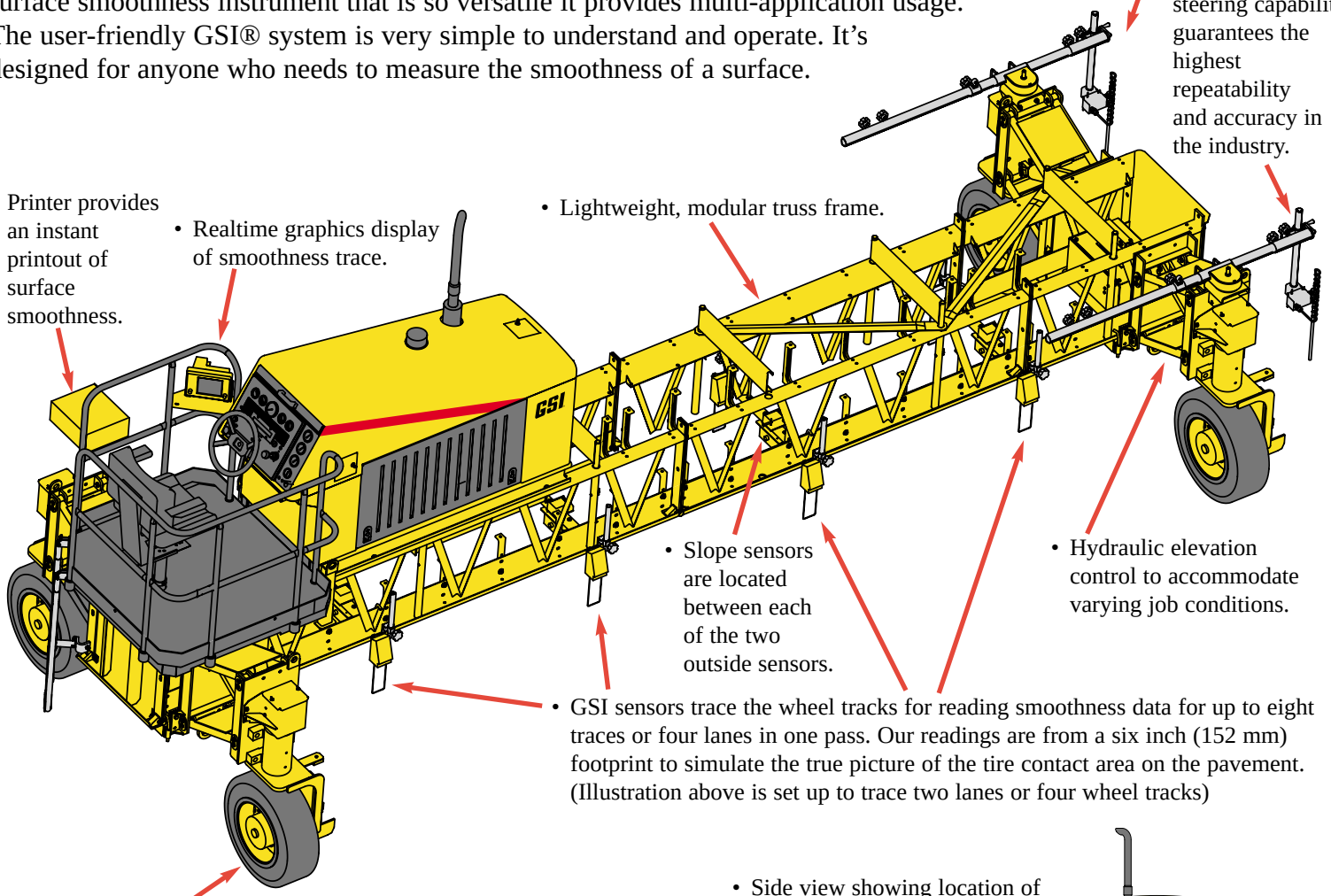
GSI® GOMACO SMOOTHNESS INDICATOR

ASAP Smoothness Readings

As Soon As Paved - We're giving a new meaning to ASAP

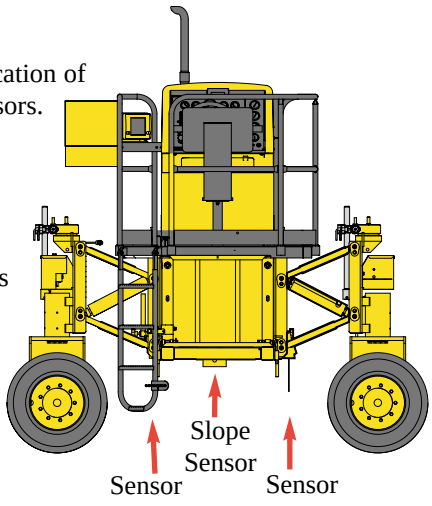
The revolutionary GOMACO Smoothness Indicator is the first in the industry to provide smoothness readings for both wet or cured concrete and asphalt slabs. It's a non-contact surface smoothness instrument that is so versatile it provides multi-application usage. The user-friendly GSI® system is very simple to understand and operate. It's designed for anyone who needs to measure the smoothness of a surface.



- Steering sensors, automated steering capability guarantees the highest repeatability and accuracy in the industry.
- Printer provides an instant printout of surface smoothness.
- Realtime graphics display of smoothness trace.
- Lightweight, modular truss frame.
- Slope sensors are located between each of the two outside sensors.
- Hydraulic elevation control to accommodate varying job conditions.
- GSI sensors trace the wheel tracks for reading smoothness data for up to eight traces or four lanes in one pass. Our readings are from a six inch (152 mm) footprint to simulate the true picture of the tire contact area on the pavement. (Illustration above is set up to trace two lanes or four wheel tracks)
- Heavy-duty, industrial puncture-proof solid tires.

This GSI traces four wheel tracks, providing accurate data for the smoothness readings on this two-lane street.

- Side view showing location of the three different sensors.
- The GSI takes smoothness readings simultaneously from three different sensors on each trace and uses the data taken at that instant in time to establish a measurement of the slab.



GOMACO's Non-Contact Profile Device – The GSI®

A GOMACO World interview with Kevin Klein, research and development manager, and Mark Brenner, research and development controls design engineer

EG-110304 D16

Both sonic and slope sensors mounted to the GSI's frame take readings simultaneously to determine pavement smoothness.

What is the GOMACO Smoothness Indicator (GSI)?

Klein: It's a non-contact profile device which can be used to develop profilographs for several different types of road surfaces. Actually, there are several ways to use it, some that we don't even know about right now.

How do you set up and operate the GSI?

Klein: Every step of the way we've tried to make it easy to operate and user friendly. Most of the technology is in the software. All of the machine components are "off the shelf items," but the software is unique. As far as set up, at the beginning of the project, the sensors and components have to be mounted onto the GSI machine or on the paver itself. It's not necessary to have the GSI printer on board at all times because you can collect data and print it out at a later time. There are a couple of calibration steps that need to be done for initial setup to calibrate the encoders or the pulse pickups in the motors. This calibrates the distance measuring devices that are on the machine. You drive the machine a known distance and then enter that distance into the GSI computer.

Brenner: You push start on the touch screen, run your machine the specified distance, stop, and then enter the exact length that you traveled. The distance traveled doesn't matter. If you went 105 feet (32 m) and overshot your 100 feet (30.5 m) line, you don't have to start over. You simply type in 105 feet (32 m) and it will calibrate to that measurement.

Klein: The next thing in setup is to enter the job-site information into the computer: highway number, direction of travel, job, contractor, city, state, etc. Then you're ready to run.

How do the sensors know where they are on the frame and what they're measuring? Do they refer back to the left wheel track?

Brenner: Actually the sensors don't need to know, the GSI computer needs to know where the sensors are located in relationship to the wheels on each end of the frame. You have to input a measurement that is the distance between the two wheels because there's an encoder or PPU mounted at each end on the wheel. You then input distance measurements for each set of instruments from your left wheel. The GSI computer then knows where each sensor is, based on these recorded measurements. For example on a radius... the sensor on the inside radius will have a shorter distance of travel than the one on the outside radius. It all refers back to the left wheel track.

Are you measuring the slab in the wheel path all the time?

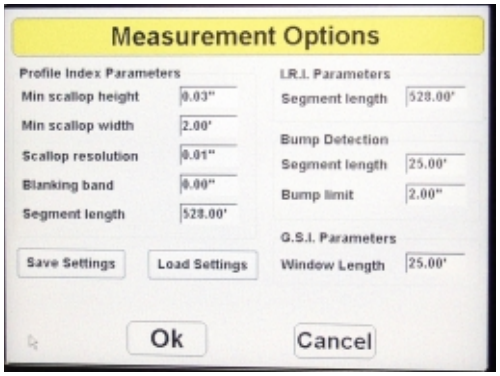
Klein: No, sometimes specifications call for quarter traces, but to our understanding, measuring the wheel trace is the most common. It all depends on the state's specifications.

What is the minimum amount of equipment involved?

Klein: To do a single trace, you would need what we are considering a single trace GSI unit. The unit includes the GSI computer,

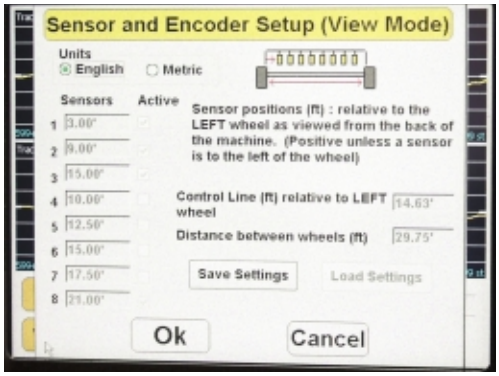
EG-010410 D8

Part of calibrating the system is entering job-site information into the GSI's computer.



EG-010410 D10

The GSI provides ride numbers for three different indexes with this set-up screen.



EG-010410 D2

Sensor positioning has to be measured out so the GSI computer knows what it's measuring.

two sonic sensors, a slope sensor, and all the mounting hardware and cables. If you are mounting on a paver, you're also going to need two encoders, one for each side.
Brenner: There's also a CAN Gateway.
Klein: In fact, on the GSI machine, there are actually two CAN Networks, one for the GSI and one for the machine control. They're both on the same machine, but they don't communicate with each other.

Can it be mounted to an ATV?
Klein: Correct, assuming that you can get the ATV to travel at steady speeds less than 80 fpm (24.4 mpm).

What kind of reports can you output from the information you collect from the GSI?
Brenner: There are three indexes being calculated continually as the machine collects data. The GSI index, PI or profile index, which is based on the California profilograph and the IRI (International Roughness Index). You can also export an .erd file, which is currently used for IRI traces.
Klein: They are all derived from the true profile of the surface, determined by the data we are collecting. Those three happen all the time, the way the system is set up now.
Brenner: External of the system, we can export the file and use it to analyze all other types of indexes off the true profile. If you can create a true profile, you can create any index required.

How do you identify where your bumps are located?
Klein: Both through the printed report or by calling up the run on the GSI computer monitor. Each shows the measured distance and where exactly the bump is located.

Is there any way to alter the data to take out a bump?

EG-090303 D12

GOMACO's GSI is designed for anyone who needs to measure the smoothness of a surface.

Klein: It's almost impossible. We're taking measurements every two inches (51 mm), even though we're getting readings 40 times per second, as the machine indexes forward. We're collecting large amounts of data to develop this profile. I don't think there's any way that the data could be altered. There are too many things that are related to the job site to accomplish that.

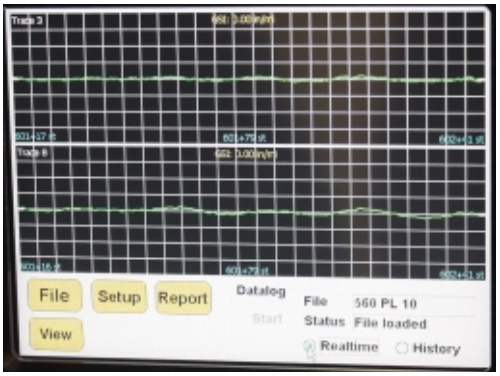
Is there an on-the-go bump alarm?
Klein: Yes, right now, a screen comes up with a warning window that says "bump" and you can go from there to look at where the bump is. We have an output for an external component like a buzzer or a light that we can drive from the computer.
Brenner: There are three bump alarm options. One is the external output, one is a pop-up screen and the other is an external warning without the window popping up on the computer screen.

After you've fixed your bump and re-run your GSI over that area again, does it make a separate script so you can see the improvements you've made?
Brenner: It saves over the file that you've just previously done.
Klein: We're developing a way to store that original bump data someplace else. Right now, if the machine moves forward, it counts so many feet. It knows and keeps track of the distance it's traveled. If it starts backing up, it starts deducting from that number.

Has the GSI been tested for accuracy?
Brenner: We've tested against proven manual profilograph machines that are out there. We have good output or graphs compared to those machines that are qualified by different states. We also had very good repeatability.

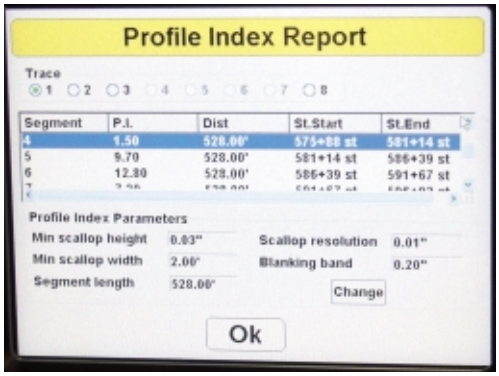
How do you justify the expense of the GSI to a contractor?
Klein: First of all, if it helps him improve his process where he can avoid expensive grinding, I think that's probably going to be a big selling feature or reason to buy. There are also the other applications the GSI makes possible to help his operation: reading the grade ahead of the paver, checking the stringline setup, checking the ride... We also had discussions about being able to develop or determine the volume of concrete it's going to take to do the job based on the grade that is already in place. It's a big issue for subcontractors where the prime contractor is getting the grade ready. If the subcontractor comes in and paves it and the prime has undercut the grade, it costs more for the concrete. We could develop a program where they'd be able to do a run first with the GSI machine, read the grade, and be able to determine what volume of concrete it will take to bring it up to the right elevation for the slab. They could then go to the prime and say the GSI is showing a 10 percent overrun and be able to ask the prime if they want to fix the grade or go ahead and pave. They could make that decision from information supplied by the GSI.

What does the future hold for the GSI? Do you see every mainline paving contractor owning one?
Klein: Absolutely. Not only is the market



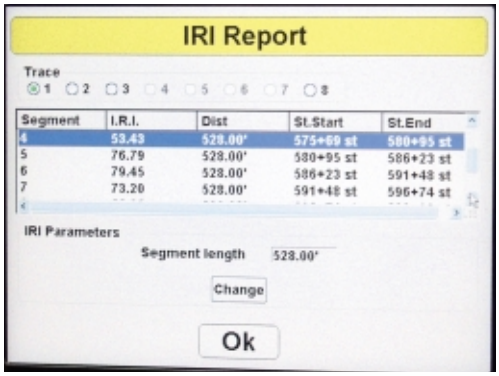
EG-010410 D13

Two different sensor traces can be displayed on the computer's screen at a time.



EG-010410 D11

A trace shows how this section of roadway did using the two-tenths blanking band.



EG-010410 D12

This stretch of roadway posted some good numbers on the IRI index.

going to be targeted towards contractors, but there are a lot of other possibilities out there. There are engineering firms, Department of Transportations, Federal highway authorities, and others. We are anxious for the GSI to be certified for accuracy by the states. We believe that the GSI index could become a norm. Instead of having to convert all the information to a California profilograph or an IRI, it's a possibility that the GSI index would be all that's necessary. I think the GSI's future is looking bright with its non-contact versatility.

The GSI is very versatile. It's not just limited to concrete paving.
Klein: Exactly. You can read asphalt slabs, flooring, the stringline, you can read the grade, the pavement behind the paver, behind the finishers, behind the texture/cure machine, two days later... I still believe it's going to teach us a lot about different mix designs for concrete paving and how those mix designs cure and what their curing process does to the ride. It may be a great ride coming out of the paver, but two days later after it's all cured out, there might be bumps showing up because of the way that concrete cured. There may be some concrete mix designs that cure more favorably than others.

Is the accuracy of the machine affected by the fact that it runs on the grade and not on the finished slab?
Klein: The machine is designed to run on any surface, within reason. You can't travel over two foot (0.6 m) rocks or extreme grades. It will give you a trace without worrying about what the machine frame is doing. That was one of the goals or parameters that we set from the very beginning. We had to be able to get this trace with the GSI independent of what the machine was running over. We knew from the very beginning that we had to develop something that would measure everything electronically and establish an imaginary baseline through the software.

Brenner: The machine can go over a fairly rough terrain without interfering with the data that the GSI collects from the slab. The variations in the frame during travel are eliminated in the software by the "two sonic sensor and a slope sensor" unit.

So far, you've worked with a couple of contractors. What have their reactions been so far?
Klein: I think they'd say they're excited about the future possibilities and they're definitely very interested in the concept. They're intrigued by the non-contact concept and the time savings by doing up to eight traces in a single pass.

EG-110303 D31

The GSI measures pavement smoothness behind the texture/cure machine on a project near Onawa, Iowa.

The GSI's on-board printer instantly verifies the smoothness of the concrete.

EG-010408 D26

GSI® – In Testing and In the Field

EG-040402 D6

The GOMACO Smoothness Indicator (GSI) was one of 68 road profilers that took part in the Federal Highway Administration's "Profiler Round-Up" study in April. The profilers were tested on two separate tracks in Blacksburg, Virginia, and Newville, Pennsylvania. The study, which was performed by the University of Michigan Transportation Institute, will compare the different types of profilers to help improve methods for verifying their results.

The GSI is unique to other profilers with its ability to measure the smoothness of both wet or cured concrete slabs. It can be mounted to either the back of the paver or the GSI framework and can record up to eight traces per pass. Any irregularities in the slab are identified, their location recorded by a distance tracking encoder, and contractors can then repair the concrete surface while it's still in the plastic state.

In the photo to the right, a GSI is mounted to the back of a GP-2600, in the center of the paver, slipforming on an airport project in Cherokee, Iowa.

HW-050412 D23

The GSI monitor was positioned on this paver for easy viewing of the smoothness trace from ground level or from the work bridge.

EG-040404 D18

The GSI took part in the Federal Highway Administration's "Profiler Round-Up" in April. Sixty-eight road profilers were compared and verified on two different test tracks, one in Blacksburg, Virginia (top left), and the other in Newville, Pennsylvania (top right).

HW-050412 D6

Here, the GSI is mounted to the back of a GP-2600 and in the center of the paver. However, the monitor can be mounted anywhere on the paver for easy viewing.

EG-060301 D22

HW-080403 D9

The GSI can operate off the same stringline as the paver. Here it is measuring smoothness directly behind the finishers.

EG-060310 D14

GOMACO's portable GSI package is available for mounting on an ATV or job-site vehicle for a single trace of existing slab or checking stringline. Stringline accuracy can be checked with the GSI equipped with paving sensors.

GSI 007

Four GOMACO GSI units are mounted to the back of the paver. This provides immediate monitoring to assure proper paver setup and performance or examine for corrective measures that need to be taken.

EG-020406D2

The GSI was successfully tested for repeatability by steering from stringline. The GSI was taken off line and returned to line for retracing. Similar traces revealed excellent repeatability by the GSI.

HW-070408 D26

A new generation GHP-2800 paves the curve on the Martinsville Speedway in Virginia for NASCAR racing. A GSI follows the paver to check smoothness results.

GSI® GOMACO SMOOTHNESS INDICATOR

GSI Specifications:

- **Engine:** John Deere 4024T Tier II diesel engine, 60 hp (44.8 kW) at 2800 rpm.
- **Frame:** Sectional truss style frame, 24 in. (610 mm) depth.
- **Propel:** Four-wheel drive hydrostatic propel system with rotary steering actuators.
- **Tires:** Solid rubber tires, 28.00 x 9.00 R15 in. (381 mm) wheel.
- **Steering:** All-wheel steer.
  a. Coordinated four-wheel steer (operational & transport mode)
  b. Crab-steer (operational & transport mode)
  c. Front-steer only (operational & transport mode)
  d. Rear-steer only (operational & transport mode)
  e. Counter-rotate (operational mode)
  f. Stringline steer (operational mode)

What is the GSI?

- New and revolutionary GOMACO Smoothness Indicator, a testing device that provides **A**s **S**oon **A**s **P**aved smoothness readings.
- A non-contact surface smoothness instrument that is so versatile it provides multi-application usage.

What can the GSI do?

- Provides immediate data to make on-the-go adjustments, if necessary, to assure maximum smoothness results.
- Gives immediate graphic display to the operator as to smoothness of the surface.
- Locates irregularities in the slab that need to be corrected and records that location through the use of a distance tracking encoder.
- Concrete surface can be repaired while still in the plastic state.
- Can read multiple traces simultaneously with the addition of more instruments.
- Checks smoothness readings of the sub-grade to obtain maximum yields and determines potential smoothness before paving.
- The GSI can be used to check the accuracy of stringline setup before the actual paving takes place.
- The GSI has hydraulic elevation control that accommodates slab heights up to 18 in. (457 mm). Frame height extensions are available for up to 30 in. (762 mm) slab thickness.
- Smoothness readings can be seen before saw cuts are made for joints and tining or the texturing of the slab.
- Data gathered is used to produce commercially known profilograph indexes.
- Printout of surface smoothness includes station or footage reference from starting station, job information, bump location, and profile index numbers.
- Provides the ability to study the smoothness of the slab during the curing process for future research on mix designs.
- The GSI automated steering capability guarantees the highest repeatability and accuracy in the industry.

How is it done?

- The GSI can commence tracing from a stopped position. This allows readings from the header without pre-roll calibration.
- The GSI can stop and start during the tracing operation.
- The GSI is operational in forward or reverse.
- Both sonic and slope sensors are mounted to the machine frame for reading smoothness data of wheel tracks on up to eight traces or four lanes in one pass.
- The GSI takes smoothness readings simultaneously from three different sensors on each trace and uses the data taken at that instant in time to establish a measurement of the slab.
- Can be mounted directly on the back of the paving pan for instant readings of the paved surface.
- Can be mounted on a machine separate from the paver so readings can be taken independent of the paver.
- GOMACO's portable GSI package is available for mounting on an ATV or job-site vehicle for a single trace of existing slab or checking stringline. Stringline accuracy can be checked with the GSI equipped with paving sensors.

Who would want to use the GSI?

- Paving contractors
- Flat floor slab contractors
- Consulting engineering firms
- DOT (Department of Transportation)
- Federal highway authorities
- FAA

HW-060413 D6

The GSI can commence tracing right off the morning header, ahead of the texture/cure machine. If used later, saw-cuts, rain or wetness of slab do not affect readings.

Rideability Comparisons On Same One-Tenth Mile Segment In Wisconsin

The comparison for the profile index reading for both the GOMACO Smoothness Indicator and the California Profilograph reading were nearly identical on this one-tenth mile segment in Wisconsin. The GOMACO Smoothness Indicator reading was 23.5 and the California Profilograph reading was 23.6.

The GOMACO Smoothness Indicator also outputs the IRI (International Roughness Index) number. The standard computerized California Profilograph cannot provide an IRI.

Actual readings from California Profilograph

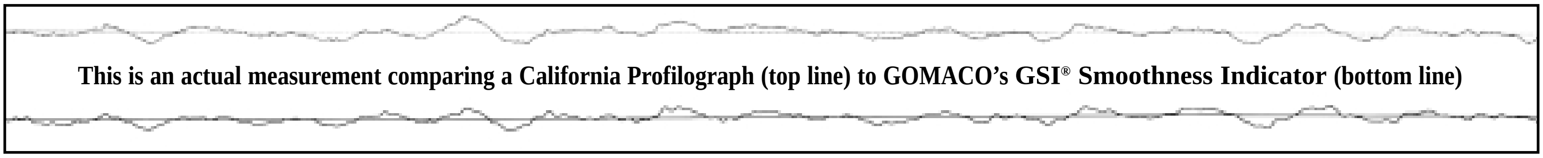
```
ODOMETER(COUNTS/528 FT)        3955
NULL BAND WIDTH(IN)            0.00
BUMP HEIGHT(IN)                0.40
BUMP WIDTH(FT)                25.00
BUMP BOTTOM                     OFF
DATA FILTER HI(CYC/FT)         0.00
DATA FILTER LO(CYC/FT)      8000.00


****REPORT HEADER SUMMARY****

    FROM        TO  DIST    COUNTS      PRI
------------------------------------------
    0+00      5+28 528.0      2.36    23.60
    5+28      5+47  19.0      0.05    13.89

              --------   -------
                 547.0      2.41

        OVERALL PRI(INCHES/MILE) =    23.26
```



This is an actual measurement comparing a California Profilograph (top line) to GOMACO's GSI® Smoothness Indicator (bottom line)

Actual readings from GOMACO's GSI® Smoothness Indicator

```
=========== Profile Index Parameters ==========
Min Scallop Height     0.03"
Min Scallop Width      2.00'
Scallop Resolution:    0.01
Blanking Band:         0.00"
Segment Length:        528.00'
===============================================

================================== Profile Index Report ==================================
Segment              Beginning         Ending            Distance          Profile Index
                     Station           Station

      1              0+19 st           5+46 st           528.00'                 23.50
      2              5+47 st           5+87 st            40.33'                  3.93
Total ------------------------------------------------------------------------------------
      2              0+19 st           5+87 st           568.33'                 13.71
==========================================================================================


================ IRI Parameters ===============
Segment Length:        528.00'
===============================================

====================================== IRI Report ========================================
Segment              Beginning         Ending            Distance                    IRI
                     Station           Station

      1              0+00 st           5+27 st           528.00'                 76.81
      2              5+27 st           6+00 st            72.33'                 72.18
Total ------------------------------------------------------------------------------------
      2              0+00 st           6+00 st           600.33'                 74.49
==========================================================================================


================ Bump Parameters ===============
Bump Limit         0.40"
Segment Length     25.00'
===============================================
```

MANUFACTURED UNDER ONE OR MORE OF THE FOLLOWING U.S. OR FOREIGN PATENTS: 3,299,786; 3,450,011; 3,541,931; 3,779,661; 3,959,977; 4,073,592; 4,136,993; 4,226,917; 4,343,513; 4,360,293; D-266,850; 853,607; 861,819; 954,773; 406,787; 1,147,187; 133,220; D-512,249; 4,717,282; 4,457,645; C-1,110,893; C-1,191,044; 12,890-1-0010; 5,061,115; 7,509,187; 7,509,615; 5,102,267; 5,101,360; 4,954,019; 4,984,639; 5,190,397; 5,209,602; 0,518,535; 2,067,126; 494,257; 69,031,836.7-08; 2,069,516; 5,924,817 AND PATENTS PENDING.

GOMACO Corporation reserves the right to make improvements in design, material, and/or changes in specifications at any time without notice and without incurring any obligation related to such changes. Performance data is based on averages and may vary from machine to machine.

Printed in U.S.A. © 2004 (10 HOG 500) GOMACO Corporation Order #GSI® GOMACO'S Smoothness Indicator

The Worldwide Leader in Concrete Paving Technology

Worldwide Headquarters
GOMACO Corporation
GOMACO International
119 East Highway 175, PO Box 151
Ida Grove, IA USA 51445
Ph: 712-364-3347 Fax: 712.364.3986
International Fax: 712.364.4717
E-mail: info@gomaco.com

GOMACO International Ltd.
769 Buckingham Avenue
Trading Estate, Slough
SL1 4NL Berkshire, England
Ph: 44-1753-821926
Fax: 44.1753.693093

GOMACO International
130 Tanjong Rhu Road
09-01 Pebble Bay
Singapore 436918
Ph: 65-6344-5702
Fax: 65.6344.0621
E-mail: tnash@pacific.net.sg

GOMACO International Australia
19 Eustace Street
Aspley, 4034
Brisbane, Queensland
Australia
Ph: 61-07-3630-5000
Fax: 61.07.3630.5888
E-mail: gomaco@bigpond.com

You can always find us at http://www.gomaco.com/Resources/gsi.html