SAE Aerospace
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AEROSPACE RECOMMENDED PRACTICE

SAE ARP4462

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BARKHAUSEN NOISE INSPECTION FOR DETECTING GRINDING BURNS IN HIGH STRENGTH STEEL PARTS

1. SCOPE:

1.1 Purpose:

This recommended practice covers the procedures and method for establishing acceptance criteria when performing Barkhausen noise testing of surface-hardened steel components to detect grinding burns (metallurgical damage caused by over-heating) in bare or chromium-plated parts.

1.2 Application:

Primarily for nondestructive testing of heat treated, high strength low-alloy steel parts which have been ground, in accordance with MIL-STD-866 or commercial standard, before or after chromium plating. This test method may be used as an independent test or to confirm grinding damage detected in accordance with AMS-2440 or MIL-STD-867 in bare or chromium plated components.

1.2.1 This test method may be used to find grinding burns in finish ground parts, provided that the parts have no defects due to earlier manufacturing processes. If the parts have defects before grinding, this method will show the presence of these defects in addition to grinding burns, unless they are removed by grinding or other method. Such defects include soft spots and edges due to defective heat treatment, decarburization, stress variations due to cooling rate changes, etc.

1.2.2 This test method is not applicable for parts which have a plated metal, ferromagnetic deposit between the substrate and chromium plating.

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1.3 Principle of Measurement:

The method used in this test is based on inductively detecting Barkhausen noise in ferromagnetic materials. The noise is generated by the abrupt movements of magnetic domain walls. The walls can be forced to move by application of an alternating magnetic field. When an alternating current coil is placed near the sample, the resulting change in magnetization will induce an electrical pulse in the coil. When the electrical pulses produced by all domain movements are added together in a bulk sample, a noise-like signal called Barkhausen noise is generated.

1.3.1 Two important material characteristics will affect the intensity of the Barkhausen noise signal. One is the presence and distribution of elastic stresses. The other is metallurgical microstructure, often related to hardness. A low intensity Barkhausen signal is generated in hard materials and a high intensity signal in soft ones. In grinding burns, residual stress and microstructural changes are generally present. Grinding burns may result from retempering when the original tempered martensite has been exposed to further heat, resulting in a loss of hardness and compressive residual stress. Rehardening may occur due to transformation of ferrite to austenite from excessive local heating.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this recommended practice to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS-2440 Inspection of Ground, Chromium Plated Steel Parts

2.1.2 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-866 Grinding of Chrome Plated Steel and Steel Parts Heat Treated to 180 000 psi or over
MIL-STD-867 Temper Etch Inspection

3. TECHNICAL REQUIREMENTS:

3.1 Equipment:

A commercial single or multichannel central scanning unit and sensor(s). The number of sensors and their configuration depends on the inspection speed requirement and the part under study. Plated parts may require a special high response sensor. Part fixturing stands or rotational devices and chart recorder may be required.

3.2 Sensor Cleaning:

The sensing heads shall be cleaned daily according to instructions from the manufacturer.

3.3 Preparation of Parts:

3.3.1 Parts shall be cleaned and dried to remove all substances which would interfere with inspection.

3.3.2 Parts may be chromium plated. The thickness shall not exceed 0.020 in (0.51 mm).

3.3.3 If parts have been magnetic particle inspected, they shall be demagnetized to 3 Gauss or less prior to testing.

3.4 Measurement Procedure:

As recommended by the equipment manufacturers. In static inspection, the sensor is held in one location, where upon the inspection is restricted to the contact area between the sensing head and the part. In dynamic inspection, the part is rotated either by hand or by a motorized rotation device. The dynamic inspection method may also be performed by sliding the sensor over the part.

3.5 Preliminary Tests:

3.5.1 Determination of acceptance criteria shall be based on preliminary testing on parts or samples representative of those to be inspected.

3.5.1.1 A sufficient number of parts or samples shall be fabricated representing each of the following four categories:

1. Sound
2. Minor burn
3. Moderate burn (optional)
4. Severe burn (optional) subsequent to 3.5.1.2 through 3.5.3.

Bare parts shall be etched according to MIL-STD-867 or similar user's specifications to show the burns and their severity. Plated parts or samples shall be stripped and etched in accordance with AMS-2440. An acceptable sound surface has no indications of further tempering due to grinding burns after etch inspection. A minor burn has light gray color change. A moderate burn has a clearly distinguishable darkening of the surface. In the case of a severe burn, the affected area is dark gray or black. It may also be partially or completely white if rehardening at the surface has taken place. The minimum number of parts or samples needed is four, two to represent sound parts and two that represent minor burns or as in 3.5.5. If the condition of the grinding burns after etching is ambiguous, more parts or samples with grinding burns

3.5.1.1 (Continued):

shall be prepared. Half the parts or samples from each category are to be etch inspected to confirm compliance to category 1 through 4 as applicable. The balance of the samples are to be used to determine the rejection criteria discussed in 3.5.1.2, 3.5.2, and 3.5.3 and also to serve as calibration samples as discussed in 3.6.

3.5.1.2 Determine the scatter of the signal from a sound part or sample. Make a note of the highest signal level from this part of sample. Determine the highest signal from a part or sample with minor defect. This signal should be higher than the highest signal from the sound part or sample. Although the highest signal level can be determined with a static measurement, the dynamic study technique will ensure that enough area has been tested to find the highest signal level.

3.5.2 The signal level from parts or samples with burns shall be compared to that from the sound parts or samples. A rejection limit shall be established and set as illustrated in Figure 1 and as indicated in 3.5.3 between the signals determined in 3.5.1.2.

3.5.3 The Barkhausen noise level from sound parts or samples will be slightly different for bare versus chromium plated parts or samples, as illustrated in Figure 2. This difference shall be taken into account when calibrating the instrument using a bare, burned part or sample prior to inspecting a plated part or sample and the rejection limit shall be adjusted accordingly.

3.5.4 A rehardening type of grinding burn will cause a hump in the grinding burn curve, as illustrated in Figure 3.

3.5.5 In applications where it is not possible to get several representative parts or samples exhibiting defects, the rejection limit may be established on one part or sample. The highest signal from a sound area on this part or sample shall be determined. Any signal exceeding the highest signal is indicative of a defect.

3.5.6 Oftentimes using Barkhausen noise method in conjunction with the conventional nital etch would ensure the best chance for good quality components. For instance, Barkhausen noise could be used for 100% inspection of production. Suspect parts found with this technique would be nital etched to confirm the presence of burns. If no systematic correlation is found between the Barkhausen noise indications and the results of nital etch inspection, this method is not to be used for grinding burn. In this case other aspects of grinding damage, e.g., residual stress, may be found to correlate with the Barkhausen noise indications.

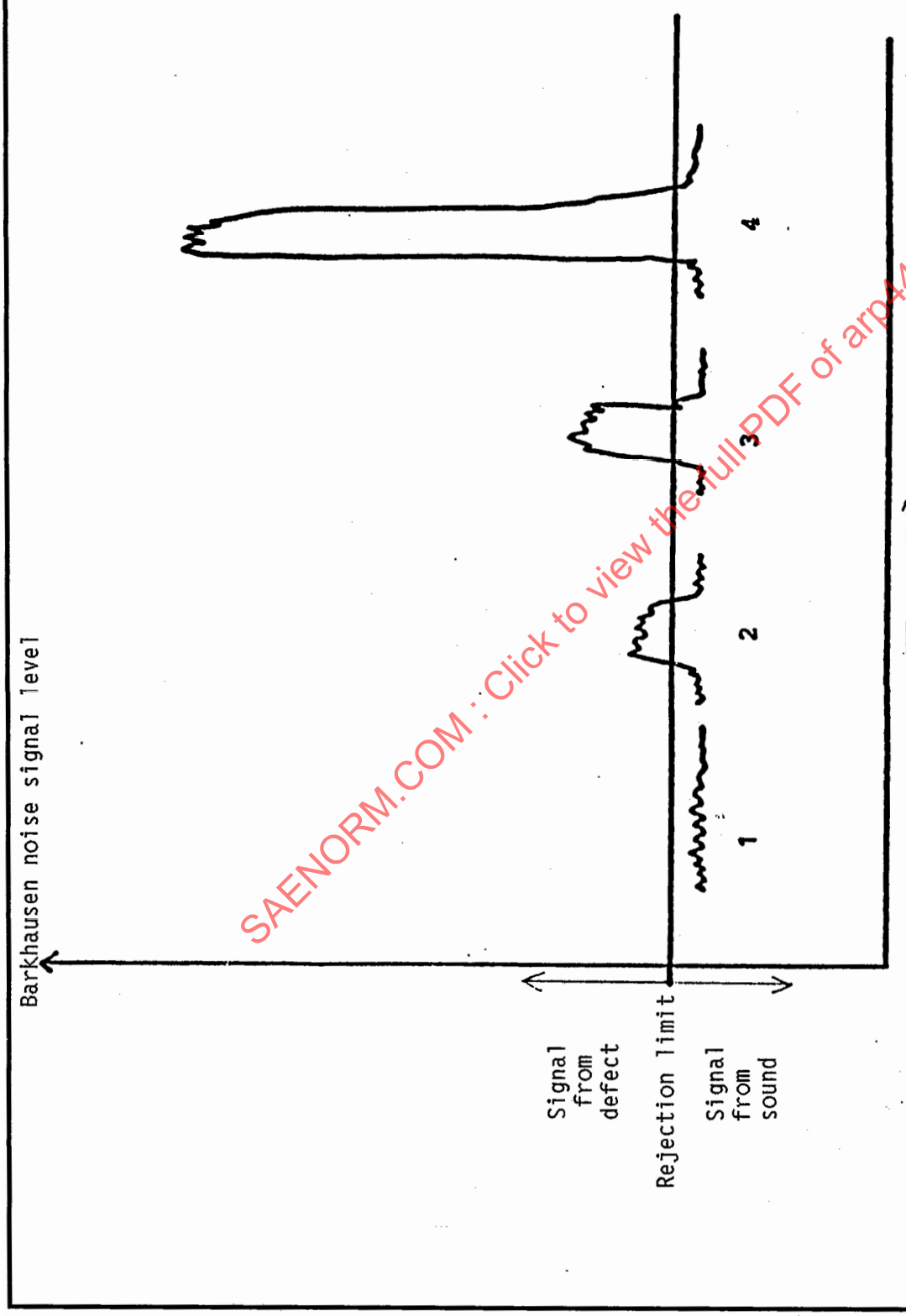

FIGURE 1 - Illustration of Barkhausen Noise Level From Samples With Various Degrees of Defects to Establish the Acceptance Criteria

1 Sound surface
2 Minor defect
3 Moderate defect
4 Severe defect

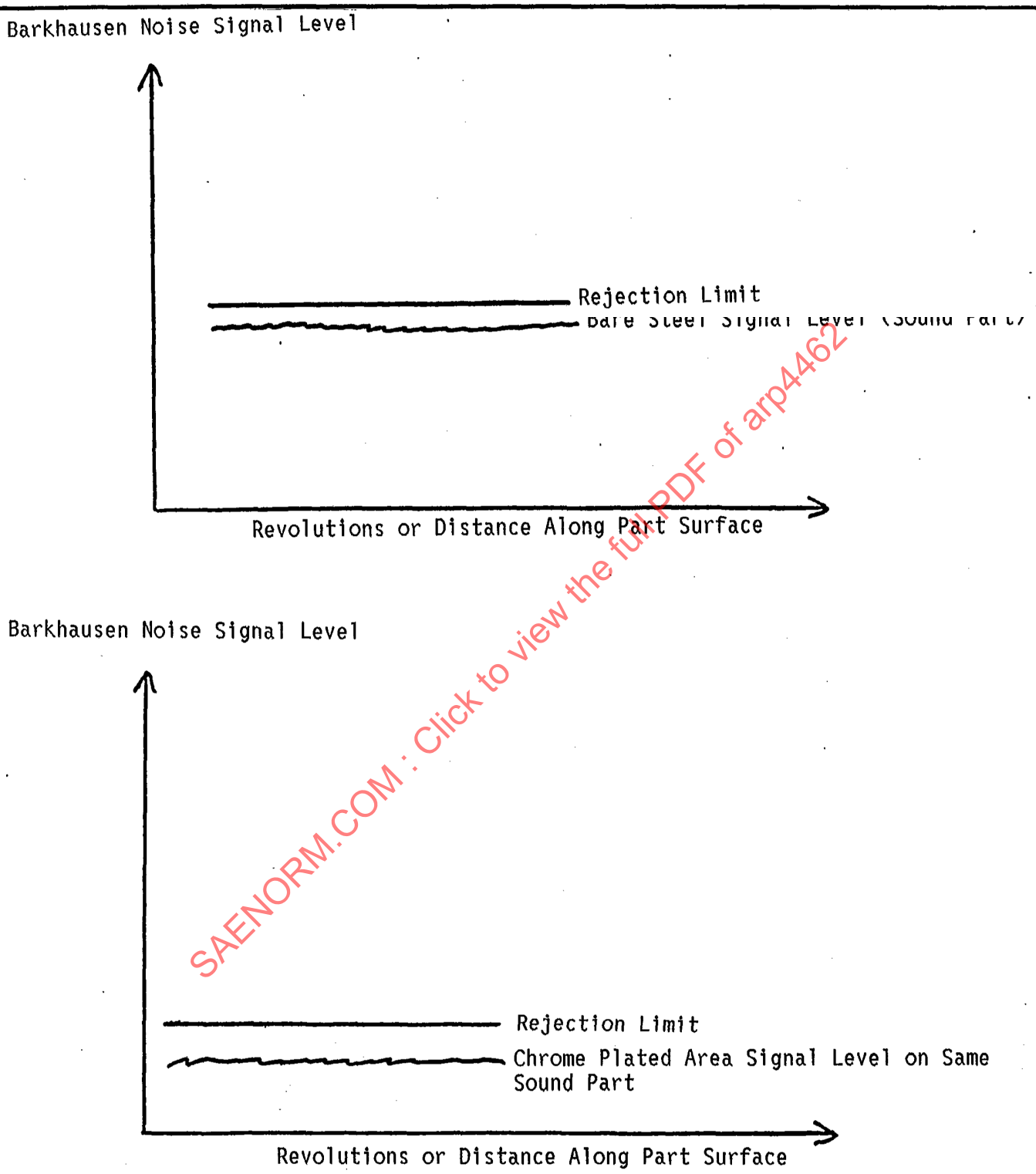

FIGURE 2 - Illustration of Variation in Barkhausen Noise Levels From Bare and Chromium Plated Areas of Same Sound Part

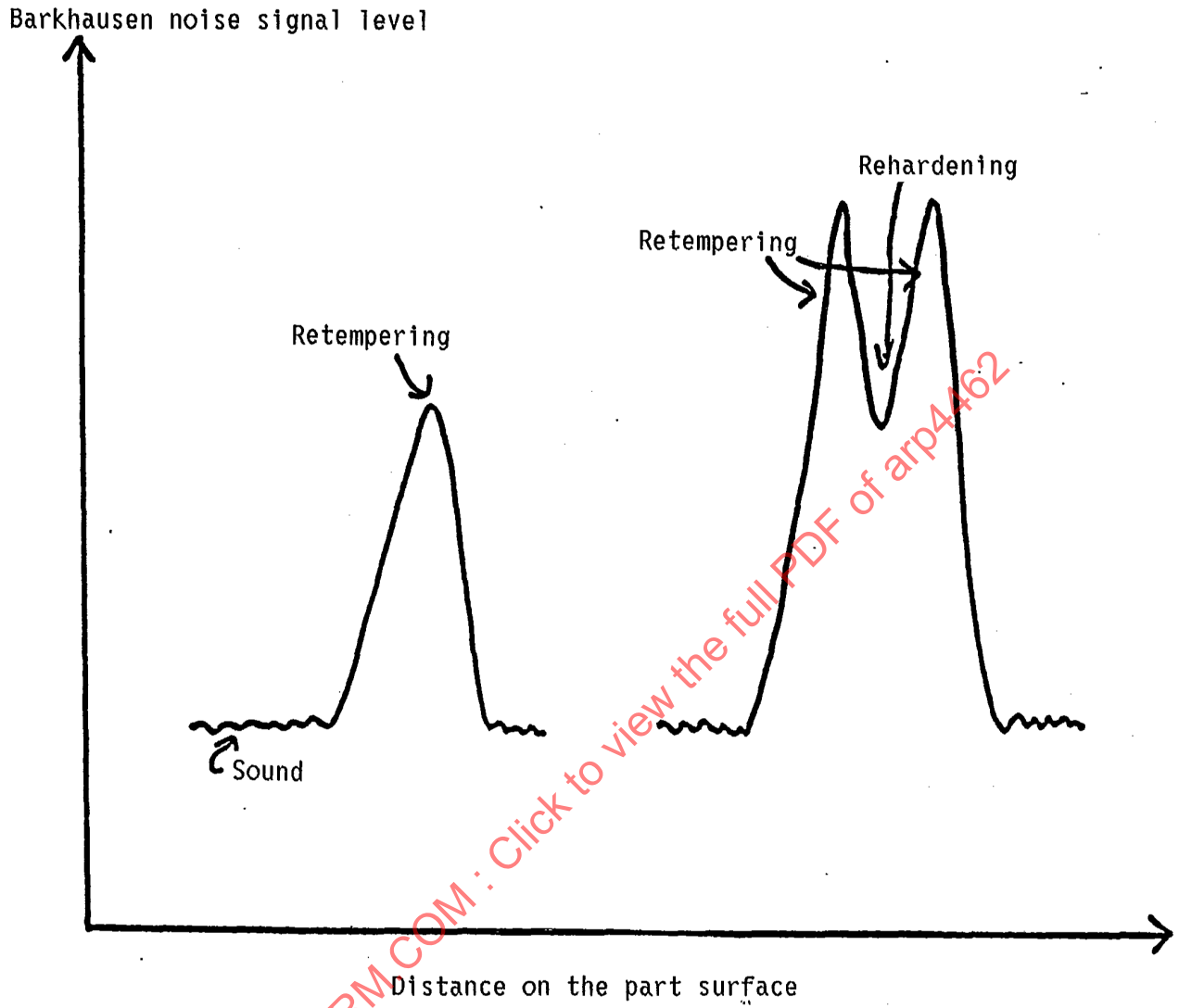

FIGURE 3 - Illustration of the Effect of Retempering and Rehardening Type of Grinding Burn or Heat Treat Defect on Barkhausen Noise