Western Instruments
Established 1965

26509 Township Road 543
Sturgeon County, Alberta
T8T 1M1

Phone: (780) 459-6720
Fax: (780) 459-7837
E-mail: info@westerninstruments.com
Web: www.westerninstruments.com

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AC Fields for Through Coatings

AC fields, whether created by *Current Flow* or induced by *Field Flow*, remain on the surface of the workpiece (Skin Effect). That being said, the field occupies the surface and penetrates only in few hundredths of a millimeter or a few thousands of an inch. Increasing the amperage or field strength does not cause the AC field to penetrate any further.

AC Yokes are manufactured with a fixed output, in that they must lift 10 pounds or 4.6 kilograms as required by various industry specifications (ASTM E709, ASME Section V, BS6072, etc.). These same specifications refer to pole spacing, however there is virtually no affect to the lifting strength by either increasing or decreasing pole spacing. As an example, a Standard AC Yoke will lift 10 pounds if the poles are 300mm (12") or 30mm (1 ¼") apart. If a Yoke fails a pull test within this range, it is because the contact feet are not sitting squarely (flat) on the surface of the Pull Test Bar. Feet do not sit flat for two reasons; either they are worn unevenly, or the hinge points are misaligned.

The distance of 30mm (1 ¼") is simply used as an example, as the space between the poles would be completely filled by *Field Blow*, and would not be used by a qualified operator. Field Blow is the area between the poles where particle tends to congregate. To take this example one step further, if the edges of the poles are place together (parallel), with the contact feet squarely on the surface of the Pull Test Bar, the Yoke may or may not lift the weight. An AC Yoke has the field alternating between poles at a frequency of 50 or 60 Hz (positive to negative) and thus searches for the path of least resistance. If the edges of the legs are in intimate contact with one another, then the field will flow through the legs rather than the pull test bar.

To summarize Pole Spacing, there is very little use to have an excessive field produced by a Yoke. If the produced field is excessive, at maximum pole spacing, the Particle Blow will simply be excessive, and would tend to confuse an inexperienced operator. An increase in field allows operators to neglect the contact of the feet of the Yoke with the workpiece. Contact Feet, over time, will tend to 'mushroom', but the Yoke may continue to lift the required weight, due to an excess in field output. Yokes with mushroomed feet need to be scrutinized for there ability to lift 10 pounds. When our engineers design a Yoke, we optimize performance, which is a balance between current draw and the Yoke's ability to lift the required weight. An optimized system, with proper maintenance, will have some Particle Blow at a safe (low) amperage level.

The earliest AC Yokes had fixed legs with a pole spacing of about 125mm (5") and were designed to lift 10 pounds. This design permitted basic testing on flat surfaces,

and didn't allow inexperienced operators to get into trouble with poor contact to the workpiece. When irregular surfaces were to be tested, and the customer's budget did not allow for an expensive Power Pack, custom high power (and weight) "Yokes" were manufactured. These high power units were not only extremely heavy, they also produced an over abundance of field to ensure there was sufficient field induced for testing with the fixed (and flat feet) against the irregular surface. When articulated legs were introduced in the mid-1960's, it permitted companies to enter the NDT Field at a relatively low cost, however, due to the influence of the larger manufacturers, the Yoke Method tended to be discouraged, as is evident in some of the reference specifications today.

With the Yoke Method now being the most common MPI Technique used in the world, more work is being done on the development of specialized units. ASTM Specifications are the most commonly used, and is generally interpreted that MPI is not to be performed on painted surfaces, so we see companies removing perfectly good coatings to inspect a workpiece that is completely safe. However ASME Section V, Article 7, Appendix I-753 outlines the procedure for MPI on a Coated Surface. In order to easily achieve compliance, Western Instruments developed the WC-6x2. While this procedure will often deter the technique of *Through Paint* inspection, it really only needs to be qualified once.

The high lift WC-6x2 grew from a Workshop we offered called "How to use a Yoke". Groups attending this workshop asked the same question..."How can we perform MPI on operating equipment, without removing coatings?" To qualify the Yoke was relatively simple, and was demonstrated by putting writing paper, averaging a thickness of 0.01mm/ 0.004" thick, over a pull test bar. Standard Yokes typically failed with anything greater than 2 sheets. The answer was obvious, that a more powerful AC Field was required to overcome the losses due to the separation caused by the coating.

The WC-6x2 was developed, and the ASME technique was simplified to just measuring the coating on the workpiece, and using the above 'rule of thumb' to ensure enough paper covers a Pull Test Bar. This has been confirmed by many Senior Inspectors. This technique is far simpler than the one outlined in Appendix I-753, which requires;

> *A sample with a known artificial or naturally occurring defect, on a similar shape to the unit to be tested, is build up with a coating similar to the actual workpiece. A pull test bar with a similar thickness of shims placed under the feet, shall confirm the pull test. The indication, detected under the coating, must be at least 50% of its length before the coating was applied.*

On numerous occasions and with sheets of paper on a pull test bar (with its poor surface conformance), this technique has satisfied the I-753 inspection criteria. The coated samples, used to confirm this technique, were latter used to qualify inspectors for MPI through paint. These same samples have been recoated several times to ensure inspectors do not see where to place the Yoke due to coating wear. The WC-6x2 has been available for 4 years, and is well proven on coated surfaces.

Earlier, Field Blow was discussed and no Yoke is immune to this. Due its very strong field, the WC-6x2 is not recommended for use on uncoated surfaces. Even with a maximum pole spacing, the WC-6x2's Field Blow occupies almost half of the distance

between poles when used on bare metal. However, on more than one occasion, inspectors have placed coatings over the pole pieces when inspecting on highly polished surfaces.

Inspectors prefer AC Fields, when inspecting for surface breaking defects, as indications form very quickly. This holds true for any inspection media, weather it be Dry, Wet (Black on White), or Wet Fluorescent. The alternative to a stronger AC field, such as the WC-6**x**2, for coated surfaces is the use of a DC field, and here inspectors prefer the use of a 12 Volt Yoke or a Permanent Magnet Yoke, due to their convenience and reliability over an AC/DC Yoke.

The use of a DC field on a coated surface is well proven, however there is the requirement of the operator to apply the particle or Bath very carefully as there is no particle mobility. When DC power is applied to the internal coil of a Yoke, the resulting field produced by the Yoke is the same as full wave. If that DC field is pulsed at 50 or 60 Hertz (Rectified), or 'Chopped' like on a Battery Powered Yoke, the inductance of the Coil and Iron Core results in a Full Wave DC field to the workpiece. When operators are using a DC Yoke, with Wet Method Media, they are taught to hold the field on for extra time to allow the particles to flow over the surface, to congregate at cracks.

In conclusion and contrary to popular belief, with the right knowledge and equipment, Magnetic Particle Inspection can be performed through coatings. This inspection can be done, wet or dry, with the correct AC Field or any DC Field, with a little care and attention.

Here is a little showmanship, with a WC-6X2 lifting 2 Pull Test Bars (W-PT) that have been fastened together, and totaling 9.2 kg or 20 Pounds. The Egg was placed under this for a press release, just to add a little effect.

This was the second attempt at this shot, as Pull Test Bars tend to 'walk' (or vibrate) against the Yoke due to the alternating field. As all inspectors know, doing a pull test with an AC Yoke is a little bit of a balancing act as well!

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