

Inspection Process, Magnetic Rubber

RATIONALE

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1. SCOPE:**1.1 Scope:**

This specification covers the general procedural requirements necessary for the performance of magnetic rubber inspection.

2. APPLICABLE DOCUMENTS:

The following publications, of the issues in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-M-6867	Magnetic Inspection Units
MIL-I-6868	Inspection Process, Magnetic Particle
MIL-I-6870	Inspection Requirements, Nondestructive, for Aircraft Materials and Parts
MIL-C-38736	Cleaning Compound, Solvent, for Use in Integral Fuel Tanks
MIL-STD-410	Qualification of Inspection Personnel (Magnetic Particle and Penetrant)

3. REQUIREMENTS:**3.1 Materials:**

When specified on the engineering drawing, contract, or purchase order, this specification applies to the inspection of ferromagnetic materials only. Ferromagnetic materials which have been plated with electrolytic or electroless platings, painted or flame spray coated may be inspected using these procedures.

3.2 Equipment:

Equipment other than that specified herein may be used, subject to approval of the procuring activity.

3.3 Magnetizing apparatus:

Any use of the stationary magnetic inspection equipment shall conform to the requirements of MIL-M-6867. The equipment shall be maintained in a manner to insure uniform, controlled inspection operations. All portable permanent and AC-DC electromagnets shall be capable of reliably providing uniform, controlled magnetic field strengths as required in the testing of each part. Each magnetizing apparatus shall be capable of inducing in the piece under inspection a magnetic flux of suitable intensity in the desired direction.

3.4 Microscope:

Replica viewing equipment shall consist of a microscope or lens capable of a minimum of 7 X magnification, used in conjunction with a high intensity lamp for replica illumination.

3.5 Gauss Meter:

A portable Gauss Meter capable of measuring accurately values up to 1000 Gauss shall be used to determine proper field strength in holes and on surfaces to be inspected. The device shall be equipped with both transverse and axial probes. Dial or similar type meters of suitable range may be used if capable of providing transverse and axial measurements

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for inspection:

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Documentation:

Applicable drawings or other documents shall specify the typical size, concentration, and orientation of defects in high- and low-stress areas in fabricated parts. The component drawing or applicable document shall also show:

- a. Method of magnetization including flux direction and field strength required.
- b. Acceptance of criteria.

4.3 Manufacturing processes:

When manufacturing processes are involved which may in any way adversely affect the quality of the material or part, such as forging, heat treating, plating, cold forming, welding, and grinding, inspection shall be performed subsequent to such processes. When certain processes are involved which may in any way interfere with this inspection, such as heavy deposits of chrome or nickel electroplating, the inspection shall be performed prior to and after such operations.

4.4 Record of inspection:

The results of the magnetic rubber inspection shall be appropriately recorded. All recorded results shall be identified, filed, and made available upon request by the procuring activity.

4.5 Qualification of inspection personnel:

Magnetic rubber inspection personnel shall be qualified in accordance with MIL-STD-410.

5. PREPARATION OF PARTS FOR INSPECTION:

5.1 Cleaning before test:

The surface of all materials and parts shall be free from grease, dirt, sealant, or other matter which might interfere with the proper distribution and concentration of the magnetic particles within the poured rubber. Cleaning shall be performed using a stiff brush, cheese cloth, and a solvent which does not damage the material under test. An air jet shall be used to remove loose lint. Removal of flame sprayed metal coatings, electroplate, or paint is usually unnecessary, however, removal of these coatings should be executed when maximum defect sensitivity is required.

5.2 Taping and damming:

Adhesive tape shall be placed beneath the hole to be inspected so as to provide a tight seal over the bottom to contain the rubber solution. When the configuration of the part warrants, putty shall be used on the upper surface of the part around the hole so as to contain any excess overflow rubber from the hole. Where the replicas of several holes are to be joined together by a continuous strip of rubber subsequent to filling and magnetization of the individual holes, it will be necessary to provide a putty dam except to protect from unwanted flow into other parts.

5.2.2 Horizontal holes: Adhesive tape shall be placed on one side of the hole, and a pinhole punched in the tape near the uppermost edge of the hole for the release of entrapped air upon pouring of the rubber. An aluminum foil (.003 inch minimum thickness) cup, shall be formed and used to guide and contain the liquid rubber on the opposite side of the hole. The dam may be held in place with waterproof putty and tape.

5.2.3 Flat surface:

5.2.3.1 Non-inverted (upward facing): Putty dams for these types of surfaces may be used for preventing run-off or over dispersion of the liquid rubber test material.

5.2.3.2 Inverted (downward facing): When required, "upside-down" surfaces shall be inspected with magnetic rubber by forming a putty reservoir beneath the test area to be inspected and pressure filling with liquid rubber. Entrapped air shall be allowed to escape by placing a small vent hole in the rubber next to the inspection surface.

6. PREPARATION OF MAGNETIC RUBBER:

6.1 Magnetic rubber base material:

NOTE: This inspection has been prepared based on the procedures required for use of MR-502, magnetic rubber base material manufactured by the Dynamold Corporation, Fort Worth, Texas. The MR-502 formula is proprietary and at the time of writing of this specification, no alternate formulas or suppliers exist.

6.2 Proper formula selection:

Selection of the proper magnetic rubber formula for a particular application shall be based on considerations of part geometry, the magnetic field strength to be applied and the time available for the test. When the part to be inspected is difficult to magnetize or where the proper magnetic pole pieces are not available for providing good magnetic contact with the part, a long migration time formula should be used.

6.3 Mixing and measurement procedures:

6.3.1 Shaking: The magnetic rubber base material must be thoroughly mixed, prior to use, by means of a mechanical shaker. As an aid to mixing, the container of rubber should have a one-half to three-quarter inch diameter steel ball placed inside.

6.3.2 Stirring: Subsequent to shaking, the container of rubber should be opened and the contents stirred with a clean wooden tongue depressor or spatula until the base material contains no streaks or color variations.

6.3.3 Measurement of base material: The base material may be either weighed or measured volumetrically, the following equality holds:

$$1 \text{ gram of base material} = 1 \text{ cubic centimeter (cc) of base material.}$$

The proper proportions of base material and catalyst are obtained from Table I.

6.3.4 Catalyzing: As specified in Table I, the applicable catalyst is added to the measured batch of base material to begin the curing of the rubber. The resulting mixture must then be stirred for 15 to 30 seconds to assure a uniform distribution of the catalyst within the rubber.

6.3.5 Pouring: Apply the catalyzed rubber to the part area to be inspected by pouring or use of a syringe. Do not apply more material than can be magnetized within its pot life.

7. APPLICATION OF MAGNETISM:

7.1 Permanent magnets:

Use of permanent magnets for inspection is not recommended except when it is impossible, due to the shape of the part, to utilize electromagnets. Use of permanent magnets require that they be left in place on the part during the active pot life of the formula. As permanent magnets provide limited field strength the slower curing formulas are usually required to insure maximum migration of magnetic particles during the active pot life. However, other formulas may be used if the minimum Gauss requirements for the application are met with permanent magnets. Several permanent magnets may be grouped together to increase field strength only if the polarity of the pole pieces does not cancel their effective field.

7.2 Portable electromagnets:

Use of portable electromagnets and auxiliary pole pieces is the preferred method of magnetization. When auxiliary pole pieces are used, they shall be selected so as to produce a minimum reduction of pole cross section.

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TABLE I - Magnetic Rubber Inspection Formula and Applications

IMPORTANT: All mix and cure parameters below were developed for MR-502 base (magnetic rubber) only. Use of any base other than MR-502 may cause these parameters to be non-applicable.

Allowable Duration of Magnetization	Min. Gauss Requirements	Catalyst	Catalyst Mix Ratio	Cure Stabilizer, ** Drops per 10 cc base	Cure Time*
8 min. (std. formula)	Surfaces 100 Bare Holes 25 Coated Holes 100	Thermolite 12 or equiv. (dibutyl-tin diaurate)	15 drops per 10 gms or 10 cc base	2 drops per 10 gms or 10 cc base	1-1½ hrs
20 min.	Surfaces 50 Bare Holes 25 Coated Holes 100	Thermolite 12	5 drops per 10 gms or 10 cc base	2 drops per 10 gms or 10 cc base	3 hrs
40 min.	Surfaces 35 Bare Holes 15 Coated Holes 50	Thermolite 12	2 drops per 10 gms or 10 cc base	2 drops per 10 gms or 10 cc base	5 hrs
60 min.	Surfaces 20 Bare Holes 10 Coated Holes 25	Thermolite 12	1 drop per 10 gms or 10 cc base	2 drops per 10 gms or 10 cc base	8 hrs

* The cure times apply to inspections conducted at an average room temperature of 76°F. Lower temperatures will result in longer cure times and higher temperatures in shorter cure times. Adjustments in the catalyst mix ratio should be made to adjust for larger deviations in temperature from the "average" temperature.

** The addition of cure stabilizer eliminates the effect of variations of atmospheric humidity on cure times.

Footnotes to Table I:

- Note 1 When using volumetric measurement, substitute milliliters or cubic centimeters for grams.
- Note 2 Pot life is the maximum time allowable between addition of catalyst and completion of magnetization.
- Note 3 Cure time is affected by temperature and contamination of the catalyst. When a particular batch of base used with a particular batch of catalyst exhibits too fast or too slow curing, the catalyst mix ratio may be adjusted accordingly. Trial batches should be catalyzed prior to inspection to determine the mixing ratio to obtain the desired cure time.

7.3 Stationary magnetization equipment:

Large, stationary magnetic particle inspection stations may be used when parts to be tested are large or can be more effectively magnetized.

TABLE II. Magnetic Field Strength and Duration Recommendations for Various Inspection Applications

<u>Type Inspection Area</u>	<u>Available Field Strength, Gauss</u>	<u>Corresponding Magnetizing Duration (each direction)</u>
Bare (uncoated) holes	50 to 100	-----30 seconds
	25 to 50	-----60 seconds
Coated holes	100 to 600	-----30 to 90 seconds (dependent on thickness of coating)
Bare surfaces	150	-----1 minute
	100	-----3 minutes
	50	-----10 minutes
	20	-----30 minutes
Coated surfaces	50 to 600	-----1 to 60 minutes (dependent on thickness of coating)

NOTE: This table should be used as a guide-line only. Variations may be made as necessary for specific applications.

7.4 Grounding:

The power supply of any electromagnet used shall be grounded to the test part prior to inspection to insure that electrical arcs are not produced between the part and the pole pieces of the electromagnet.

7.5 Field strength and direction:

Field strength will be measured, prior to application of the rubber, with a Gauss Meter. Unless critical flaw area is known, each area tested shall be magnetized in at least two directions, 90 degrees apart. A minimum of 30 seconds shall be allowed before magnetization in the second direction is performed. In all cases, precautions will be taken so as to insure that the magnetic lines of force run approximately perpendicular to the anticipated direction of cracks.

8. IDENTIFICATION OF REPLICAS:

8.1 Methods:

All magnetic rubber replicas must be identified during or after curing. Identification may be accomplished using (1) treated paper, (2) aluminum foil impression, or (3) other means that provide permanent, easily read identification.

8.2 Information required:

For proper identification, the following information shall be included with each replica:

- a. Aircraft or part number.
- b. Hole number or identification of inspection site.
- c. Date.
- d. Formula used (optional) field strength.
- e. Name or identification number of the person producing the replica.

9. CURE PERIOD:

9.1 Movement:

During cure of the rubber replicas, movement of the rubber inspection material must be avoided. Any movement of the part being inspected must be accomplished very carefully.

9.2 Removal:

When removing replicas from holes, a push rod or dowel shall be used to facilitate extraction and to minimize tearing of the rubber. Additional cure time must be allowed if the rubber continues to stick to the part. If the inspection area of the replica becomes damaged, the inspection must be repeated.

10. REPLICA INTERPRETATION:

10.1 Visual and microscopic:

The overall surface area of a replica should initially be examined visually with no magnification in order to detect any gross defect indications. The replica(s) shall then be examined under strong illumination with a microscope having a minimum of 7 X magnification. All indications of cracks or flaws on the replica shall be noted and recorded.

10.2 Replica quality:

Where the inspector is in doubt regarding the validity of an indication in the rubber, he shall re-cast the replica.

11. POST INSPECTION PROCEDURES:

11.1 Replica storage:

Replicas, when stored for a long period, may shrink and excrete catalyst. Therefore, for dimensional accuracy, the measurement of crack lengths, surface blemishes, tool marks, and similar surface characteristics from a replica should be made soon (within 72 hours) after its removal from the surface of the part. This is especially important if periodic inspections are being performed to monitor dimensional change.

11.2 Cleaning:

The test part must be cleaned, subsequent to removal of the rubber replica, with a suitable solvent capable of removing any residual silicones. Where the part is to be re-plated, re-painted or coated with sealant, this removal and cleaning is extremely important in restoring the original adhesive properties of the surface.

11.3 Demagnetization:

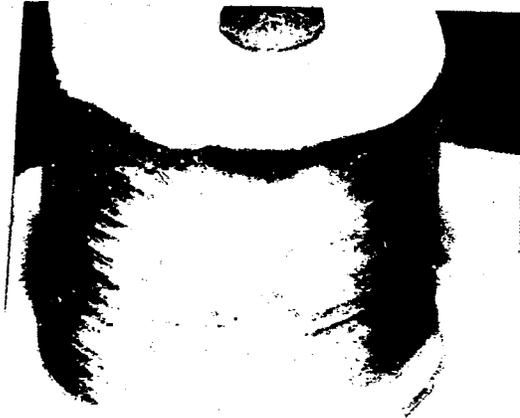
The AC circuit of the electromagnet shall be used to remove any residual magnetism left within the part after test. Demagnetization shall reduce the level of the field within the part to a satisfactory level consistent with the requirements for that application.

PREPARED UNDER THE JURISDICTION OF AMS COMMITTEE "K"

APPENDIX

ANALYSIS OF RUBBER REPLICA INDICATIONS

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(a) Example of low magnetism. Note absence of "halo" at edge.

(b) Proper magnetism. "Halo" is seen at edge and crack indications are displayed.

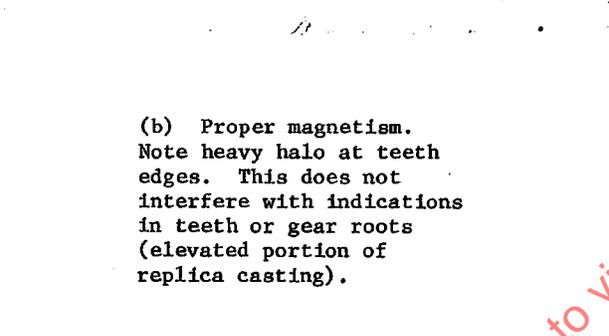


(c) Too much magnetism. Crack indications are hidden in heavy magnetic background.

FIGURE 1. Magnetism Level Evaluation for Holes



(a) Example of low magnetism.
Halo at teeth edges is light.
(Depressed portion of casting).



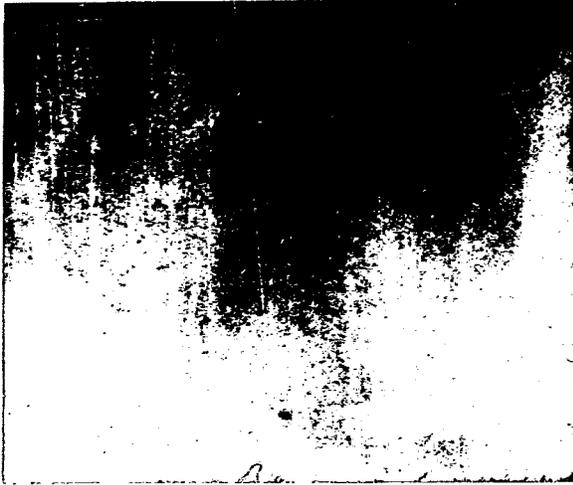
(b) Proper magnetism.
Note heavy halo at teeth
edges. This does not
interfere with indications
in teeth or gear roots
(elevated portion of
replica casting).



(c) Too much magnetism. Crack
indications hidden in excessive
magnetic background.

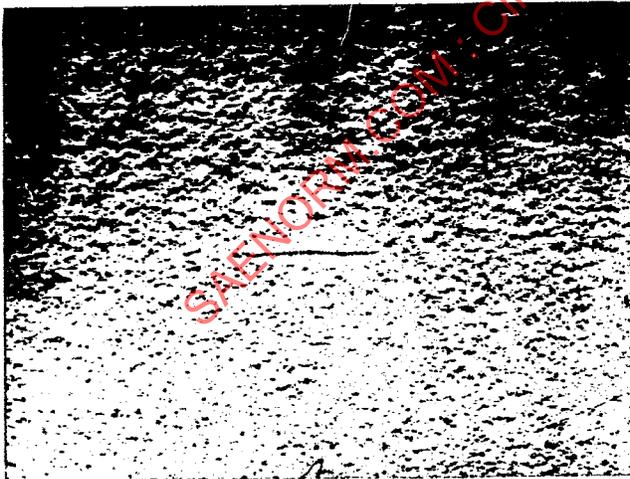


FIGURE 2. Replicas of Gear Teeth



(a) Low magnetism. No magnetic background seen.

(b) Proper magnetism. Light magnetic background seen in rough areas of surface.



(c) Too much magnetism. Small indications could be hidden in excessive background.

FIGURE 3. Evaluation for surfaces

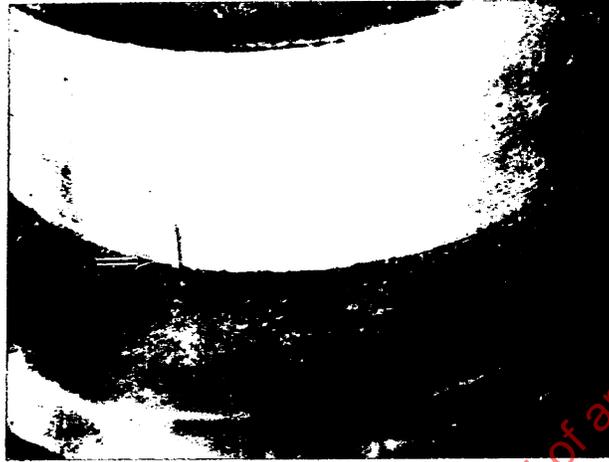


FIGURE 4. MRI indication of crack on edge of hole and extending onto adjacent surface.



FIGURE 5a. Crack indications on taped side of hole. Should be recast with tape on opposite end to see if indications extend around edge.



FIGURE 5b. Same hole as shown in Figure 9, except replica recast on opposite side to display indication extending around edge.



FIGURE 6a. MRI replica casting of bare (unpainted) hole, showing a large and a small crack (Magnification 5X)