes of stopping, this author felt that the 500cc to 600cc range machines are reasonably representative of the majority population of snowmobiles out on the trail and are reasonably consistent with the stopping times generated by both the 340cc and 440cc class as well as the 800cc and 900cc classes. One technical caveat here is that when maximum friction and mechanical damping are reached, and the snowmobile is being stopped by mechanical interaction as opposed to shear friction, the lighter machines will stop quicker. This is so because if you have the same level of retarding force mechanically on the surface at the interaction point between the studs and the surface, a heavier machine, with more momentum, will push through this retarding force easier, hence it will go farther. However, in general, the extra distance associated with the weight will not be a significant factor in determining the safety aspects of traction products. In light of the above, it was decided to use three 500cc 2 cylinder machines. The machines were all the same approximate weight with the same approximate dimensions and geometrics. The machines were in pretty much new condition and there were no add-on components or accessories. The tracks were all adjusted to optimum and they were all equipped with a new drive belt.

CONCEPT OF TOTAL STOPPING DISTANCE (TSD)

In the process of riding a snowmobile, similar to that in which any type of vehicle is being operated, **one of the main concepts in crash avoidance is *TOTAL STOPPING DISTANCE***. Total stopping distance (TSD) is the distance required, from a given speed, for a snowmobile to come to a complete stop from the point of first detection of a hazard. As a rider is operating his snowmobile, if confronted with a hazard, the rider first has to detect the hazard. After detection of the hazard, he then has to perceive what the hazard is and make a decision as to what his reaction is going to be with regard to trying to avoid the hazard. This time displacement, from detection through the decision making process, is called ***PERCEPTION TIME***. The distance covered during the perception time is called the ***PERCEPTION DISTANCE***. Subsequent to the perception, the rider then has to react based on the decision made during the perception time. The time it takes to react is appropriately called ***REACTION TIME***, and the distance covered during the reaction time is called the ***REACTION DISTANCE***. If the decision is made that an emergency stop is required, the braking time and distance then follows the reaction time. In essence, once the reaction is made to apply the brakes, it will take a certain distance, such distance being a function of the speed and traction capabilities of the snowmobile, for the snowmobile to skid or slide to a stop. This distance, that in which it takes the machine to skid or slide to a stop, is called the ***BRAKING DISTANCE*** and its time displacement is identified as the ***BRAKING TIME***. If we add all three of these together, we have the ***TSD***. In essence, if we add the perception distance, the reaction distance, and the braking distance all together, that would equal what is defined in the field of accident reconstruction and safety as ***the TOTAL STOPPING DISTANCE***.

FACTORS EFFECTING TOTAL STOPPING DISTANCE

PERCEPTION TIME. Perception time is a function of human physiology and can vary quite a bit depending on the situation as well as the condition of the operator. Factors such as fatigue, old age, impairment due to alcohol or drugs, and inexperience all in general contribute to and increase perception time. In addition, perception time is broke up into two basic areas. The first is what we call a ***SIMPLE PERCEPTION***. A simple perception is one in which the decision making process will go fairly quick. As an example, consider a situation where a snowmobiler is traveling down the trail and all of a sudden has a deer jump out in front of him from the right. Further consider that off to the left of the trail is a snow covered field with no obstructions. It would be a fairly simple decision for the snowmobiler to realize that the most likely course of action would be to slow down, attempt to stop, and simultaneously drive to the left off into the safety of the field. For the normal alert and attentive operator, this would most likely be a rather simple decision making process. On the average, based on various tests done in the human factors arena, a simple perception takes on the order of .75 to 1 second.

The second type of perception is what we call ***COMPLEX PERCEPTION***. Unfortunately, many of the situations a snowmobiler is confronted with are not as simple as that which was described above. Consider the same snowmobiler now traveling down a trail at the same approximate speed. Instead of a deer jumping out from the right side, assume it is a child. Further assume that in back of that child, or on the right side of the trail, are two other children. Instead of having the safety of a non obstructed and snow covered trail bordering an open field to the left, assume there is a 200' ravine and further assume that there are snowmobiles coming the other way on the trail. In this situation, not only is it impossible to make an appropriate decision in a second, you could probably sit four hours and decide what would be the safest thing to do in this situation since there really is no answer. The time span for a complex reaction can take upwards of three, four, five seconds or even more. At some point, the rider is going to decide to do something even though it may not be the best thing to do.

BRAKING DISTANCE. Once a decision has been made to come to an emergency stop, it is then going to take a certain distance for the machine to come to a stop. This distance is going to be a function of the speed of the machine, weight of the machine and rider under some circumstances, and the available traction and friction between the snowmobile and the surface it is traveling over. There is a mathematical relationship between speed, friction, and stopping distance. Basically, just about any physics book will talk about the mathematical relationship which says that kinetic energy is equal to one half of an objects mass multiplied by its velocity squared. In addition, kinetic energy can also be equated to the product of weight, friction, and slide distance.

These equations are as follows:

$$KE = 1/2\ MV^2$$

also

$$KE = wfd$$

where:

M	=	Mass
V	=	Velocity in feet per second
w	=	Weight
f	=	Friction
d	=	Distance in feet.

Some algebraic manipulation of these two equations yields an equation which in the accident reconstruction profession is known as the slide to stop equation. This equation simply says that

$$V_{MPH} = \sqrt{(30)(D_{FT})(f)}$$

WHERE:

V_{MPH}	=	initial velocity in miles per hour
30	=	mathematical constant used in converting from feet per second to miles per hour
D	=	Distance in feet
f	=	Friction

As can be readily scene, the main variable here, assuming the distance would be known, is the friction. Some further manipulation of this equation, basically solving it for distance, yields the equation that says:

$$D_{FT} = \frac{(V_{MPH})^2}{(30)(F)}$$

With this equation, if we know the speed, and we know the friction, we can calculate the required braking distance. Once again, the variable here is friction. If we want to calculate how long it would take a snowmobile to brake from 30 mph, we can also make that calculation.

The concept of friction and drag factor are really where the traction products become important. Basically, friction is the adhesion force between the track and the snow surface. However, in the case of a snowmobile, it is not simply an adhesion force that we deal with. There is also mechanical damping of the track digging into the snow and the force generated in pushing the snow. The effective drag factor is really the important number. The ***EFFECTIVE DRAG FACTOR*** is basically the effective drag that the snowmobile experiences over the slide distance. This drag factor is substituted for the friction value in the equation. On snow, this drag factor is affected and usually becomes higher with increased speeds since at the beginning of the slide, the snowmobile is generally neither plowing or pushing any snow, and if it is, the amounts are small. As the machine begins to slide down the surface, snow begins to pile up in front of it and the machine now stops or decelerates quicker since the weight of the snow is now in front of the snowmobile. However, on icy surfaces, the effect of plowing does not really become important. The only real, relatively effective traction that the machine can get on an ice surface is that which is provided by traction studs. In general, a snowmobile without traction studs, sliding on ice, from 50 miles per hour, will slide on the order of fifteen to sixteen hundred feet before coming to a stop. The same snowmobile, with traction studs, will slide to a stop in somewhere on the order of two hundred to two hundred and fifty feet from 50 miles per hour. **IN ESSENCE, IT WOULD TAKE A SNOWMOBILE APPROXIMATELY SEVEN TIMES THE DISTANCE TO STOP ON ICE WITHOUT STUDS AS OPPOSED TO THE DISTANCE IT WOULD TAKE FOR THE SAME MACHINE TO STOP WITH THE USE OF TRACTION STUDS**. However, just as important, the machine sliding on the ice without the studs will just about be totally out of control. Assuming a .05 friction, which is pretty reasonable assuming very slippery ice, any irregularities such as superelevation of the icy terrain, and/or weight shift of a rider or passenger can easily throw a snowmobile into some type of a spin, which then puts the machine and its riders in a precarious position in that it can trip and roll over with resultant injuries, even without striking another machine or obstacle.

COMMON TYPES OF SNOWMOBILE ACCIDENTS

It is a well known fact, and this report is not going to in any way attempt to confirm the statistics which are pretty much commonly known, that alcohol and speed play a significant part in a very large percentage of snowmobile accidents.

The alcohol impairment basically increases perception time, increases reaction time, decreases an operators visual acuity, decreases an operators level of fear, and interferes with the operators motor coordination. Speed obviously requires a greater distance for perception, a greater distance for reaction, and a greater distance to stop in any given situation, along with providing a potential for more serious injury biomechanics. Higher speeds yield higher potential crash Delta-V's and injury creating crash forces.

Even in the above situations, the ability to better control the machine in terms of steering and stopping would certainly enhance the ability of even an intoxicated driver to avoid a crash.

The following is list of some fairly common types of snowmobile accidents which although in some cases do involve intoxication and high speed, in many cases do not.

These are generally the types of accidents where even safe and conscientious snowmobile operators, without enhanced traction control, can get into trouble:

1. **APPROACHING INTERSECTIONS AND TRAIL HEADS**. In many situations, as snowmobiles travel across a trail, they are not really digging up or pushing the snow over the surface. However, on approaches to intersections, the operators generally tend to slow down and apply brake pressure. Simple physics tells us that while the machine is in constant motion, the forces exerted on the travel medium are relatively minimal since there is no acceleration. Remember, force is equal to mass multiplied by acceleration. (F=MA, Newton's 2nd Law of Motion). However, when the machine begins to stop, a negative acceleration has to be generated and the force that supplies this negative acceleration has to, in most cases, be the interaction between the track and the travel medium. Hence, often, machines slowing or stopping on approach into

intersections or trail heads tend to plow and/or push the snow cover out of the way which may expose hard icy surfaces underneath. The machine may be decelerating at a rate that seams appropriate to the operator and then all of a sudden, an icy surface is encountered, the negative acceleration rate decreases significantly, and the machine simply cannot stop in time, thus sliding into the intersection. Obviously, this sometimes creates an accident with another machine, may cause the sliding machine to go through the intersection and off the trail on the other side, or result in one of many other possibilities. Such situation is usually unexpected, unforeseen, and in most cases, unavoidable by the snowmobile operator. These hazards are certainly magnified significantly when the snowmobile is being operated by an inexperienced operator, who is not aware of the possibility that this type of thing may at some point happen on approach to intersections. In this situation, the use of traction studs would not only serve to maintain the lateral control under the above conditions, but would most likely increase the deceleration rate once the picks started digging into the icy surface.

Under similar circumstances, properly designed and installed snowmobile traction studs are a significant enhancement to stopping ability, crash avoidance, and snowmobile safety in general for both the operator of the machine, his passenger, and any other machines or pedestrians in and near the vicinity of the subject intersection.

2. **<u>APPROACHING AND NEGOTIATING CURVES</u>**. Snowmobiles usually will begin to decelerate as they approach a curve. This deceleration, as in the above situation at intersections, can push and/or plow snow out of the way exposing an underlying icy and slippery surface. This can create immediate lateral instability of the machine if there is any superelevation or irregularities approaching or in the curve, which is very common. In this situation, the snowmobile may be out of control before it even enters the curved portion of the roadway or trail. Properly designed and installed traction studs offer a significant enhancement to stopping ability, maintenance of control, and ability to properly slow for upcoming curves.
3. **<u>ENCOUNTERING ICE WHILE IN A CURVE</u>.** This is a situation that causes quite a few accidents ranging from crashes in which the machine simply looses control and goes

off the side of the trail, to crashes where the machine goes into the oncoming lane and impacts with other traffic. Injury severity ranges from no injuries to fatalities. Just as the idea of additional force being required to slow a snowmobile, additional force is required to turn a snowmobile. When there is an icy and slippery surface underneath a snow traveled way, it is common for snowmobiles, in the turns, to dig in and push and/or plow the snow surface out of the way exposing the underlying ice. This can be compounded by the first snowmobile that may loose control in this situation. As a snowmobile looses lateral control, it can yaw or spin out which will in effect make the area that the track plows out increase from the width of the track to almost the length of the track as the snowmobile spins out 90 degrees.

The following two photographs illustrate this fairly well.

Under this circumstance, since the snowmobile already has a centrifugal force propelling it tangent to the curve that it is trying to negotiate, the failure to have traction studs to dig in the ice can cause an immediate and rapid loss of control of the machine. As is obvious, in this situation, the carbides on the skis are very important as well. Without carbides and wear rods, the snowmobile will have a tendency to under-steer and go off tangent to the curve since the skis, on ice, will not supply, in most cases, appropriate steering force. On roads that are scraped down and fairly slippery, many riders are aware of the condition as they travel down the road. However, it commonly occurs that overnight, a snowfall ranging from just a dusting up to a significant amount can fall and cover up the fact that the roadway underneath is very slippery. This new fallen snow may be very powdery, unsettled, and easily pushed out of the way as a machine comes into a turn. In essence, as machines are going straight, they simply pack the snow down but tend to blow the snow out in the curves. Once again, this sudden, invisible, and unexpected encountering of an icy surface while in a curve usually causes immediate and unrecoverable control loss. In these situations, the use of properly designed and installed traction studs and carbides are very effective in allowing the operator to maintain control, and negotiate the curvature of the roadway or trail.

4. **PLOWED & SCRAPED ROADWAYS/TRAILS.** Somewhat similar to the above, on plowed and scraped roadways, it is not unusual to find that in turns, the snow surface may be down to the ice and sometimes even the pavement from the additional forces generated on the traveled median by vehicles encountering the curve. In this situation, there is no substitute for good carbides. The carbides will allow for a significant relative magnitude of steering force as opposed to that which would simply be supplied by wear rods or skis themselves.

5. **MOUNTAINOUS AREAS**. In riding mountainous areas, it is normally the case that the trails are rather winding, either due to environmental characteristics or design, as the designer of a snowmobile trail will usually not want to give long and steep upgrades to riders. The easiest way to avoid this is to give the trail somewhat of a

serpentine affect when possible. Based on geographic considerations, it is very common to find that water coming down off the tops of mountains will get into some of the curves on the trails creating ice. This usually occurs when there is a warm day and the snow melts, when it rains and the trail is then frozen over at night, or by a cold front moving in. An operator coming down a mountain trail on snow, suddenly encountering ice on a turn will most likely loose control if not for the usage of properly designed and installed traction studs and carbides. The reverse also occurs when a machine is going up on a surface like this and gets into a situation where the operator has to turn and climb at the same time. Here, even if the carbides supply the turning force, the failure of the traction studs can cause the rear of the machine to slip out and cause a spin-out. A magnified effect of this can be that the machine will loose its upward momentum and even begin to go back down out of control and possibly tumble over. The use of properly designed and installed traction studs and carbides in this situation is definitely effective and significantly increases the level of safety afforded to the operator and others in the vicinity.

6. **CRASH AVOIDANCE / TOTAL STOPPING DISTANCE**. When the conditions get icy and/or very slippery, traction studs and carbides certainly increase the capability of an operator to turn and stop his snowmobile to avoid crashes. It has to be remembered that any snowmobiler, despite the geographical considerations, may be required to take evasive action due to the actions of another snowmobile, car, etc. Any enhancement to his ability to turn, accelerate, and/or slow down and stop, significantly increases the operators ability to avoid an impending hazard. In general, and overall, the use of carbides and properly designed and installed traction studs does significantly increase the operators ability to maneuver and control his machine.

7. **TURNING IN PARKING LOTS, NEAR DRIVEWAYS, TRAIL HEADS, ETC**. In many jurisdictions, trail heads are basically plowed right down to the road. In

addition, there are many situations where snowmobilers pull into restaurants, gas stations, tourism offices, etc., and the parking lots and parking areas are plowed right down to the pavement and/or are sanded. Under these conditions, the use of carbides gives a significant enhancement to the turning ability of a snowmobile. In many cases, when a snowmobiler pulls into one of these areas, he cannot turn his machine hard enough to be able to turn around and/or negotiate exactly where he wants to go within the parking lot area. In some cases, especially with an inexperienced snowmobile operator, their machine may lurch forward, go straight, and go right into a roadway or trail where there is oncoming traffic. In other situations, it will force the snowmobiler to get off the snowmobile and lift the snowmobile around which can cause back and physical injuries by itself. With good carbides, a snowmobile can turn much better in these plowed and paved areas.

ACCIDENT PREVENTION - GENERAL

In general, accident prevention and snowmobile safety go hand-in-hand. Although there are many factors such as experience, alcohol/drugs, fatigue and other human factors issues involved with the analysis of any one particular accident, or the subject of accident prevention in general, one of the common denominators that always comes into play is vehicle dynamics. Even if the major cause of an accident is intoxication and/or reckless speed, the ability of that operator to control his machine may in many cases allow him to avoid a crash. If an operator comes into an intersection where the last 200' on approach are solid ice, his intoxication will probably not have as significant an effect on his failure to stop for the intersection as would the icy conditions, if his machine was not studded. This, of course, is a function of his speed, but the common denominator is that any driver, under most conditions, will have a much better chance of avoiding an accident or maintaing control of his/her machine if he/she can adjust and control his vehicle at an optimum. The two main factors involved with the ability to control a machine are turning and acceleration. This can also be described as lateral and longitudinal acceleration. ***POSITIVE ACCELERATION*** is basically the rate at which speed is increased, and ***NEGATIVE ACCELERATION***, commonly called deceleration, is the rate at which speed decreases.

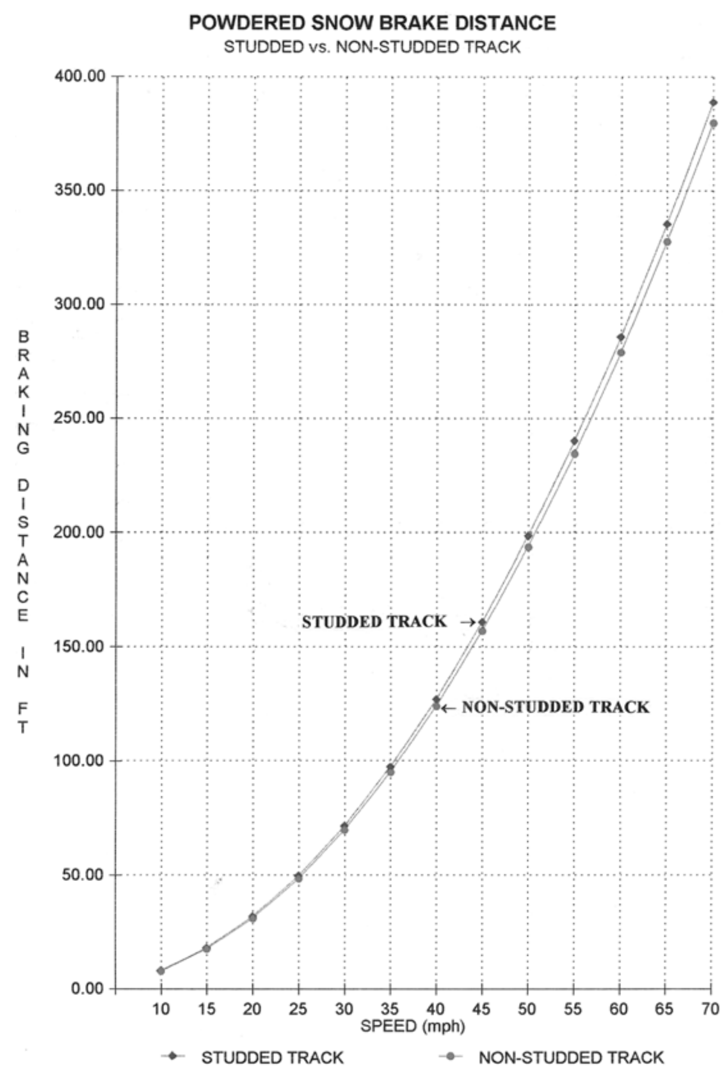
STEERING. Obviously, the ability to steer a snowmobile is a very important factor in controlling a snowmobile, as well as being able to avoid a hazardous situation. On snow, the steering force between the skis and the snow are generated through the interaction of the surface of the ski and the snow median that it is traveling over. However, a ski is not designed to provide for steering traction on a hard, icy, or paved surface. As a snowmobile goes into a curve, Newton's First Law of Motion tells us that the snowmobile is going to tend to go straight or tangent to the curve, unless there is a turning force exerted on the snowmobile. If there is not enough grip between the ski and the icy surface, which certainly can be the case without appropriate wear rods and/or carbides, the snowmobile will tend to go straight or tangent to the curve. This is commonly called "**under-steer**". In essence, the skis can be turned all the way to the left for a left hand curve, but the snowmobile will continue to go straight. Even if the snowmobile doesn't go completely straight, a slip angle will be developed. The slip angle is the angular displacement between the heading angle of the skis and the direction in which the center of mass of the snowmobile is actually traveling. Many snowmobilers actually purchase carbides for the front of there snowmobile but do not have traction studs in their tracks. This in itself can create some hazardous situations if the snowmobiler is not familiar with how to handle the machine. In essence, if there is too much traction in the front, and the snowmobile goes into a turn, the rear of the snowmobile will not be able to relatively match the friction of the front of snowmobile, and the back end of the snowmobile can spin-out causing control loss and possible injuries. Although this study is not directed at finding the optimum set up for various machines, the study generally has resulted in the conclusion that the best equipped snowmobile to negotiate curves on icy surfaces is one that has carbides and traction studs installed according to the manufacturer's specifications. In essence, the combination of properly designed and installed traction studs and carbides provide significant enhancement to the question of accident prevention and overall level of snowmobile safety in the general area of accident prevention.

ACCELERATION. In some situations, as is obvious to most of us that are involved with snowmobiling, traction studs are utilized as a performance option. If a snowmobiler wants to drag race and be able to go faster, especially on an icy surface, he will put traction studs in his tracks so he gets a better grab on the icy surface. Obviously, his is a significant enhancement to performance. However, it has to be remembered that any enhancement to performance is also desirable for creation of deceleration, as well as positive acceleration. The fact that the usage of traction studs will significantly increase the acceleration rate of a snowmobile on an icy surface, certainly does not outweigh the benefit gained through the fact that the same traction studs will significantly increase the capability of the operator of the snowmobile to avoid an accident, and to bring his machine to a much quicker and more controllable stop from any given speed. In essence, even though a person purchases traction studs for acceleration, they would also be gaining the benefit of significantly greater deceleration which serves to enhance the safety out on the trail for all other riders and traffic as well in terms of control and stopping ability.

TESTING AND DOCUMENTATION

As part of this study, various tests were performed with regard to the turning and stopping abilities of snowmobiles with studs as opposed to without studs, and with carbides as opposed to without carbides. Since the concept of the effectiveness of traction products in powdered snow is obviously negligible, there was not a great effort here to scientifically show the fact that they do not have an great enhancement under these conditions. However, studies that this writer has previously conducted do bare this out. The following graph shows an example of braking distance of a snowmobile under powdered conditions with and without a studded track.

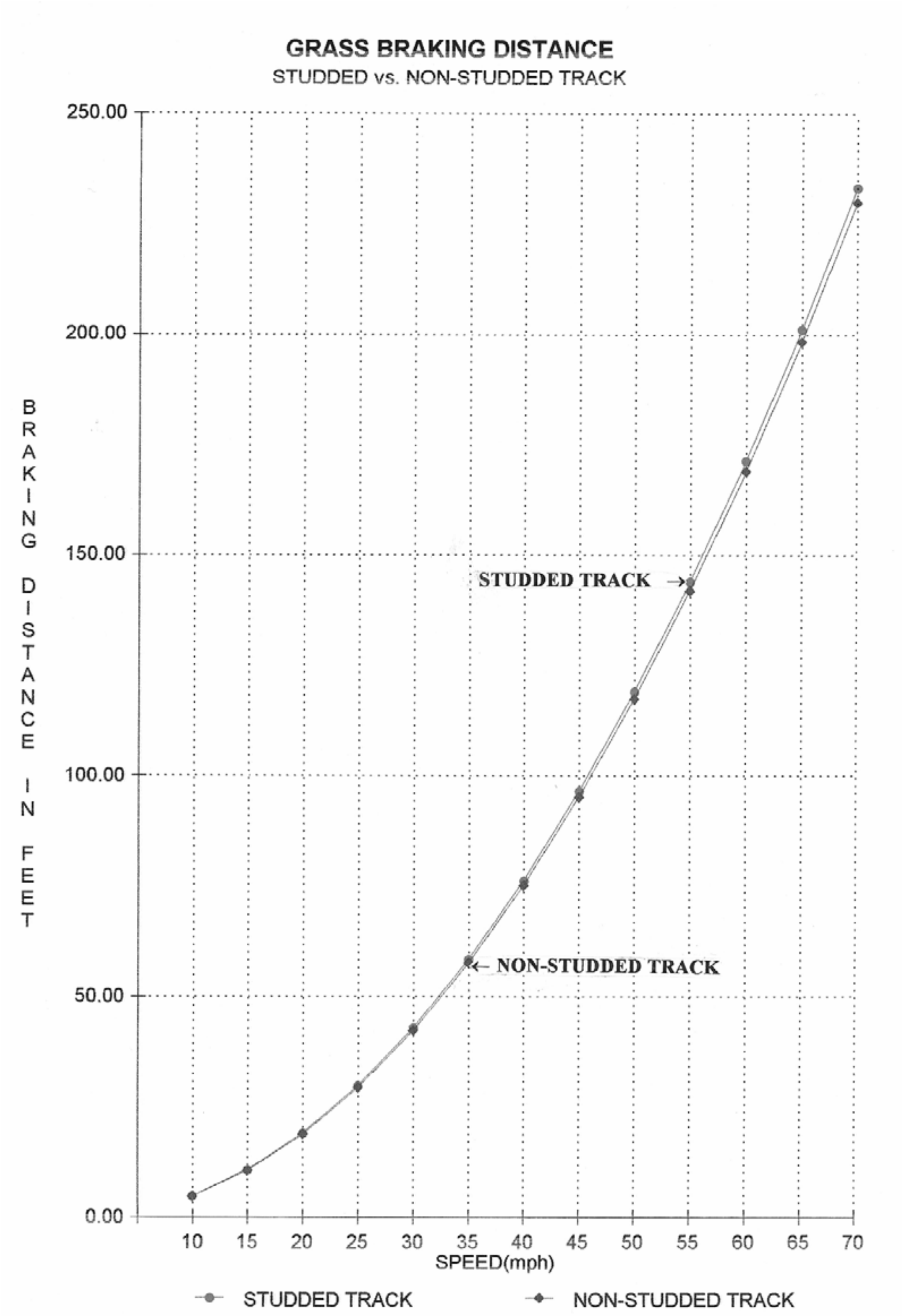
TEST MACHINES: STOCK 1997 500CC
2 CYLINDER
LIQUID COOLED
STUD SET-UP: 144 .875'S



Due to error factoring, and the range of expected results from the testing methodology, this graph represents basically the same acceleration curve.

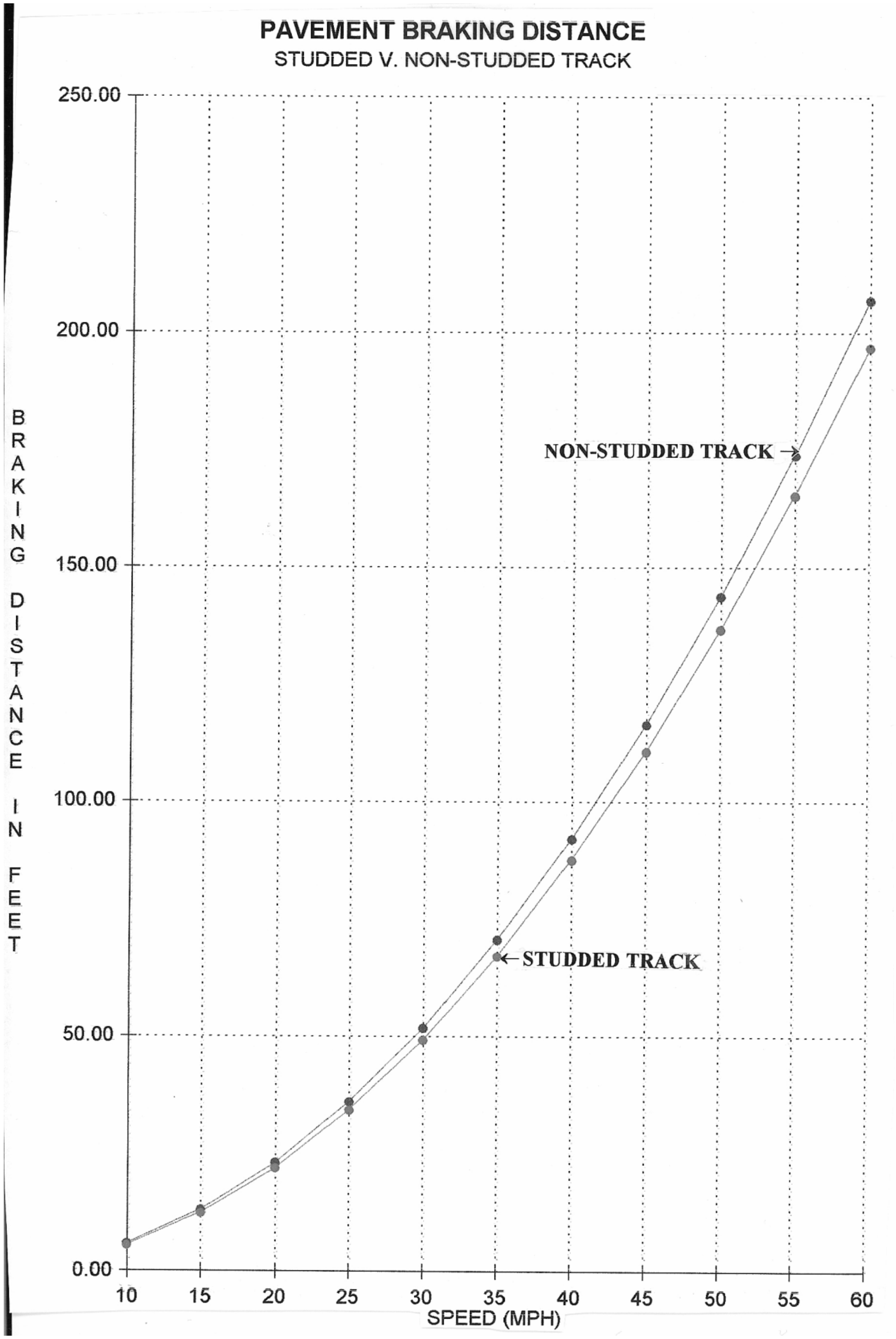
Tests were then performed on grass and pavement, at full braking, with the results described in the following graphs.

TEST MACHINES: STOCK 1997 500CC
2 CYLINDER
LIQUID COOLED
STUD SET-UP: 144 .875'S



Due to error factoring, and the range of expected results from the testing methodology, this graph represents basically the same acceleration curve.

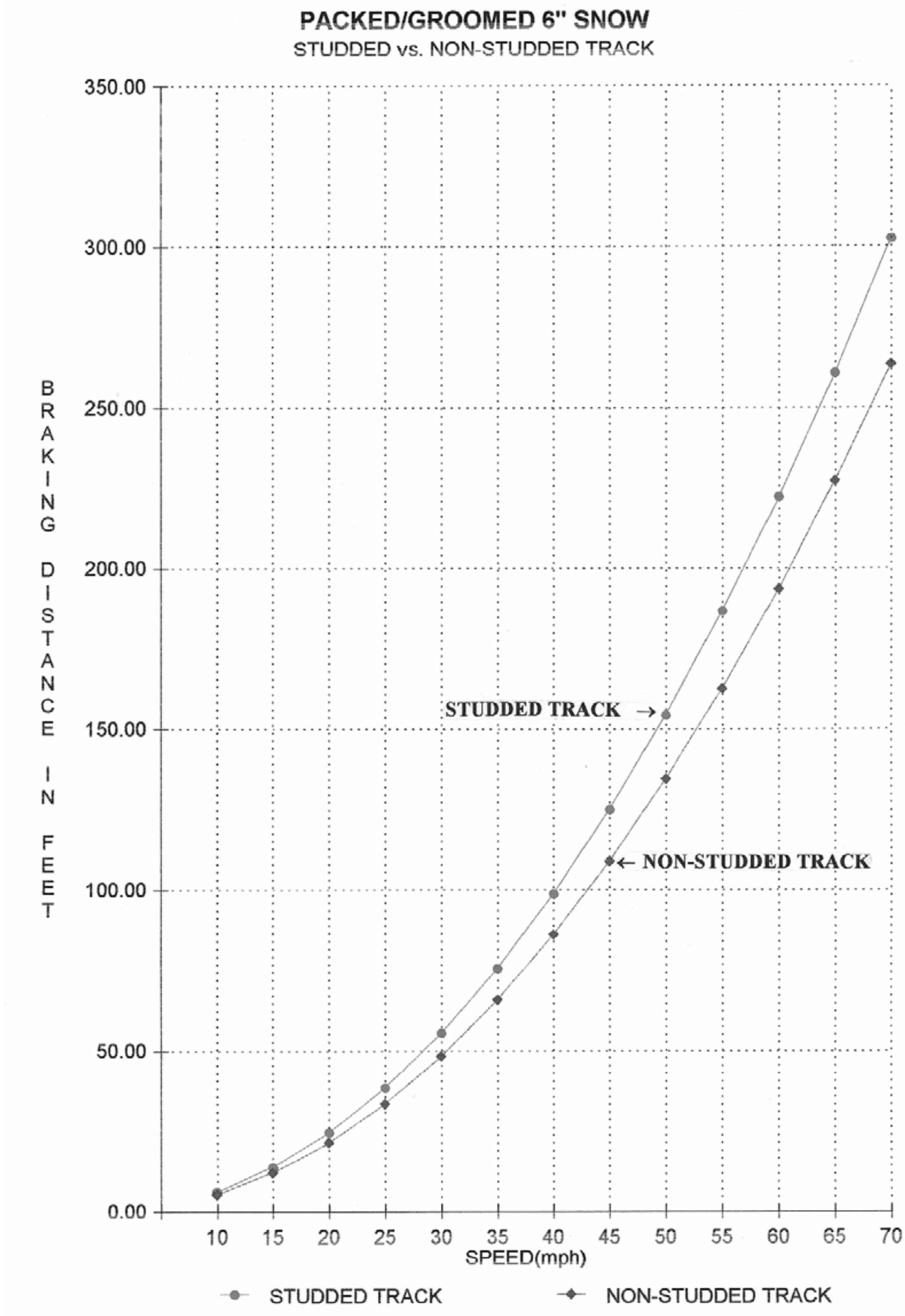
TEST MACHINES: STOCK 1997 500CC
2 CYLINDER
LIQUID COOLED
STUD SET-UP: 144 .875'S



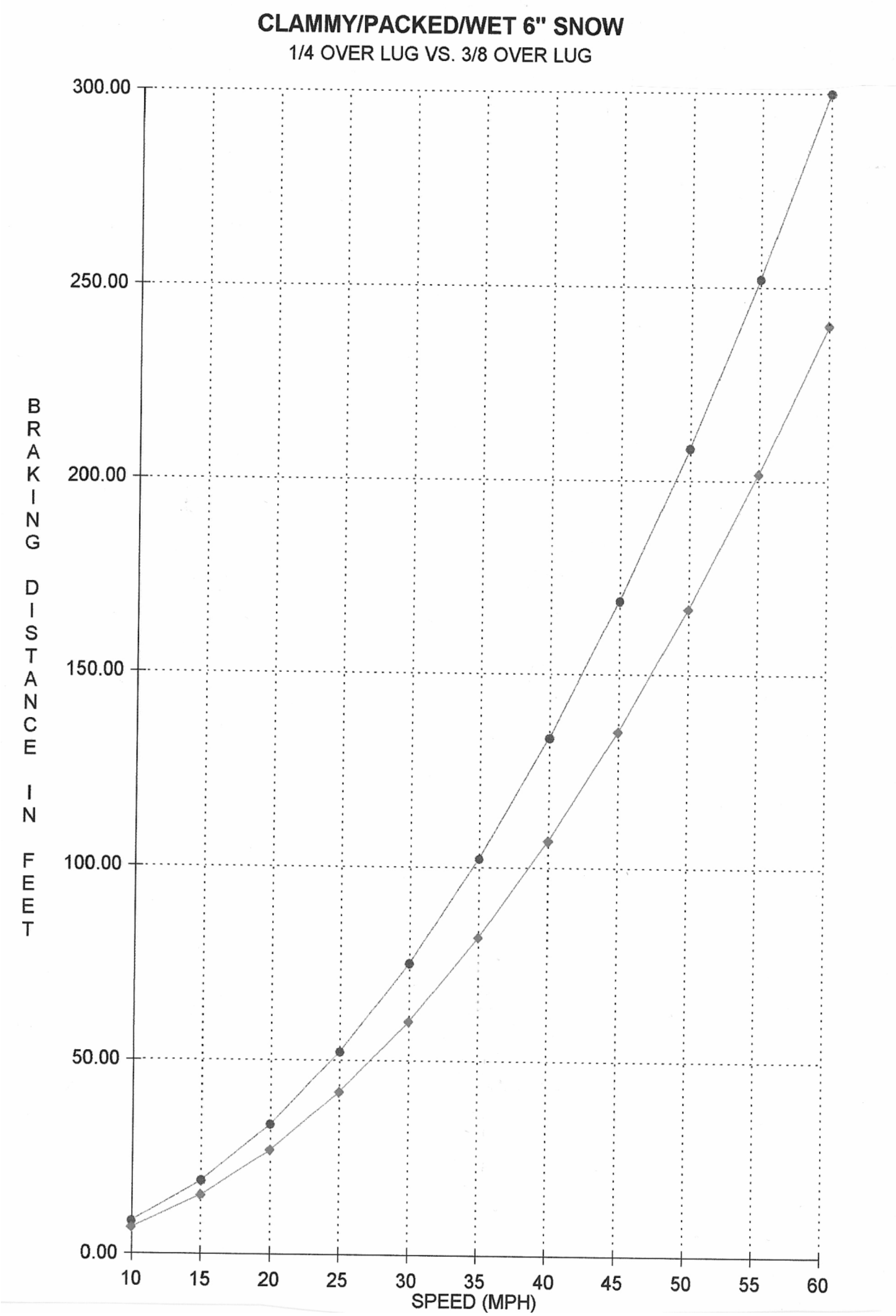
Due to error factoring, and the range of expected results from the testing methodology, this graph represents basically the same acceleration curve.

To round out the non-ice testing, the following set of graphs with their associated conditions were generated from the test data.

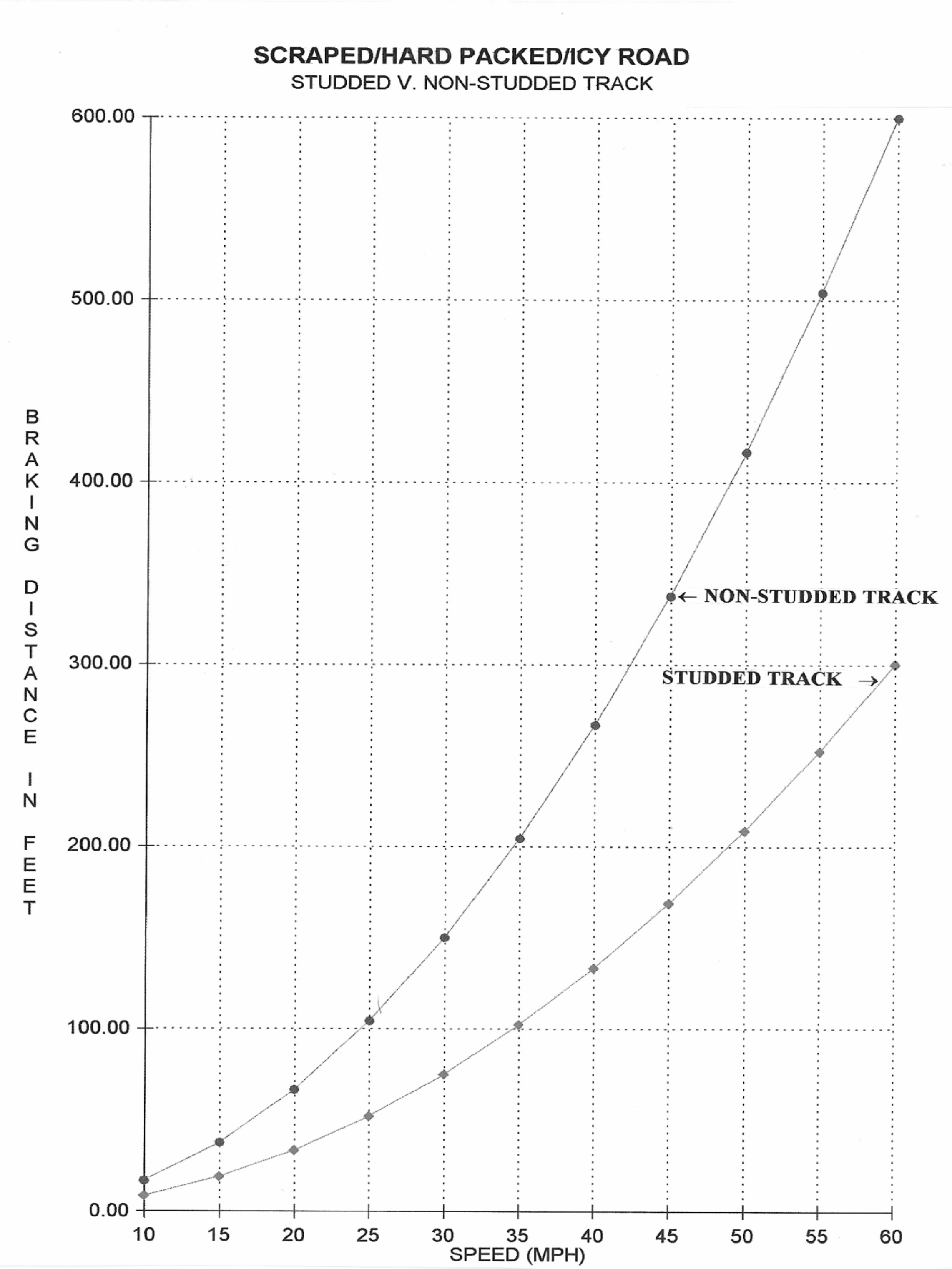
TEST MACHINES: STOCK 1997 500CC
2 CYLINDER
LIQUID COOLED
STUD SET-UP: 144 .875'S



Due to error factoring, and the range of expected results from the testing methodology, this graph represents basically the same acceleration curve.


CLAMMY/PACKED/WET 6" SNOW
1/4 OVER LUG VS. 3/8 OVER LUG
BRAKING DISTANCE IN FEET
300.00
250.00
200.00
150.00
100.00
50.00
0.00
10
15
20
25
30
35
40
45
50
55
60
SPEED (MPH)

TEST MACHINES: STOCK 1997 500CC
2 CYLINDER
LIQUID COOLED
STUD SET-UP: 144 .875'S



Due to error factoring, and the range of expected results from the testing methodology, this graph represents basically the same acceleration curve.

TESTING ON ICE

As expected, the testing showed that the main effectiveness in enhancement to overall snowmobile safety generated by properly designed and installed traction products occurs on icy surfaces. For this reason, an elevated focus was generated with regard to analyzing the relative turning and stopping ability of snowmobiles equipped with traction products on ice, as opposed to snowmobiles without traction products installed. The ice testing was done on a small lake located in Whiteport, New York.

Three similar type machines were used with the only track set up difference being one machine having traction studs extending over the track lug 1/8", the next machine having traction studs extending over the track lug 1/4" and the third machine having traction studs extending over the track lug 3/8". The first tests were done with a fourth snowmobile that had no traction studs at all and the available friction was simply not enough to trip the accelerometer on the unit utilized. In essence, friction of .05 is utilized for a non studded snowmobile track sliding over ice. This obviously can vary somewhat due to temperature and actual condition of the ice.

The three test machines were originally equipped with 192 picks and a series of skid tests were performed. Picks were then removed in 16 pick increments down to a total of 96 picks. The following table shows the average deceleration factors that were generated under these conditions.

LAKE ICE FRICTION TABLE

NUMBER OF PICKS	EXTENSION OVER LUG			AVERAGE
	1/8"	**1/4"**	**3/8"**	
192	.36	.45	.39	.4
176	.32	.43	.39	.38
160	.3	.44	.4	.38
144	.32	.42	.38	.37
128	.29	.4	.4	.36
112	.27	.4	.38	.35
96	.24	.32	.37	.31

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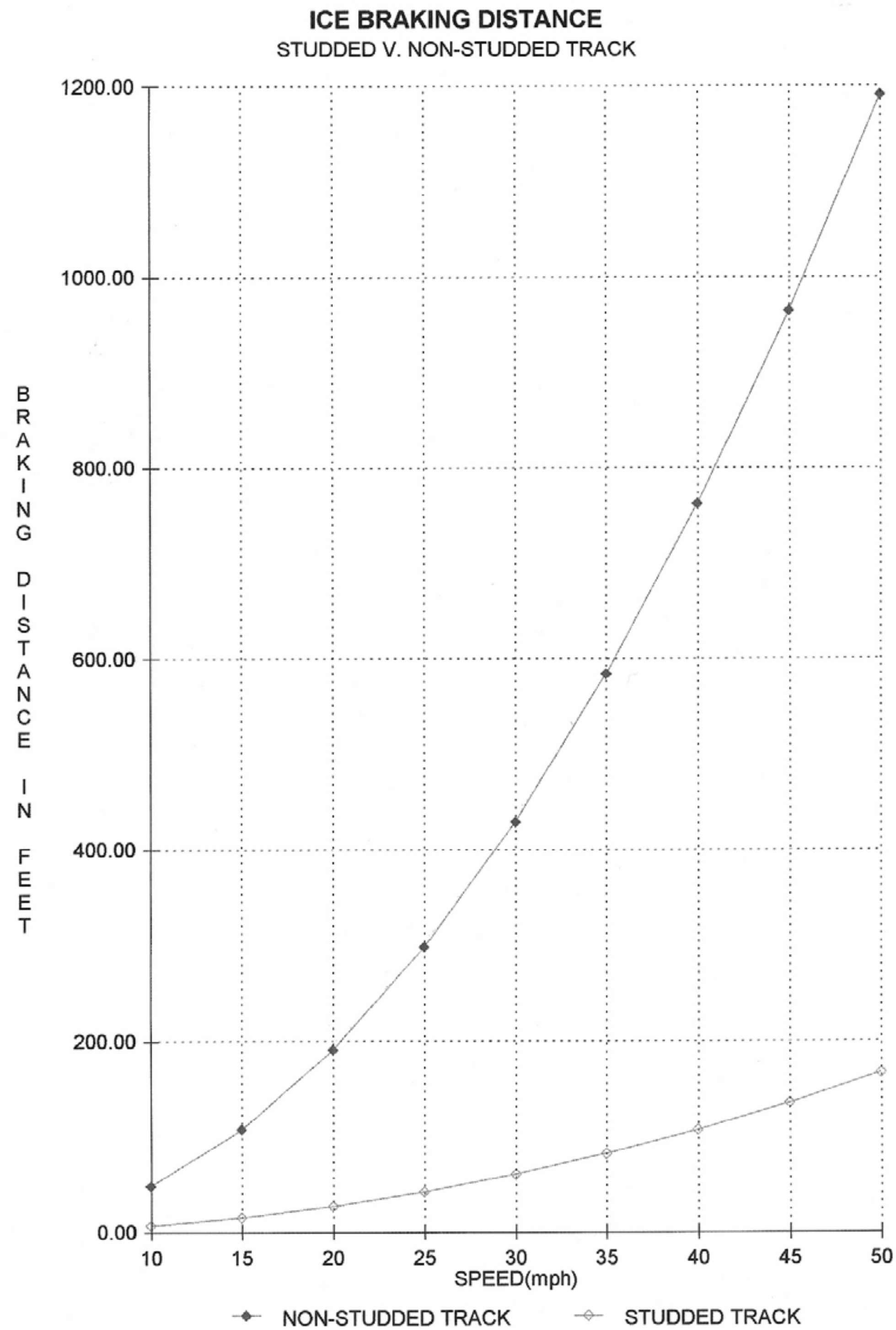
The range of these results show the lowest deceleration factor with 96 picks extending 1/8" over the track lug whereby a deceleration factor of .24 was generated. The highest deceleration factor was gained with the 192 pick set up with the studs extending 1/4" over the lug. It is interesting to note that the 1/4" over lug values appear to be somewhat higher than the 3/8" over the lug values. However, these results are for all practical purposes fairly consistent. It is most likely that the 3/8" over the lug picks began to exceed the available integrity of the ice as well as the fact that the longer picks have a little more leverage and allow for more rearward bending on the stud and track relative to the vertical. The effect of the floating also has to be considered. It is, however, interesting to note that under all circumstances, reducing the number of picks did reduce the effective deceleration factor. The following photographs illustrate some of the marks that were generated in the ice surface during this testing:

Even with the error factoring range, the effect of a studded track here is significant in terms of stopping ability.

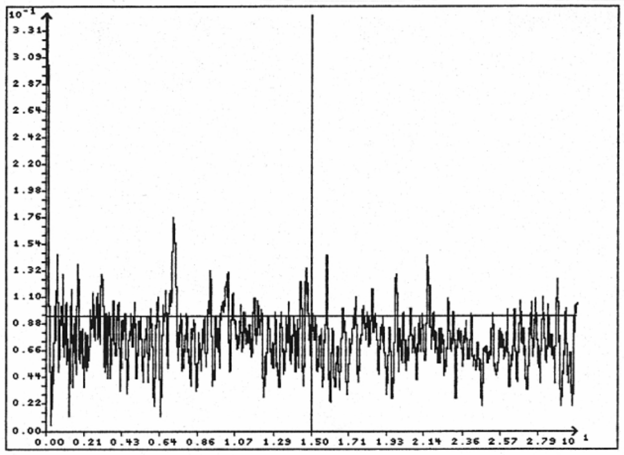
TEST MACHINES: STOCK 1997 500CC
2 CYLINDER
LIQUID COOLED
STUD SET-UP: 144 .875'S



STEERING & TURNING ABILITY

The steering and turning ability of the machines with and without the carbides were then tested. Basically, with no carbides or wear rods, the skis would just turn all the way to the side and the snowmobile would simply go straight creating the maximum slip angle based on the maximum available steering angle. In essence, the slip angle was equal to the maximum steering angle. The results of this are obvious, and a lot of time and effort was not spent on getting complete scientific documentation of this. However, we did feel it was important to take a sled with pretty well worn out wear rods and do some lateral tests with this machine as opposed to a machine that had good carbides. The first set of tests were done on a skid pad that we generated out on the lake which had a 30' radius as illustrated by the following photographs:

Using the sled with the wear rods in poor condition, we were able to sustain approximately 6 mph on this skid pad. Utilizing the sled with the carbides, we were able to sustain 16 mph. The following graphs illustrate the lateral G-forces attained in the lateral skid pad type testing.



COORDINATE

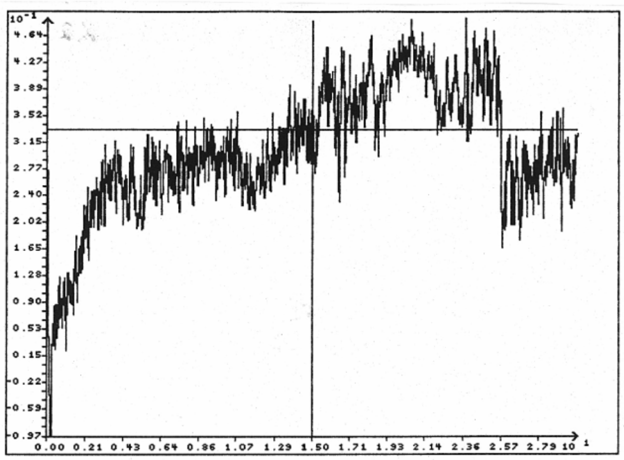
X Axis: TIME = 15.010 SEC

Y Axis: G = 0.095 G

********** PRIMARY RUN **********

Vehicle: L17 Location: WHITEPORT, NY Date: 1/20/97 Run: 8
Run Length: 40.00 Sec. Weight: 745.0 LBS Cal Factor: 1.000
Smooth Factor: 0 Altitude: 0 FT Temp: 28 F Drag: 0 LBS
Wind: 0 MPH FlatPlate: 0.0 Sq FT

NOTES: SKID CIRCLE/30FT RADIUS/MAX SUSTAINED SPEED 6MPH/BAD WEAR RODS/96 PICKS .25 OVER LUG/175LB RIDER/LAKE ICE



COORDINATE

X Axis: TIME = 15.010 SEC

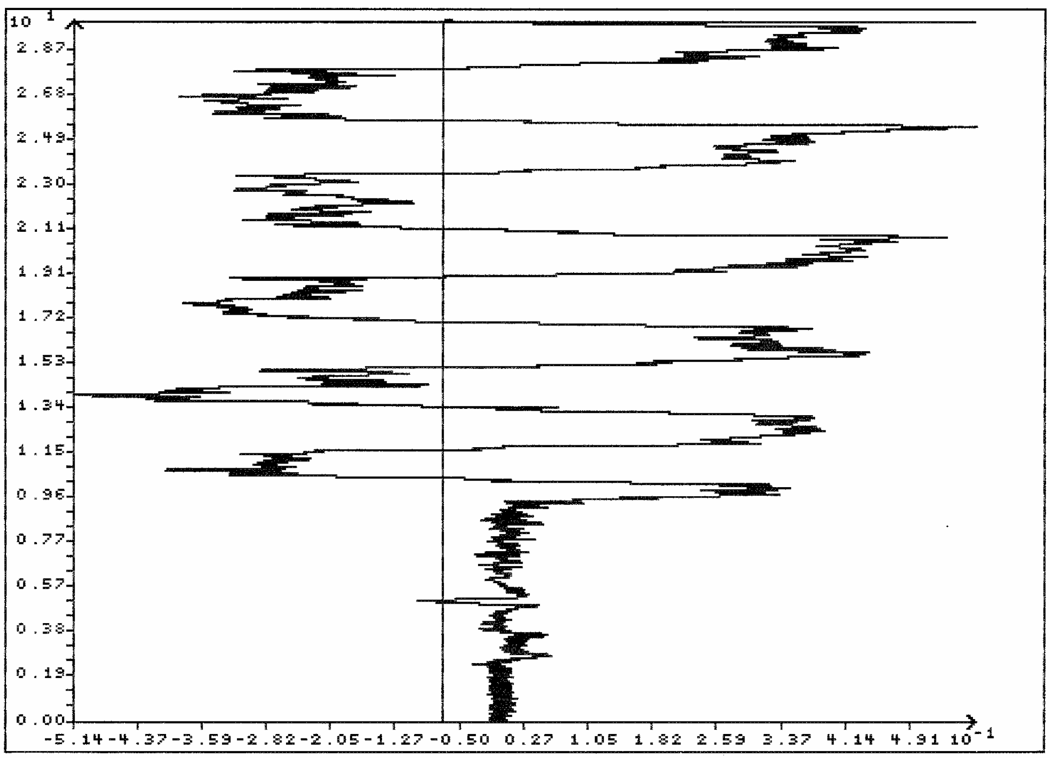
Y Axis: G = 0.333 G

********** PRIMARY RUN **********

Vehicle: L2 Location: WHITEPORT, NY Date: 1/20/97 Run: 1
Run Length: 30.00 Sec. Weight: 745.0 LBS Cal Factor: 1.000
Smooth Factor: 0 Altitude: 0 FT Temp: 28 F Drag: 0 LBS
Wind: 0 MPH FlatPlate: 0.0 Sq FT

NOTES: LATERAL WITH GOOD CARBIDES ON LAKE

The next set of tests were conducted in a lateral serpentine method whereby we simply steered the machine to maximum with the decelerometer in continuous G mode. The following graphs illustrate the G-forces that we were able to generate with the carbided machine. The machine with no wear rods or carbides did not handle well enough to register appropriately in the serpentine motion. Hence, it is clear that any machine without a reasonable balance of properly designed and installed carbides and traction products is not safe. Furthermore, a machine not utilizing both carbides and studs, on an icy surface, creates a very hazardous situation.



COORDINATE

X Axis: G = -0.070 G

Y Axis: TIME = 30.000 SEC

********** PRIMARY RUN **********

Vehicle: L13 Location: WHITEPORT, NY Date: 1/20/97 Run:
Run Length: 40.29 Sec. Weight: 745.0 LBS Cal Factor: 1.000
Smooth Factor: 0 Altitude: 0 FT Temp: 28 F Drag
Wind: 0 MPH FlatPlate: 0.0 Sq FT

NOTES: LATERAL SERPENTINE/CONTINUOUS G-MODE/GOOD WEAR ROADS/

PHOTOGRAPHIC ILLUSTRATIONS

During the skid pad test, photographs were taken of the front skis of the machines as they were in the process of turning. As is readily seen, the red snowmobile, as it is turning, is digging into the ice and kicking out a large ice spray readily seen down by the left ski. However, the machine that does not have the carbides on it, is not kicking out any snow spray at all. This is a good graphic illustration of the additional turning grip ability available with carbides.


FORMULA 500
ski-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