



# NEW PIGMENT BONDING APPROACH TO MAGNETIC PARTICLE TESTING

***“Extended-life”  
materials assure  
complete, durable  
pigment bonding,  
continuous process  
utility.***

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Industry needs to see parts defects more rapidly, more clearly, more surely, and with testing materials that stand up longer and under production line stresses. This need has led to some fundamental improvements in the quality of magnetic particle testing specifically in composition of the particles themselves; in wetting and dispersing them; and their durability. These improvements, in turn, have been translated into improved bonding efficiency of the fluorescent pigment to the magnetic particles and,

therefore, higher test reliability as well.

Underlying these developments is the extension of nondestructive testing (NDT) requirements to include microscopic defects, as well as defects under chrome or cadmium plating. These very fine defects require the use of micron sized (2 to 10 microns) magnetic particles. Such very fine iron oxide complicates the particle/pigment bonding process, calling for bonding techniques perhaps more sophisticated than what may be generally used.

Testing efficiency overall is directly related to the durability and completeness of pigment bonding. If the bonding is compromised by incomplete pigment coverage of each particle, or if a breakdown in bonding and pigment separation occur over time, accuracy and clarity of readings at defect sites are also compromised. In varying degrees, this condition has been commonly accepted.

## **Extended-life materials**

The integrity of the bond bears directly on the durability of the test materials as well and their applicability to continuous processes, for example. Such “extended-life” test materials, as we call them, are the result of proprietary techniques (involving both process and equipment) used to combine a new organic resin with a new high-UV-excitation level pigment.

Figures 1 and 2 compare the bonding

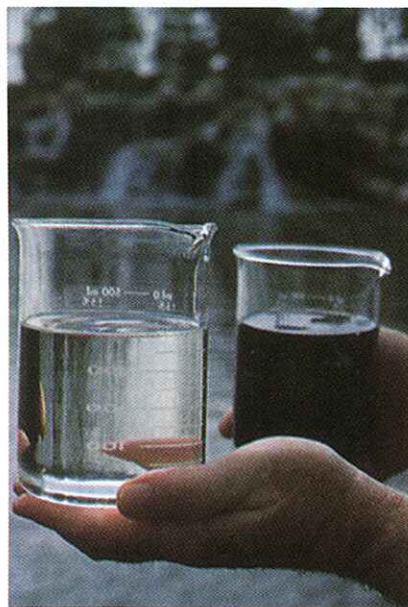


Figure 1. Clarity of beaker contents on the left demonstrates absence of loose pigment, or high bonding integrity of the extended life materials. The beaker on the right shows pigment particles in suspension before the test.

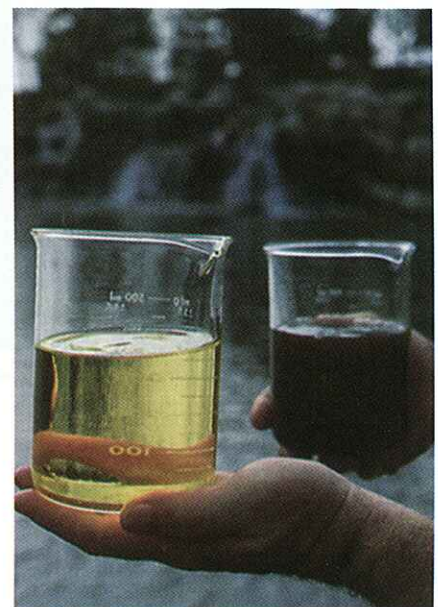


Figure 2. Results with commonly used agents are shown here. Discoloration of the solution in the beaker on the left indicates pigment contamination resulting from incomplete bonding.

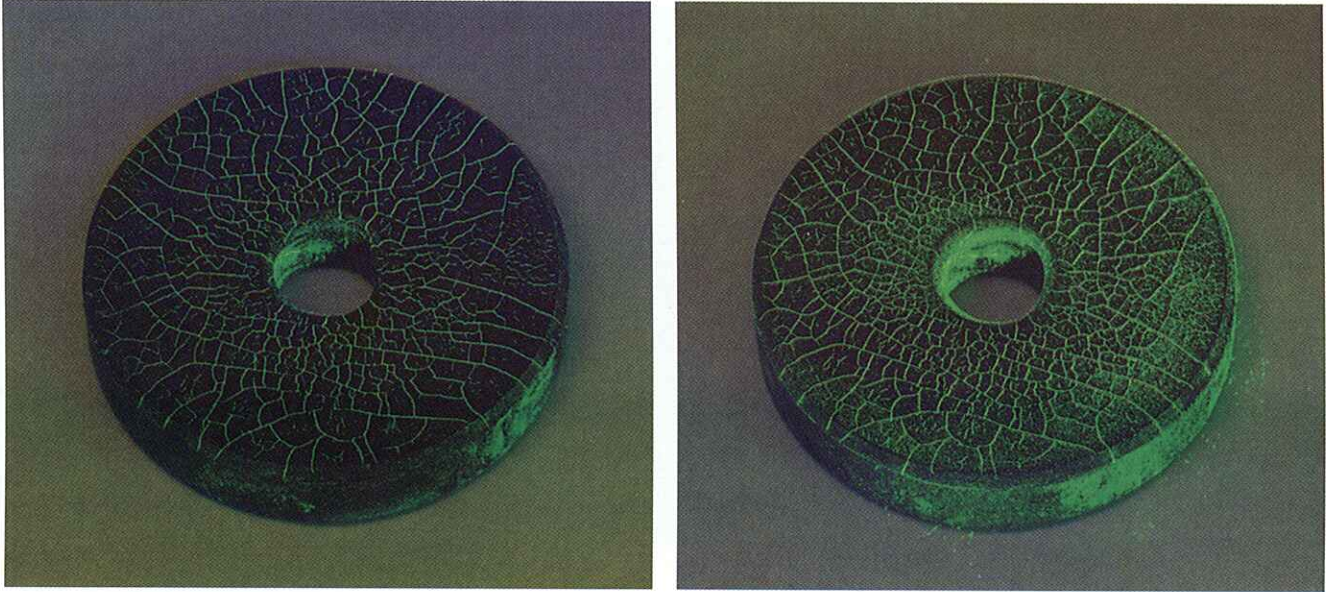


Figure 3. These Tiede pieces demonstrate sharp contrast and reduced background in water- (left) and oil-based media.

integrity of the new materials with those commonly used. The test involves suspending the magnetic particles in a light inspection oil and placing the mixture in a blender (Osterizer) continuously for 30 minutes with no cooling period. Following this treatment, the particles are allowed to settle, then removed with a magnet.

The beaker on the left in Figure I contains the new materials, and the clarity of the contents demonstrates the absence of loose pigment in the solution and thus a high bonding integrity. (The beaker on the right in that figure shows particles in suspension before the test.)

Figure 2 shows the results of the same procedure with more commonly used materials. Discoloration of the solution at left indicates pigment contamination caused by incomplete bonding. (Again, the beaker on the right is the test material with particles in suspension before the test.) This comparison simulates several weeks' use of a test bath material under actual production/inspection conditions.

There are several advantages to adopting testing procedures based on the extended-life concept. Because bonding of the fluorescent pigment to the particles remains virtually complete, "noisy" and confusing background in nondefect areas is substantially decreased. The tight bonding of the new materials also reduces the background of test material over the complete test-part surface. The intensity of fluorescent readings at defect sites is greatly increased because of the greater particle sensitivity.

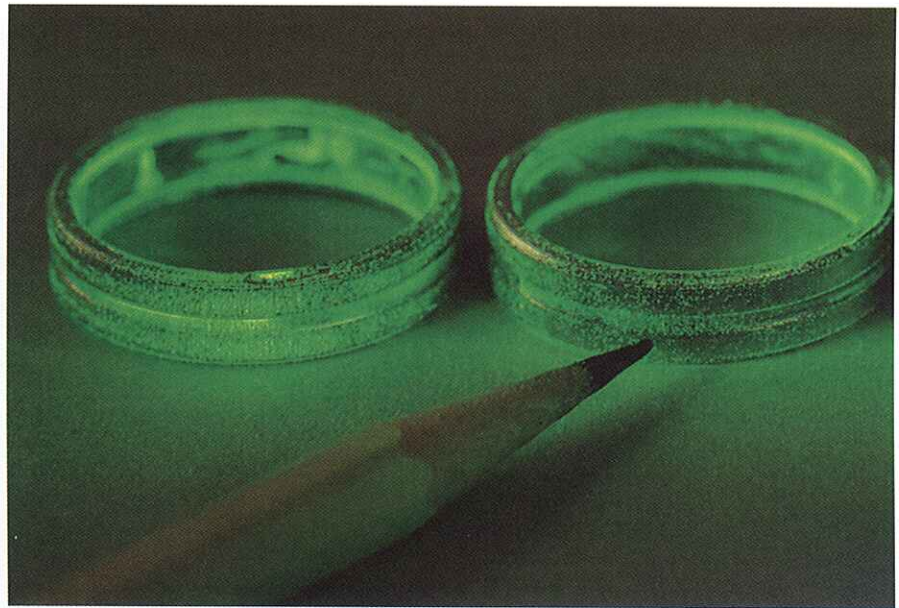


Figure 4. A 30-day-old test bath with the new extended-life agents revealed a microcrack (pencil point) in the roller bearing outer race on the right. The other race was similarly run through a bath containing commonly used materials.

The extended-life test materials have been successfully formulated to function in either oil- or water-based carriers (in manual or automated test systems) with equal clarity and intensity of readings. The Tiede test pieces in Figure 3 demonstrate the sharper contrast and reduced background obtained in both oil- and water-based media.

**Oil-based applications**

Typical of critical inspections to which the extended-life materials are now being applied are aeronautical roller

bearing components being manufactured to MIL-Q-9858A standards. A major bearing manufacturer is among those experiencing outstanding durability with the new materials. After 30 days of use on a 'round-the-clock basis, the test bath maintained complete integrity. The sharpness and intensity of defects, and the absence of confusing background, were as good on the thirtieth as on the first day.

Figure 4 compares the background effect produced on test parts by the new materials (right) with commonly used materials. After grinding, these roller

# MAGNETIC PARTICLE TESTING



Figure 5. Water-based medium is used for connecting rod inspection. Defects like the one seen here stand out with no confusing background.

bearing outer races were magnetized at 500 amp. The pencil points to a micro-crack (inclusion) in the groove of the race. The test bath had been in use 30 days.

The bearing race at left in Figure 4 was tested with more commonly used materials, which also had been in use for 30 days. The photo demonstrates a noisy background. A defect in almost the same position as that on the race at right in the figure is shrouded in background confusion. It's normally difficult to detect shallow surface defects in this type of smooth-surfaced, 0.003-inch cadmium plated stainless steel.

The test bath used in this comparison had processed hundreds of configurations of inner and outer races and bearing rollers. Many of these configurations required up to five magnetizing shots during testing. These components are used in flight surface systems such as flaps and ailerons. An aircraft such as the Boeing 767 has more than 600 oscillating-type bearings alone. The bearing manufacturer who provided the test site has been involved since the 767's design stage, and the company's standards far exceed requirements.

## Automated systems, new water-based chemistry

A major high-production, malleable-iron foundry specializing in automotive parts has been using the extended-life materials in a water-based medium. This foundry's inspection system for connecting rods, for example, was designed to

overcome: low-contrast crack indications with confusing background in defect-free areas; variations in crack indication intensity; and uncertainty in distinguishing edge indications from cracks. And all with high precision rates.

The system demands integrity and durability of fluorescent particles. The inline inspection system is today being used to inspect more than 1,000 connecting rods per hour at several stations in the foundry.

The procedure, a computer-vision test, involves running the parts on a conveyor through a magnetic particle bath and magnetizing the parts while in the bath, followed by carefully monitored spray rinsing of the parts to remove excess particles. Rods are viewed by four cameras utilizing strobe lamps. The image is digitized and fed into a microcomputer. The rapid optical readings are screened by the on-site monitor, reflecting "go" or "no-go" status. Acceptance or rejection is based on the geometry and intensity of the indications.

Manual viewing of rejected parts is done under black light in a minibooth at each inspection station. The indications stand out in brilliant fluorescent contrast devoid of confusing background (see Figure 5), evidence that pigment bonding and all the complex elements that have gone into the new materials indeed hold up over time.

An integral support system in the foundry's connecting rod test provides continuous monitoring of the bath concentration. A turbidimeter measures the

density of the particle solution and provides a digital readout for control. This requires no dye separation for accurate readings. Automatic monitoring of the bath can be adapted to statistical process control (SPC).

The rapid optical readouts that are part of automatic testing demand magnetic particle wetting agents that prevent agglomeration and backgrounds that might present a noisy image to system cameras. These are prevented by a full and complete wetting of each particle rather than by bunching.

A liquid concentrate comprising magnetic particles and wetting agents has been developed for this foundry computer-vision test system. A premixed package of particles and concentrated liquid wetting agent saves time and reduces chance for error; on-line proportioning of particle mix and wetting agent isn't necessary. Inspectors simply refer to instructions on the bottle when replenishing a bath.

Automated magnetic particle inspection requires rapid dispersion of particles to the defect site and full coverage of the test surface without run-off. The new water-based concentrate (patent pending) modifies the water carrier to provide uniform and complete coverage of test surfaces. Coverage is equal to that obtained with solvent carriers, and particle migration is effective over machining oil films.

Water-based carriers are an ideal fit with the fast-paced, full-reliability demands of automated magnetic particle testing. The flammability, fumes, disposal and storage problems of solvents are eliminated. Rust inhibitors added to the bath are effective. Particle sensitivity and customized geometry, size, permeability and retentivity of particles to defects has advanced markedly. And particle fluorescence and brightness also have been improved.

The subtleties of improved bonding of fluorescent pigments and the advances in wetting-agent chemistry represent only a beginning of a new level of technology one that must keep pace with the high standards of testing generally and the realities and potential of automated inspection. And most certainly, with growing automation making 100-percent inspection a reality as opposed to audit or sample testing the extended-life materials are a significant advance in magnetic particle testing for both automated and manual systems. ■

# All-In-One Chemistry and Patented Water Base System Simplify Procedures, Enhance Accuracy

As industry changes from using oil to the use of water as the preferred carrier in magnetic particle testing, differences in requirements from industry to industry have had to be met. Whatever the application involves, magnetic particle testing is being called upon to do its job faster, with full repeatability of test results and maximized accuracy. And, to do it utilizing ingredients that are beyond reproach from safety and environmental acceptability standpoints. Many previously accepted nitrite and chromate compounds are now considered hazardous.

Circle Chemical research chemists identified the basic ingredients and the composition of components that make for successful meeting of varying application requirements. These components include: corrosion inhibitors, surface tension reducing agents, anti-foaming agents, viscosity adjustment agents, and Ph buffering agents. A critical balance must be achieved whatever the application objective—across the micro to macro defect finding range.

Circle also approached application analysis from the viewpoint of developing test materials which are simply easier to use, less vulnerable to human-error throughout the inspection process. Commonly, the various ingredients that make-up a magnetic particle test bath have been proportioned and mixed manually at the time of initiating or replenishing the bath—a procedure always vulnerable to some degree of error.

Improvement of water-base test material formulas was given top research priority. Out of this effort have emerged significant Circle Chemical patents. (Basic Patent is U.S. Patent No. 4,701,275, October 20, 1987) The result has been advancements in water-carrier performance that have carried it beyond the dispersion and coverage capability of solvent (oil) carriers. The new water-carrier has become something more than water in the Circle system. Now water-base magnetic particles have a mobility capability equal to, or better than oil-base materials...over any test part surface—from rough castings to highly machined and polished components. Improved, fully verifiable rust inhibition agents are also in the picture.

The bottom-line of these advancements is that water-base test systems can now do anything that oil-base systems can do—with the added advantages of being cleaner, quicker, safer and environmentally acceptable to work with, and dispose of. The next step in meeting the 'easier to work with' objective was improved handling and packaging of test materials.

The All-In-One Chemistry concept emerged from this effort. Circle's prechemistry has perfected the combining and packaging of all chemical agents for wetting mobility, corrosion inhibition and the other agents in a premix with their Mi-Glow magnetic particles—packaged as pre-proportioned liquid concentrates in increment-marked containers. Liquids produce superior results over powders. Powders take time to dissolve, and some never dissolve fully. Powders



All chemical agents and particles combined and packaged in premix liquid concentrate.

are also more sensitive to local water conditions. The All-In-One formula is simply added to the water carrier to make up the test bath, eliminating human error in piecemeal combining of ingredients, while safe-guarding test repeatability and assuring maximized testing accuracy.

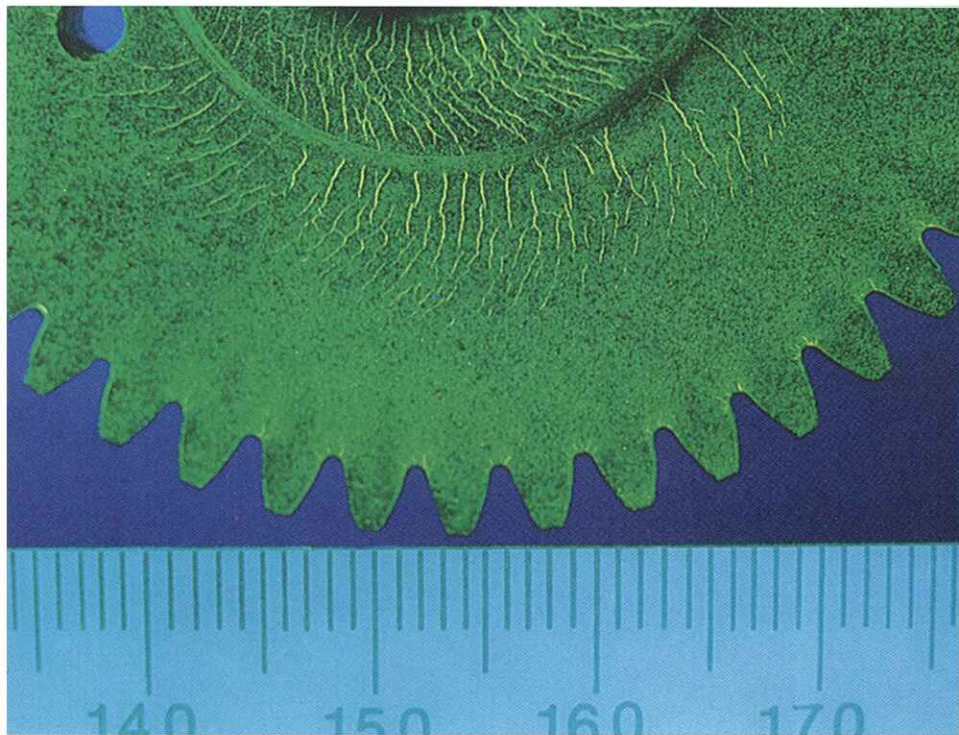
The full range of test sensitivity requirements, from micro to macro defects, and varying needs in particles and agents are now included in the premixed All-In-One formulas. Over 35 years of specialization in

magnetic particle material development has given Circle the experience and knowledge to develop three basic formulas that answer 90-plus percent of testing needs. The balance is answered with thoroughly customized systems. In the case of very high sensitivity CircleSafe materials, particles are packaged separately and added to the All-In-One formula. Dynamic chemistry has advanced the capability of magnetic particle test materials to meet today's changing manual and automated inspection needs.

## BRIGHTER STRONGER LONGER

Demonstrably superior in meeting the need for ultrasensitive magnetic particles, the Mi-Glow 800 Series introduces improved accuracy and visual clarity in presenting critical defects to the human eye and video camera. The most elusive defects stand out now in brilliant fluorescent contrast, devoid of confusing background. Defect images are brighter, more intense, clearly defined for the most demanding fast-before-the-lens inspections.

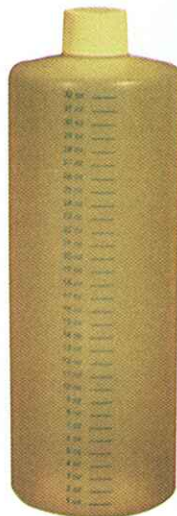
Extended-Life materials stand up longer in the test bath, with full-effect, for an extended period of time, under heavy and continuous usage.



Micro-defects are clearly defined at base of teeth of this small two-inch diameter gear. Cracks are  $\frac{1}{4}$  mm long  $\frac{1}{10}$  mm wide. Tested with water base Extended-Life Materials. (Measurements shown in centimeters)

## PRODUCTS FOR REVEALING MINUTE, CRITICAL DEFECTS

- Mi-Glow 800** Particles designed for use in solvent media or for water base applications with specially formulated conditioners.
- Mi-Glow 810** A premix of Mi-Glow 800 fluorescent particles and powder wetting agent, for water system use only.
- Mi-Glow 778** A liquid concentrate with Mi-Glow 800 particles and liquid wetting agent. Designed for water system use. Allows for easy conversion from oil to water medium. Contains special corrosion inhibitors. Accuracy-controlled application. . . premixed, preproportioned packaging of particles and concentrated liquid wetting agents. The graduated-scale Circle container provides a time-saving, foolproof mixing guide when initiating or replenishing a bath.
- CircleSafe 870** A liquid concentrate for use with Mi-Glow 800 particles gives water the characteristics of oil for the most demanding applications.



Complete safety information is available for these products.

Mi-Glow 800 Extended-Life™ Magnetic particles and systems meet all pertinent Military and Industrial Specifications. Certification provided with each shipment.



30 Years of Specialization  
In Test Chemicals



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