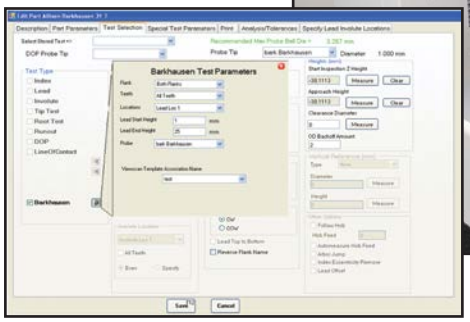
No Compromising on Quality at Allison Transmission

Gleason 350GMS helps put higher quality, more reliable gears into its next-generation TC10 automatic transmission.

In the past, Class 8 tractor operators have been forced to sacrifice vehicle drivability and transmission reliability and performance just to squeeze a few precious extra miles out of a tank of gas. For many, those days are now coming to an end, thanks to Allison Transmission's all-new TC10 automatic transmission, which delivers 5% more fuel economy than their current manual or automated manual tractors. The TC10 also provides smooth, seamless acceleration and the peace of mind that comes with a 5-year, 750,000-mile warranty.



Allison conducts a typical Barkhausen inspection on the Gleason 350GMS, using simple step-by-step programming steps in the familiar *GAMA Windows* environment.

High quality transmission gears produced in Allison's ultra-modern Plant 16 at their Indianapolis, IN global headquarters play a significant role in the TC10 performance story. For example, in the past a finish profile grinding operation after heat treat would have been considered the exception rather than the rule for gears of this type. Now, grinding is a requirement for many of the 20 gears found in this countershaft 10-speed transmission. But with profile grinding comes the potential for grinding burn — the often unpredictable thermal damage that can occur to a hardened gear during grinding. Grinding burn can cause re-tempering and the creation of a softer microstructure that ultimately causes high tensile stresses and a gear that wears prematurely or fails catastrophically—a condition that Allison is keen to detect, but not through the traditional nital etching method.

Making the case for Barkhausen. In the early stages of the TC10 project, Allison Transmission decided to take a different approach to the detection of grinding burn and other surface damage that can result from case hardening and even parts handling – a method that today is paying significant dividends in gear quality and performance, according to Ann Wilkerson, Allison Transmission manufacturing engineer. "While a number of the TC10 ground gears are purchased, we do have one particularly challenging helical gear with very high tolerance requirements that we decided to produce from forgings in-house, including a final finish grinding operation where the potential for grind burn exists," explains Wilkerson. "Neither installing a nital etching line nor outsourcing the gear for nital etching were options from a cost and delivery standpoint, and because of our concerns about the process itself. Fortunately, the Gleason GMS gear inspection solution allows us to perform not only the typical gear checks required in our day-to-day prototyping and production work, but also Barkhausen and surface finish measurement. Through the use of the GMS and Barkhausen, we've had considerable success in refining our grinding and dressing cycles to minimize grind burn — not to mention detecting evidence of grind burn that would not have shown up with nital etching."

A standard Barkhausen inspection on this Allison helical gear consists of two traces per tooth flank, four teeth evenly spaced 90 degrees apart – 16 total traces.

The Barkhausen noise analysis (BNA) method is based on the measurement of a noise-like signal, generated when a magnetic field is applied to a ferromagnetic sample. By applying an alternating magnetic signal to the gear, and essentially magnetizing it, any discontinuity in

the microstructure becomes the source for a noise-like signal that can be detected and measured. James Thomas, applications engineer for American Stress Technologies, a pioneer in the application of Barkhausen technology and supplier of the technology to Gleason, explains it this way: "Barkhausen is very instructive because it provides a relative measurement that changes with varying stress in the material or microstructural variations in the material. We simplify it by expressing the measure with a signal number. With more tensile stress, the number increases; with more compressive stress, it decreases. As microstructure goes softer, the number increases; conversely, the number decreases with a harder microstructure. With grinding/retempering burn, you have a transformed, softer layer of microstructure with a different density than the surrounding material, thus creating high tensile stresses that might be 20 to 50 microns deep. The softened microstructure and high tensile stresses both drive the Barkhausen number we're able to report higher.

"Nital etch allows for detection of transformed microstructure on the surface, but it is insensitive to residual stresses that accompany grinding burn and reach a peak in the sub-surface."

Wilkerson concurs. "Nital etch is 'shades of grey' – you can't know with certainty about damage sub-surface," she says. "Say you've burnt a gear in a roughing pass, then finish ground it. On the surface it might appear OK with nital, but underneath there may be a layer of tempered material. As bad as we intentionally burnt the artifacts (master gears) we used for understanding and setting the high limit BNA number and for comparison to the parts we're producing, they didn't look that bad with nital etch. Barkhausen tells a completely different story."

American Stress Technologies' Rollscan 300 digital Barkhausen noise analyzer and probe are easily integrated into the Gleason 350GMS. End result? All of the necessary gear inspection can be conducted on a single GMS machine, in a single setup, saving time and helping ensure inspection accuracy.

Barkhausen and GMS integration. Today, as Allison Transmission ramps up production of its TC10 transmission, the Gleason 350GMS is tasked with all the inspection requirements of the gears produced by Allison in Plant 16. Equipped with the *GAMA* applications suite of software, the GMS series empowers Allison's operators with the ability to completely inspect gears. *GAMA* puts a host of powerful features right at their fingertips, creating a simple, intuitive human/machine interface. The process of creating a new program, for example, is as easy as point and click, and can be done in just minutes in a few easy steps and regardless of the operator's level of experience, or gear type. Allison's GMS is equipped with a series of scanning probes with various stylus sizes and configurations to meet the requirements of any spur or helical, internal or external gear as large as 350 mm in diameter – all interchangeable with an automatic probe changer.

Gleason and American Stress Technologies have partnered to seamlessly integrate AST's proven Rollscan 300 digital Barkhausen noise analyzer and probe into the GMS platform. The operator sets up and conducts a Barkhausen test on the GMS just as he would with any inspection. He simply selects the Barkhausen test, and then fills in the test parameters in the familiar Windows-based GUI, identical to those used for any other GMS inspection. Since the probe must be free to rotate to follow the gear flanks, it must be manually aligned by the operator so it is flat against the first tooth flank to be inspected. Then *GAMA* does the rest, automating the Barkhausen measurement process, displaying results

The GMS' surface finish measurement capability allows Allison to inspect this internal ring gear after finish shaping. Inspection parameters are selectable from a variety of industrial standards, and parameters such as Ra, Rq, Rz, and Rmax. Programming for this measurement as well is incorporated into the *GAMA* suite of software.

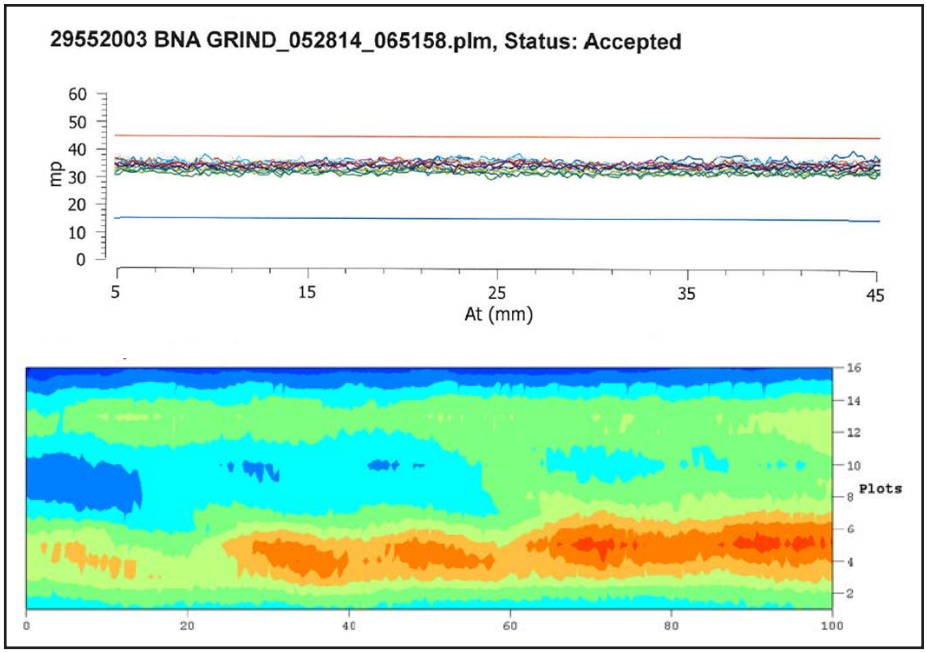
The new Allison TC10 tractor transmission: delivering 5% better fuel economy and a host of other long-sought benefits to Class 8 tractor operators.

to the operator as the measurement progresses, and providing results in the desired format –a plot of all traces with the desired/appropriate BNA numbers for each trace. The results and probe alignment can be verified by comparing the Barkhausen measurements with a known artifact (master gear) or, where more detail is needed, as a "heat map," visually depicting grinding burn as a hot spot.

"What made us particularly confident in our purchase decision of the Gleason 350GMS was our familiarity with Gleason metrology equipment (legacy systems are in use throughout Allison, and several GMM and GMS models have been purchased for Allison's India operations), and the knowledge that Gleason has excellent software engineering," recalls Wilkerson. "We knew they had good people to help us with the integration of Barkhausen and surface finish measurement."

Gleason Regional Sales Manager for Metrology Products Dave Taylor concurs. "The successful integration of Barkhausen analysis and internal surface finish inspection into the 350GMS is an example of our ability to meet ever-changing customers' needs with our resident staff of software and hardware engineers. We relish opportunities such as this."

Surface finish measurement. The TC10's higher gear quality requirements have even extended into surface finish – yet another reason the Gleason GMS has made so much sense for Allison, according to Wilkerson. The GMS has the capability to perform a wide range of surface roughness measurements and thus eliminate the setup time and additional equipment expense usually required when performing this inspection off-line. For Allison, this means that meeting the new surface finish inspection requirements for an internal ring gear after the finish shaping operation is all in a day's work. "The GMS works particularly well because with surface finish you always want to check perpendicular to the lines of finish and in the case of shaping these are axial lines, so we're checking from root to tip along the involute – a natural path for the GMS," she says. "The movements of the machine inherently ensure measurement reliability."

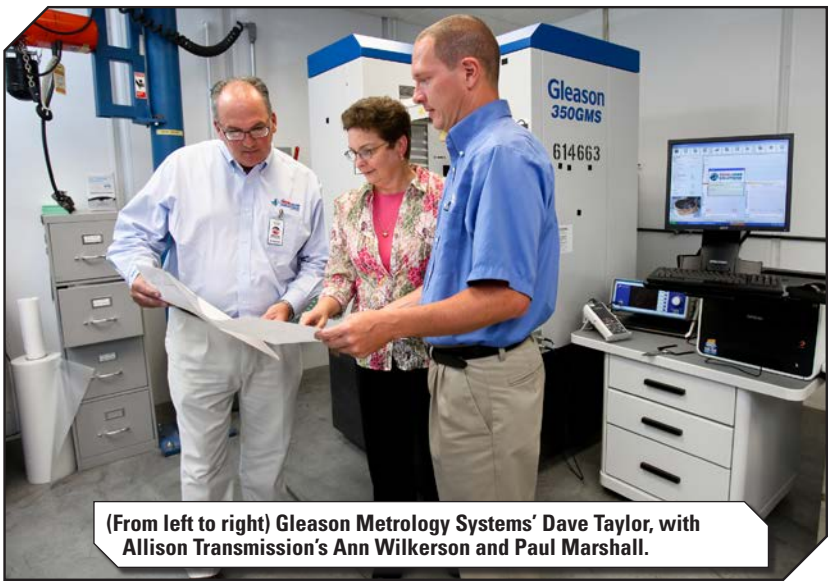


Barkhausen inspection results: measurements comparing the actual part with an artifact that has grind burn (top). A detailed heat map (below) can be produced by using 16 traces per tooth flank. This pictorial analysis shows grind burn as hot spots.

Commercially available probe styli are used, with choices to meet the tolerances of most required roughness parameters including Ra, Rq, Rz and Rmax. As with the Barkhausen inspection, programming for this measurement is incorporated into the *GAMA* suite of software, and results are made available on screen as well as in printed reports.

Finally, Wilkerson points out that, despite the array of different inspection tasks the GMS can perform, surprisingly few special arbors and fixtures are required. "The machine with its 3-D probes and journal reference software, working in combination with the 3-jaw chuck, allow us to set it up for almost any application without additional tooling, and this includes measurement of all purchased gears.

"At the end of the day, we're getting a lot of extra mileage out of the 350GMS."



(From left to right) Gleason Metrology Systems' Dave Taylor, with Allison Transmission's Ann Wilkerson and Paul Marshall.

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