EQUIPMENT AND PROCEDURE FOR ON-SITE INSPECTION OF MAGNETIC SEPARATORS

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1. **Scope**

1.1. This standard presents a unified approach to magnetic measurement of permanent magnetic and electromagnetic separation equipment at the installation site.

1.2. This standard is intended for magnetic separation equipment, whose function is to remove ferrous tramp from product streams. This standard does not cover devices whose purpose it is to hold a ferrous workpiece by means of magnetic force (holding magnets).

1.3 The purpose of magnetic measurement is for verification of magnetic performance as a quality control procedure or for evaluating equipment when considering a performance upgrade.

1.4. Magnetic testing at the installation site is most readily done by measuring the relative attractive force produced by a magnetic separator upon a ferrous test piece.

Although the test piece may not geometrically represent the ferrous tramp to be captured, if selected properly, it can provide a repeatable indicator of magnetic strength. While electronic measuring equipment such as gaussmeters and fluxmeters provide more a definitive magnetic test data in the laboratory, their cost, availability and difficulty of data interpretation prohibit their use in many "field" situations.

1.5. HAZARDS-The act of performing tests outlined in this standard may present a number of hazards to the operator depending on the nature of the test. It is the responsibility of the operator to become familiar with the equipment and to implement appropriate measures to ensure personnel and equipment safety throughout all phases of testing.

2. **Terms and Definitions**

2.1. *Capture*-The act of magnetically extracting ferrous tramp from the product stream.

2.2. *Collection Area*-Locations on the magnetic face where tramp collects due to high concentrations of magnetic flux. These may be above internal magnetic poles or at external pole extensions.

2.3. *Force Gauge*-A force measuring device which can display the peak force measured. The gauge may be a simple spring type scale or an electronic digital load cell.

3.4. *Magnetic Face*-The surface of a magnetic separator through which magnetism emanates and on which ferrous tramp is held at collection areas.

2.5. *Magnetic Separator*-Equipment designed to magnetically remove ferrous tramp from product streams. The magnetic energy source may be either permanent or electro magnets and the configurations and magnetic circuitry may vary widely.

2 6. *Polarity Indicator*-A device used to identify the polarity (north or south) of a magnet and may also be used to indicate the center of a magnetic pole or the direction of magnetic flux at a specific location. The indicator may be a simple attraction/repulsion device, a compass type device or an electronic device.

2.7 *Pull Test*-A test procedure which measures the magnetic attractive force exerted on a ferrous test piece.

2.8 *Retention*-The ability to magnetically hold ferrous tramp to the magnetic face against the force of product flow.

2.9. *Spacer*-A shim of non-ferrous material used to create a specific air gap between the magnetic face and the test piece.

2.l0. *Test Piece*-A standardized ferrous object used to generate attractive force to a magnetic field for measurement in a pull test.

2.11 *Tramp*-Magnetic ferrous or weakly magnetic non-ferrous debris to be removed from the product stream

3. **Testing Overview**

3.1. The method of magnetic testing should be determined by the objectives of the test.

3.1.1. For **quality control verification**, a singular pull test can be repeated periodically with the same test apparatus to determine if any magnetic degradation has occurred. This test should be designed for repeatability by choosing a test piece and a location on the magnetic face of the equipment which produces consistent results.

3.1.2. When **evaluating magnetic equipment or comparing potential upgrades**, testing should be selected which most closely simulates the intended operation of the magnet. For instance, two critical functions of a magnetic separator are: to capture tramp from a specified distance and to adequately hold the tramp to the magnetic element once captured. Therefore, ideally, a pull test should be performed on a test piece which most closely resembles the expected tramp both at the specified distance and at the magnetic face. In reality several limitations exist. Often the expected tramp is very small and the pull forces at specified distances are too small to accurately measure with conventional force gauges. This has lead to the standardization of test pieces which produce measurable pull forces on and at limited distances from the magnetic face.

3.2. When comparisons are being made between potential equipment for a given application, testing should be done at functionally equivalent points on all separators. This implies that a pull test performed at a specific distance from the magnetic face should be at the location of maximum field intensity for each separator at that distance. Although a gaussmeter is the most accurate tool for locating the maximum field intensity, the test piece, if allowed lateral freedom, will usually seek the area of maximum intensity.

3.3 When testing a given magnet for changes in performance, consistency must be maintained through thorough documentation. Many factors contribute to significant variances of magnetic strength over the magnetic face of an individual separator so that an inspection log must be kept to document the test apparatus used and the exact location on the magnet face where the test was performed. On some equipment, it is necessary to use a polarity indicator to determine the location and the midpoint of internal magnetic poles so that the exact test location can be documented and replicated.

4. **Apparatus**

4.1. Apparatus Overview

4.1.1. Because of the variety and range of magnetic separation equipment, it is likely that no one set of magnetic force measuring tools will suffice for every application. However, a basic kit of test pieces, spacers, a force gauge, and a polarity indicator can produce test results which are sufficient for most situations.

4.1.2. The accuracy of the magnetic measurement data is a function of the accuracy of the test apparatus and the repeatability of the test procedure. The key to apparatus accuracy is calibration of the force gauge and strict adherence to specifications for test pieces.

4.1.3. Field tests of magnetic separators are generally performed solely by manual effort so that test pieces and spacers should be selected which produce pull force readings in the range of .5 to 20 lbs. Relatively high forces can pose safety hazards, especially with spring scales, due to the sudden release of the test piece. Relatively low forces should be avoided, if possible, to maintain accuracy of the measurements.

4.2. Components-The following test components comprise a minimal set of tools that can measure a wide variety of magnetic separators. Specific applications may require specialized test pieces and spacers or components of higher tolerance. Recommended materials, tolerances and calibrations are suggested below which should permit a minimum test repeatability of $\pm$l 0% at full scale measurements.

4.2.1. Force Gauge-The pull test accuracy is primarily dependent on the force gauge accuracy. Digital load cells can offer .02 lb. resolution or better while spring scales may only be reliable to .25 to 1 lb. resolution depending on the range. It is good practice to use a force gauge which offers better than 10% accuracy on the force to be measured (i.e. for measuring a 2 lb. force, a force gauge with a resolution of .2 lbs. or better is required (2 x 10%=.2)). Force gauges must be calibrated periodically to ensure rated accuracy. Digital gauges must be inspected and certified

while spring scales should be calibrated against a known weight of the approximate test force just prior to each test. A force gauge should be selected which can record and save peak readings.

4.2.2. Polarity Indicators-Are used, when required, to identify the location of magnetic poles on which to locate the test piece or to document which pole or polarity was tested.

4 2.3. Test Pieces-Are used to generate repeatable attractive forces in magnetic fields. Test balls should be used whenever possible to measure the strength of local magnetic fields. Test plates are better suited for measuring magnetic strength at greater distances from the magnetic face.

Test Balls-Test pieces made from steel spheres offer highly repeatable results due to their uniformity and universal symmetry. The sphere is an excellent test piece for simulating holding force on tramp on or near the magnetic face. The test ball eliminates any potential problems with surface flatness and positioning often associated with test plates. Standard test ball sizes are .250"O, .500" O, and 1.000"O. Material must be C1018 and the diametrical tolerance should be .001". A linkage must be provided by which the force gauge can be attached to the test ball. The linkage and its means of attachment must be non-ferrous and may neither add to nor subtract from the sphere's magnetic properties.

4.2.3.2. Test Plates-Test plates generate attractive forces which indicate the strength of a magnetic field passing through a perpendicular plane at a given distance from the magnetic face. Plates provide greater surface area at a given offset than do spheres which makes them particularly suited for measuring the weaker magnetic fields present at greater distances from the magnetic face. Plates should generally not be used to measure attraction directly on the magnetic face because of low repeatability. A standard test plate size is .125" thick x 1.000" wide x 3" long with a volumetric tolerance of $\pm$ 5%. Material must be ClOl8 steel and the testing surface must have a flatness of .005" or better. A linkage must be provided by which the force gauge can be attached to the test plate. The linkage and its means of attachment must be non-ferrous and may neither add to nor subtract from the plate's magnetic properties.

4.2.4. Spacers-Spacers are used to accurately position a test piece at a given offset from the magnetic face. Spacers are to be made from a non-ferrous material which has no effect on the magnetic circuit. Spacers should have a thickness tolerance of $\pm$ .005" or less and should be flat within .005". Spacer thickness' of .l25" and .250" are common for 1"O tube style magnets while .500" and 1.000" are common for plate style magnets.

5. **Preparation**

5.1 If possible, position the magnet to be tested in an accessible location on a solid working surface with the magnetic face horizontal.

5.2. Clean and remove any steel objects or dirt from the magnetic face.

5.3. Determine which test(s) are required to evaluate the desired performance of the magnetic separator. Perform trial tests using several test pieces and spacers to find a combination which provides test values in the measurable range of the force gauge.

5.4 Select a location on the magnetic face where tests will be performed. Use the polarity indicator to find internal pole locations if necessary. In general, it is best to perform tests in the center of the magnet's width (along centerlines of magnetic symmetry) and in areas of highest magnetic strength (where the test piece naturally centers itself). Test plates should always be oriented so that the longest dimension is parallel with the direction of the magnetic field (i.e. bridging from North pole to South pole).

5.5. Calibrate the force gauge as required.

6. **Procedure**

6.1. Record the time, date, inspector's name and ambient temperature in a test log.

6.2. Record the type and size of test piece, spacer thickness, force gauge used, test location and polarity for each test to be performed in a test log.

6.3. Zero the force gauge while hanging vertically with the test piece attached.

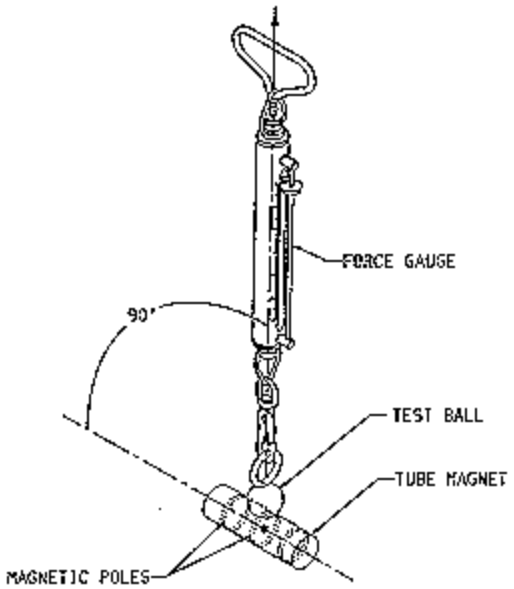
6.4. Carefully position the spacer (if required) and test piece in the designated position on the magnetic face. **USE CAUTION**-do not allow hands or fingers to be pinched or trapped by the test piece.

6.5. Attach the force gauge to the linkage of the test piece.

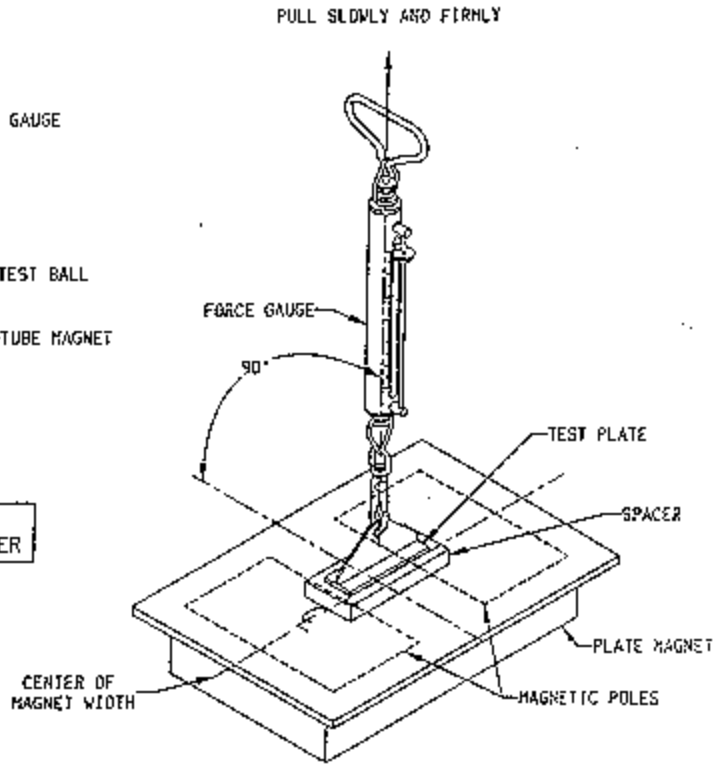
6.6. Pull the force gauge slowly and firmly in a direction perpendicular to the magnetic face until the test piece breaks away from the magnetic field. **USE CAUTION**-test pieces pulled by spring scales may re1ease sudden1y and can potentially harm the operator or others.

6.7. Record the peak reading measured by the force gauge.

6.8. Repeat test steps 6.3 through 6.7 until three readings are recorded which are within 10% of each other. Record the average of the three readings in the test log.



PULL TEST ON TUBE MAGNET
WITH TEST BALL AND NO SPACER



PULL TEST ON PLATE MAGNET
WITH TEST PLATE AND SPACER