EMD E-News letter Volume 1, No. 2

ELECTRONIC MEASURING DEVICES, INC. Mar. 5, 2003

Welcome to the 2ND edition of Electronic Measuring Device's E-News letter. We have gotten a lot of positive feedback and actual requests to be on our distribution list. This forum is creating some interesting thoughts. Every once in awhile, a customer will relay to me what the result of our measurement capabilities did for their own business and industry. Breakthroughs in dimensional measurements allow for a new level of capability in other disciplines, which then in turn is a breakthrough for others. My whole career has been a passion for instruments and what they enable society to accomplish. Everything is interrelated and the chain of events, which lead to discoveries, is amazing.

An EMD breakthrough in the dimensional measurement, enables the manufacturability of more precise components, which then lead to more precise assemblies, which allows for breakthroughs in other instruments, which then allow for more capability in compound and molecule identification which then allows a pharmaceutical company to design and manufacture more a complex compound, and then finally a researcher will discover a cure for the common cold or cancer.

In this installment, I thought we would deviate from our usual dimensional metrology field into an area that we recently got into through by accident through one of our customers. The customer was using the system to measure the typical GD&T mechanical aspects of his electromechanical assemblies. They expressed an interest in measuring the magnetic field strength of a magnet within an assembly. In the past, they created specialized single purpose fixtures and setups.

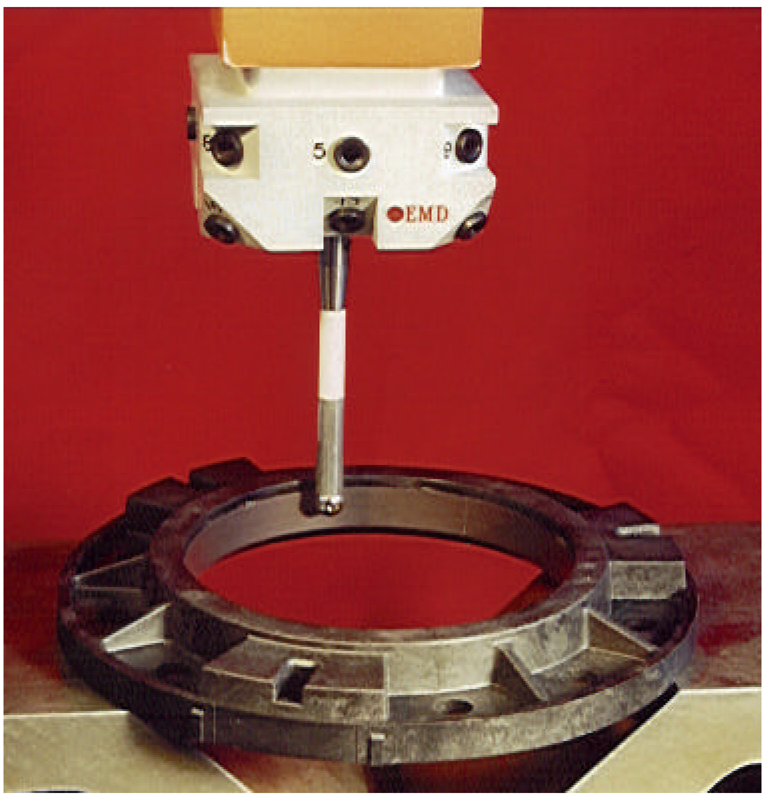

Fig.1 Picture of a magnetic encoder ring used in a truck axle ABS (Anti Lock Brake System). The ring contains alternating north south poles (25 per revolution) which directly feeds back wheel position and rate of rotation to microprocessor. The stylus was normally calibrated against a ceramic calibration ball for dimensional metrology purposes. The probe head units are normally in (grams or Newton's) was scaled against an independent magnetic field indicator.

The CMM became the perfect platform for blending in the magnetic field measurements with the existing part coordinate system and physical mathematical model of the assembly. What started out as a pretty complex adventure finally turned into a classically simple and elegant solution. All we ended up needing was a little software smarts and an unusual stylus. I hope this example will prompt others, with similar problems to approach us. Every branch of measurement (light, sound, color, electric potential, ionic fields, etc. etc. etc.) will at some point or another need to be related to a mechanical structures and or devices. The CMM will be the platform of choice as the key instrument, which has the capacity of bridging the void between dimensional metrology and these other disciplines.

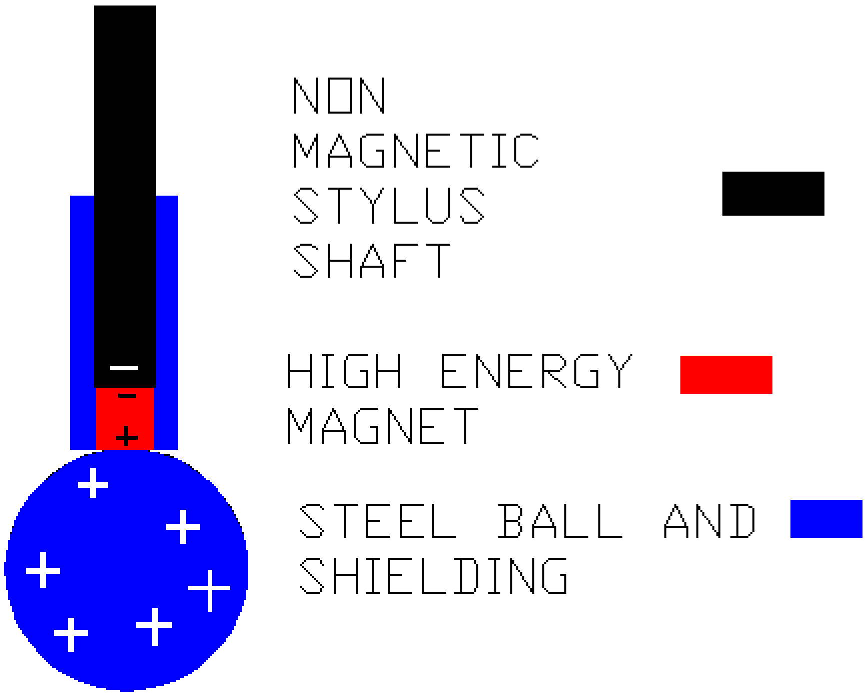

Figure 2 The next stylus iteration involved placing a high-energy magnet directly behind the steel ball and shielding the stray field with iron case. This in effect gives the steel ball an Omni-directional field polarity. It acted like a point in space being attracted to (negative) or repelled from a (positive) magnetic field.

Direct Magnetic and Electromagnetic Field Measurements on a Coordinate Measuring Machine

From Klaus, Chief Operating Officer

What is a Magnetic Field?

We have heard about Magnetic and Electromagnetic fields since our grade school science classes. This force is the principle force of virtually all mechanical devices on this planet. Even gas-powered engines, which are primarily exothermic chemical reactions, need multiple electromagnetic sub systems in order to function. The average automobile has hundreds of electromagnetic subsystems today, from solenoid locks, blower motors, fuel pumps etc. the list goes on. Their number and importance of such devices increases every day.

In our school textbooks, we see a representation of these fields, as sweeping lines of force radiating from north to south poles. These representations are derived from mathematical equations. Magnetic fields by themselves cannot be directly seen. The indirect powdered iron experiment, place a magnet under a sheet of paper with powdered iron on top is as close as we get to actually see a field.

The mathematical theories break down in practice, much as the powdered iron clumps and creates some random spiral or swirl. Place iron or any magnetically active substance in or about a field and wild distortions occur and the theory becomes riddled with complexity. Magnetic fields are highly non-linear and small dimensional variations may have large affects on the overall field. Mathematical prediction of complex magnetic systems is highly uncertain and thus experimentation and testing becomes critical.

When we began to look at making these magnetic field measurements we knew that basically CMM methodology of building a part coordinate system and building a mathematical model of the physical workpiece was essential. The trick was making the magnetic field measurements itself in that model.

Hall effect transducers, which are electronic Chips, is the preferred modern method of measuring a magnetic field. From a dimensional metrology stand point though it is difficult to establish a point or area in space that describes the “effective” chip? Although a method of spatial calibration could be possible the directionality of the chip sensitivity makes it a poor candidate as an Omni-directional sensor, which is desirable from the coordinate metrology standpoint.

Another magnetic field sensor is the classic Gaussometer. Which is essentially a spring loaded indicator needle attached to a magnet. Magnetic fields acting on the magnet displace the spring and move the indicator. The EMD Sceptre probe head has some similar properties. It is designed as one of the world’s most accurate electronic indicator needless and is held to a null position by a similar spring per axis. Three axes are stacked perpendicular to each other, which gives it a three-dimensional spatial force and displacement sensing capability.

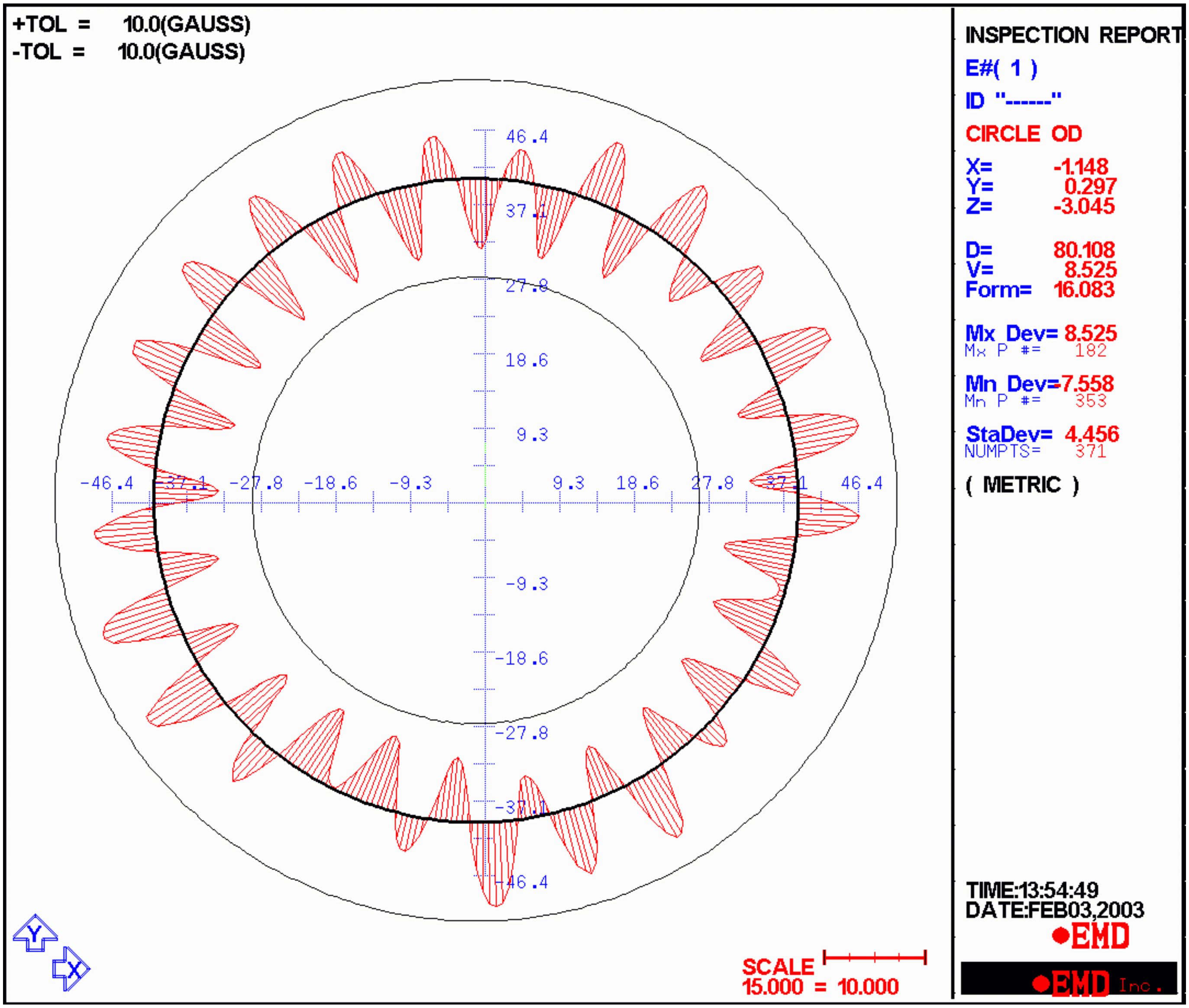

Fig.3 As the machine sweeps that circle in space the stylus is attracted and repelled by the alternating magnetic poles on the ring. In this case we are not measuring dimensional roundness but field intensity.

The first attempt at making it magnetically active involved using a simple steel ball stylus. The steel ball is essentially compatible with CMM methodology, stylus calibration techniques and calibration ball artifact. Using a simple ball had the drawback that it could not identify the polarity of the field. The ball would magnetically act like a point in space but would only be attracted toward a magnetic pole regardless of whether north or south.

The stylus could make dimensional measurements and establish a mathematical part reference system that geometrically coincided with the effective point in space of the stylus. In this case when the system scans a magnetic field it follows a nominal path in space while collecting the probe head displacement values which in turn are scaled and converted to gauss.

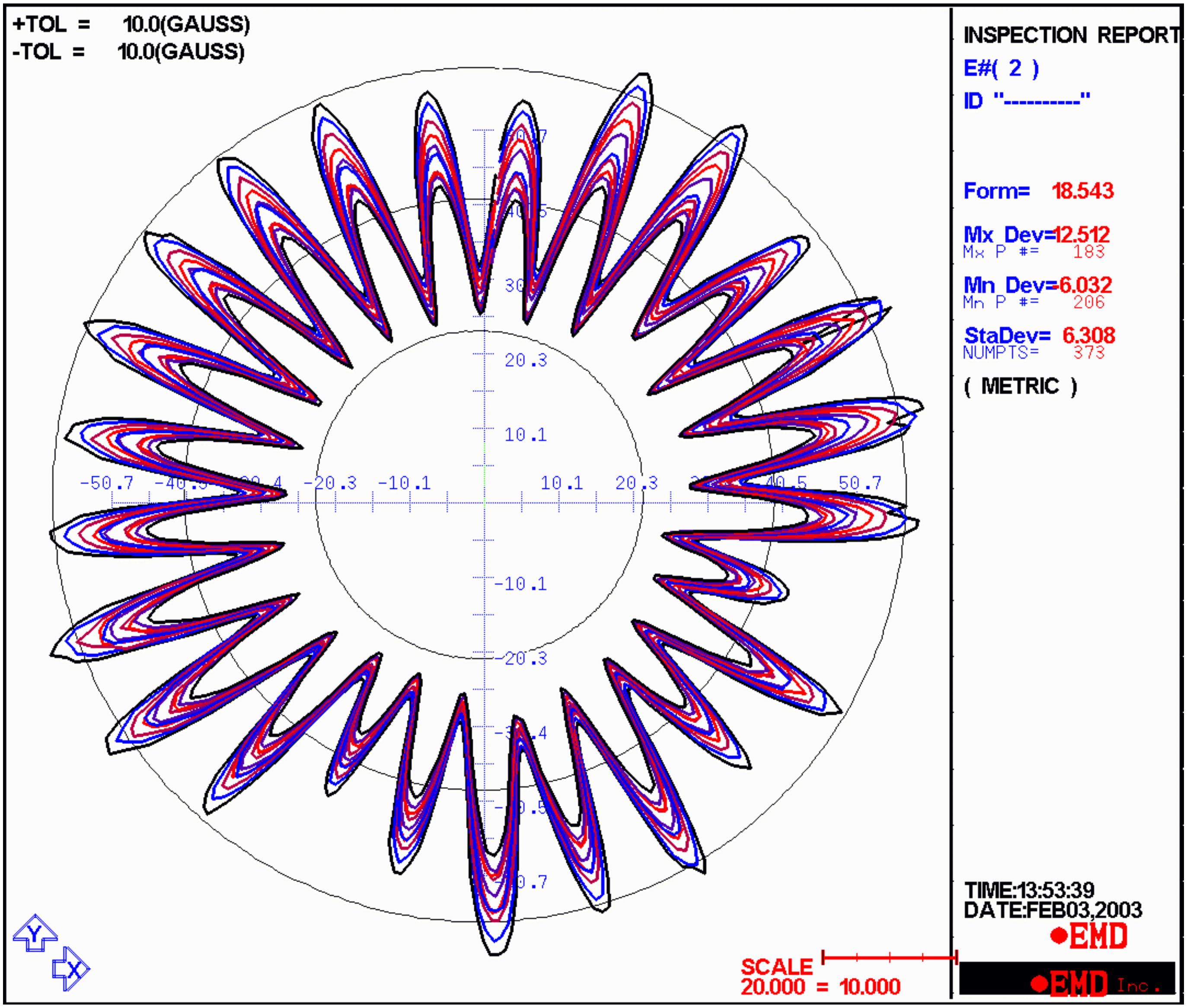

Fig. 4 is an overlay of multiple scans at varying working heights. As the gap between the stylus or pickup is decreased, the field strength increases.

In this case there is a theoretical working gap between the ring and the magnetic pickup in the final wheel assembly. The system effectively sweeps a circular track in space, which would coincide with that pickup. Based on the mounting holes and locating pads which datum the part coordinate system. A nominal path is established as a fixed radius from the effective center of the ring.

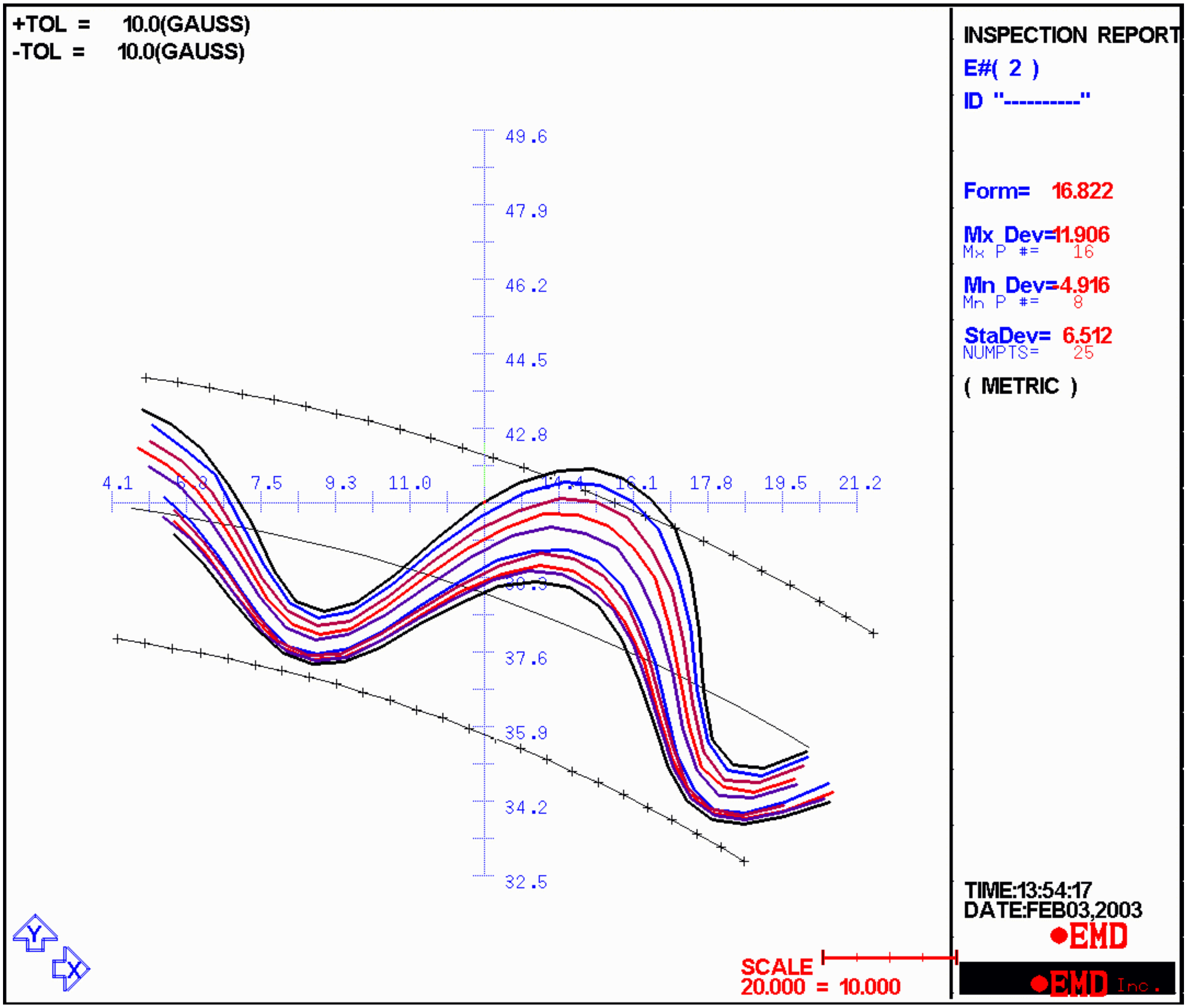

Fig.5 Blow up of field strength at a pair of poles on the ring every .002 inches about the working distance. Outer black field is at .004" working gap, blue 0.006", purple 0.008", red 0.01" etc every .002 " addition working distance.

Conclusion: Making magnetic and electromagnetic field strength measurements on a CMM is possible with a degree of accuracy and flexibility not available on any other instrument. The abilities of a CMM to establish a universal part coordinate system and the position in that system and make Omni-directional field measurements is unique.

Questions & Answers From Sceptre Users

I need to measure very fragile and delicate workpieces. What are the limits on contact force of the Sceptre System and probe? Teri from Ohio

Dear Teri,

Everything is an Engineering compromise. The control parameters of our probing cycle are completely software adjustable. Our default control parameters, which is a compromise of speed and accuracy, has an approach speed of 1.5mm/sec and a trigger/measuring force of 25 grams. The maximum over travel force reaches about 50 grams in the probe cycle and then returns and stabilizes at 25 before data is stored and processed into readings. This is a result of the time lag in the mechanics between triggering a stop and the actual stopping of the slides.

We modify those parameters frequently on customer needs. If we reduce just the approach probing speed to say 0.5mm/sec then total over travel force would be below 35 grams, 25 trigger force plus 10 in over travel. This obviously will increase the total cycle time; we would spend three times longer in space before reaching the part.

Historically, we have installations that measure wax, explosives and other delicate materials where we have measured items with as little as 3 grams with a total over travel of 5 grams. It will take some testing and exploration of the specific hardware platform, environment and a better understanding of your metrology need to determine the best set of probe cycle control parameters.

Operating at these low levels may require speed, hardware and environmental compromises. Do not expect to see this kind of performance at a trade shows. Air movement, sound, building vibrations all become a significant portion of the probing cycle.

At one time in the distant past, I was responsible for an installation where HE High Explosives were directly measured on a CMM. I had a vested interest, in not wanting to be a resident of several states at the same time. We performed gage R&R tests where thousands of hits were independently monitored for measuring force and crash protection.