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Real-Time Continuous Friction Measurement has Arrived

by
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In 1996, an observer predicted: "Within our lifetimes, 'intelligent highways' will provide drivers real-time information on roadway service conditions (e.g. the coefficient of friction) and allow public works managers to understand exactly how long it takes to restore bare pavement operating conditions with the safety and mobility benefits they confer." Just nine years later, that lifetime wait is over. Real time friction measurement is here. Its advent is sooner than expected; its portent, all that we could have expected.

Friction has been used to measure road surface conditions for as long as there have been roads. Who hasn't slid their foot tentatively over the road surface to check on just how slippery conditions really are? Or gently touched their brakes to see if there is a negative reaction? How else can a driver determine if there is ice, particularly black ice, on the road surface?

For years, airports have used friction measurement to determine whether or not the runway surface is in an acceptable condition for landing an aircraft. Roadway maintenance gurus have long hoped to adapt these systems for use on snowplows in winter conditions, but they found them too delicate to cope with this hostile under-truck environment. These friction measuring instruments were also cost-prohibitive. Most required a dedicated vehicle and a technician to operate — and they obtained their friction measure by spraying water on the road surface to get the result – not very useful in sub-freezing temperatures. Other friction-testing equipment required a driver to put his vehicle into a (hopefully-controlled) skid to obtain a measurement – a risky proposition. Winter maintenance engineers remained convinced of the theoretical advantages of using friction measures to improve winter roadway operations, but technology lagged their vision.

Thinking outside the box

A decade ago, an "outside" technology emerged that looks like it may provide what winter maintenance professionals have been looking for. Automobile racecars, unsurprisingly, need to know that fine line between a champion's ability to tune the car to minimize drag but still keep the vehicle on the track at high speeds: the opposite of flying – you want to optimize speed without getting airborne. Racecar engineers had been relying primarily on "seat of the pants" judgments about how the car is handling. Enter well-known racecar design engineer Don Halliday who'd worked at every level up to and including the Indy 500. Halliday identified a more analytical way of measuring grip and, in 1995, patented a device which measures grip on all four corners of a vehicle. The device has been used successfully in Indycar, CART and NASCAR racecars. It's been adopted by a major tire company for tire development. It provides a continuous fingerprint of the friction between tire and track surface. The technology was established for racecars.

Four years ago, Keith Swearingen, Administrator of the Ohio DOT Office of Maintenance Management, asked Halliday to design a friction-measuring device for plow/spreader vehicles. It had to be rugged, reliable and give repeatable data. Originally, the friction readings were to be provided to the operator via an in-cab display with easy-to-interpret green, yellow and red LED lights: green indicating good surface conditions, yellow indicating more slippery conditions and red lights warning of dangerous driving conditions, i.e. ice. More lights – less friction. The data would be stored for later analysis.

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RGT In Cab Display

Halliday's race technology evolved into a tough, corrosion-resistant prototype Roadway Grip Tester (RGT) using a ThomTech data acquisition system to record the friction capability of road surfaces in any condition: wet/ dry; or at any stage of plow and deicing operations. It also records ambient air temperature and road surface temperature, as well as other variables. The RGT meter measures friction using a fifth wheel permanently locked at a fixed angle of 1 or 2 degrees to the line of travel and quantifying the friction resistance of that tire.

The design creates very little mechanical friction in the load measurement direction and thus has very good electro/mechanical side force resolution with very low drag. No water is needed, no braking required, and data is available continuously and at any speed. The prototype proved so effective that Ohio DOT installed it on units during the 2003/2004 winter. The next summer, Ohio DOT added a

Typical Undertruck RGT installation

Washington undertruck RGT

tow-hitch version of the RGT for use on supervisors' vehicles. Other snowfighting agencies have also refined the application. The special challenge in Wyoming is snow being blown over the road surfaces creating intermittently dangerous road conditions. The 'Snow Blowing Group' set the RGT wheel as close as practicable to that of a standard wheel track so that they can determine the net effectiveness of their treatment process in the wheel track.

Wyoming Truck with RGT Tow Hitch model – left

Converting this technology into a valuable management tool began only last winter when Ohio DOT began the process of incorporating friction into its winter maintenance strategy. ThomTech set up a customized web site to display real time continuous friction measurement for each vehicle. The following "grip maps" are snapshots of the ring road around Columbus, Ohio during a 2005 winter event. They indicate how conditions changed during three consecutive hours. The maps illustrate just how quickly changes in friction level occur and how *localized* these changes can be. With this detailed real-time information, managers can deploy their trucks more effectively ensuring they are at the right place at the right time. The next step is to disseminate that information on the Internet for public as well as agency use. Washington DOT has the same vision and has placed the RGTs on snowplows in the Snoqualmie Pass. The friction data will be displayed on the state public web page, to enhance the description of conditions on the Snoqualmie pass.

Using friction data for snowfighting operations

A major concern for winter maintenance organizations is the volume of materials they use, both because of expense and because of the potential negative impacts on the environment and infrastructure. Lacking real time data on roadway surface conditions — operators err on the side of caution by applying more product than necessary, for longer than necessary – the philosophy being "more is better." They are rightly concerned that they do not move on to another section of road leaving behind dangerous conditions on their patch. Friction data give the operator a means to determine when to start the application, how much is required and when to stop and move on. Friction data do not replace operator judgment, but inform and enhance an operator's good sense and experience. With very little training, operators using friction data begin to moderate the volume of product used, and feel comfortable moving to another lane when green conditions are indicated.

The Alberta Department of Infrastructure and Transportation contracts out its winter maintenance service and has been exploring ways of monitoring the performance of their contractors:

"Grip Maps" of 270 ring road around Columbus Ohio demonstrate changing road surface conditions.

Columbus Ohio 3/1/05 4-5pm

Columbus Ohio 3/1/05 5-6 pm

Columbus Ohio 3/1/05 6-7pm

to have a measurement of how effective its programs are and whether the province is getting value for money. They intend to use friction measurement to hold their contractors accountable. Friction measurement will provide an analytical way of determining when roads are returned to a "green" (i.e. safer) driving condition, and in what period of time. Friction data can also be used to study the phenomenon of 'chemical slipperiness' that occurs with some products, e.g. mag chloride, which react to elevated temperatures by becoming more slippery.

As a winter maintenance manager – if you ponder any of the following questions- friction data can certainly help achieve the answer.

- How can we indicate changing road conditions to the public?
- Are our plows always in the right place at the right time?
- How effective has anti-icing been?
- How can I optimize the use of equipment and personnel?
- Do my operators know when to start and stop applying product and how much to use for the circumstances?
- Are we using the most effective product for the conditions?
- How can I help inexperienced operators do a good job?
- How can I offer the best possible service to my boss – the voting public?

The primary goal of every winter maintenance organization is to return the roads to safe, drivable conditions in the shortest possible time, thereby reducing accidents. RWIS has allowed managers to be more informed about guesstimations that they make with regard to when and whether to deploy plows. The variation in road friction conditions is very complex and is dependent on many inputs, some of which include:

- Ambient weather conditions including effects of wind
- Temperature of road surface
- Traffic frequency and type (commercial /passenger)
- Traffic direction
- Lane use frequency
- Road surface type
- Winter event treatment type and concentration
- Treatment frequency
- Local effects like shadows on surfaces
- Geography i.e. bridge surfaces

Only continuous real-time friction data, however, can draw a picture of what the customer will be experiencing on that road, at that time and at that place, allowing managers to optimize the use of equipment, materials and personnel.

Lights	HFN
1	114
2	109
3	104
4	98
5	93
6	88
7	83
8	79
9	75
10	72
11	70
12	67
13	64
14	61
15	59
16	57
17	56
18	54
19	53
20	52
21	50
22	47
23	45
24	41
25	37
26	33
27	30
28	26
29	22
30	19

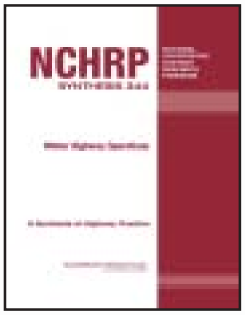
Real-Time Continuous Friction Measurement *(continued from page 3)*

Like many new areas, friction measurement is challenged by a lack of standards. The ASTM standard records variations in friction numbers depending on vehicle speed and runway-like testing using sprayed liquids is inappropriate. Halliday developed the Halliday Friction Number (HFN) scale using an intuitive slipperiness reference. This scale creates a linear relationship between force change on the RGT wheel and the HFN. Arbitrarily, for comparative measurement, the value 100HFN was assigned to represent the friction reading generated on a good smooth, dry, tarmac road at 38ºF. By comparison, a smooth ice rink surface generates an HFN of 15. Powder snow on clean tarmac without ice generates an HFN of 52. The RGT display uses 30 LED lights of three different colors. The graduation between the three colors has been intuitively set at green to yellow at 70HFN and from yellow to red at 50HFN. All lights are on when the HFN is 19 or below.

The use of friction as a management tool depends on choosing a replicable metric that all parties agree in advance represents an accurate reading of roadway surface friction.

Snowfighter trainers: If your responsibilities include training snow & ice personnel, you should be aware of two new electronic discussion groups of trainers, dedicated to sharing information among trainers about techniques, resources and other questions to improve your effectiveness. The U.S. group is hosted by the University of New Hampshire on behalf of the National LTAP Association; e-mail WinOps.Trainers-request@lists.unh.edu. In Canada, the Transportation Association of Canada is the host; contact Diane Jodouin at DJodouin@tac-atc.ca

Important new NCHRP reports published: The National Cooperative Highway Research Program (NCHRP) has just published two new reports of special interest to snowfighters: *NCHRP Synthesis 344: Winter Highway Operations* (online at http://trb.org/publications/nchrp/nchrp_syn_344.pdf and *NCHRP Report 526: Snow and Ice Control: Guidelines for Materials and Methods* (online at http://gulliver.trb.org/publications/nchrp/nchrp_rpt_526.pdf). *Report 526* was previewed in our Summer 2004 *Salt and Highway Deicing* newsletter.



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You just enjoyed another electronic *Salt and Highway Deicing* Newsletter! It helps you make better decisions in your winter maintenance responsibilities and gives even more information by active links to www.saltinstitute.org <http://www.saltinstitute.org> with specific pages to further snowfighter information. Feel free to forward this newsletter to other interested persons so they can also enjoy this informative free quarterly. Be aware Salt Institute never sells or distributes any of your contact information to any outside source. Please sign up at: http://www.saltinstitute.org/subscribe/index.html