

METHODS OF MEASURING DECARBURIZATION

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. **Scope**—This report covers the recommended practice for the evaluation and measurement of decarburization in ferrous material. Included are definitions of types with charts and micrographs and methods most commonly used for the measurement of decarburization.

2. References

2.1 **Applicable Publication**—The following publication forms a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001

SAE J423—Methods of Measuring Case Depth

3. Definitions

3.1 **Decarburization**—Decarburization is the loss of carbon at the surface of commercial ferrous materials which have been heated for fabrication or when heated to modify mechanical properties.

3.2 **Complete Decarburization**—Complete loss of carbon as determined by examination.

3.3 **Partial Decarburization**—Any measurable loss of carbon content, less than complete, with respect to carbon level of base material.

3.4 **Effective Decarburization**—Any measurable loss of carbon content which results in mechanical properties below the minimum acceptable specifications for hardened material.

4. **Types Of Decarburization**—Three general types of decarburization may be prevalent in ferrous materials dependent on manner and degree of carbon loss from the material. Classifying decarburization into three types may aid in selecting the process necessary to utilize the material to meet a product specification. Accompanying photomicrographs are illustrations of typical conditions which may be encountered.

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- 4.1 Type 1 Decarburization**—Indicated by the curve and photomicrographs in Figure 1, covers that condition in which carbon free ferrite exists for a measurable distance below the surface. Underneath the ferrite will exist varying degrees of partial decarburization.
- 4.2 Type 2 Decarburization**—Indicated by the curve and photomicrographs in Figure 2, covers that condition in which there is a loss of more than 50% of the base carbon at the surface but where no measurable depth of complete decarburization is evident.
- 4.3 Type 3 Decarburization**—Indicated by the curve and photomicrographs in Figure 3, covers that condition where some loss of carbon at the surface is evident but to a degree less than 50% of the base carbon of the material.
- 4.3.1 Further subdividing of Type 3 Decarburization may be necessary for highly stressed members such as spring or high strength materials. In this category, the effective decarburization may be determined by microhardness testing for materials lower than 0.6% base carbon.

Chemical analysis procedures may be required when examining high carbon materials.

- 5. Methods Of Measuring Decarburization**—The common methods used for the measurement of decarburization are:
- a. microscopic;
 - b. hardness, including cross section microhardness traverse, longitudinal traverse, and file hardness; and
 - c. chemical analysis.

The accuracy of the method to be used is dependent on the degree of decarburization, microstructure, and base carbon content of the steel. The metallographic method is sufficiently accurate for most annealed and hot rolled materials, but inaccurate for small amounts of decarburization in high carbon (above 0.60%), high hardness steels. The hardness method is also insensitive in this latter case and recourse must be taken to chemical analysis.

The file method is often suitable for detecting decarburization of hardened materials during shop processing but not for accurate measurement.

It is fundamental that true measure of decarburization lies in chemical analysis for carbon content. This method is normally used only in research investigations or to check accuracy of other methods. With the possible exception of specialized electron microprobe analytical techniques, which are recommended when available, analysis is difficult and slow in application because of limitations of size and section of material. The method of procuring sample itself depends upon shape and hardness of test piece. Parts and/or test specimens too hard to machine should be tempered at 600 to 650 °C (1100 to 1200 °F) to permit machining of surface layers into chips for subsequent carbon analysis. Obviously, a sample which is annealed to permit milling of chips may be modified in its condition of decarburization. Standard methods for carbon determination are described in textbooks of analytical chemistry.

5.1 Microscopic Method

- 5.1.1 **SPECIMEN**—The area to be examined should be cut at right angles to the surface. Samples are preferably taken when the material is in full annealed or in hot rolled condition. Other conditions, such as spheroidized annealed, hardened, or cold worked material, may be examined but care must be used in interpretation. For sections up to 13 mm (1/2 in), the entire cross section is normally mounted for examination. For larger sections, a specimen should be cut to include about 19 mm (3/4 in) of the surface to be examined. Corners of straight sided sections should not be included, since they are not considered representative.

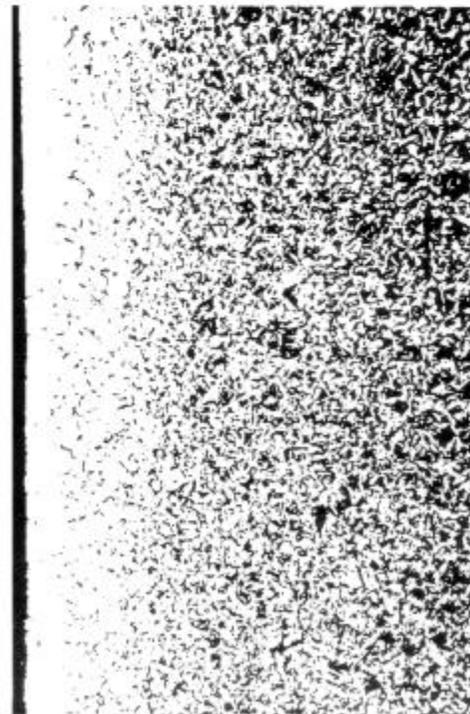
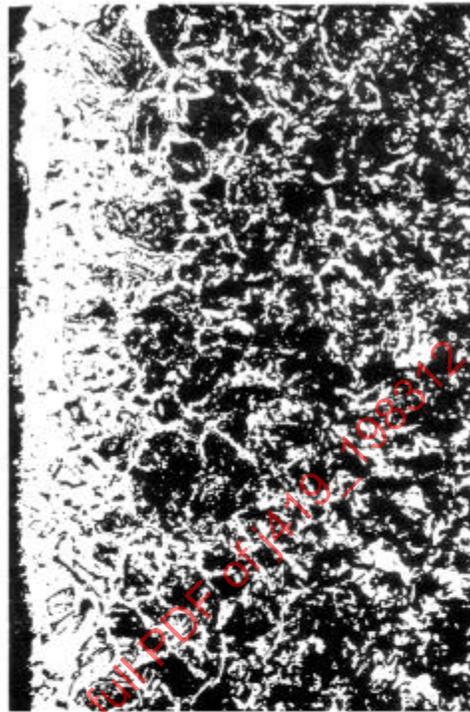
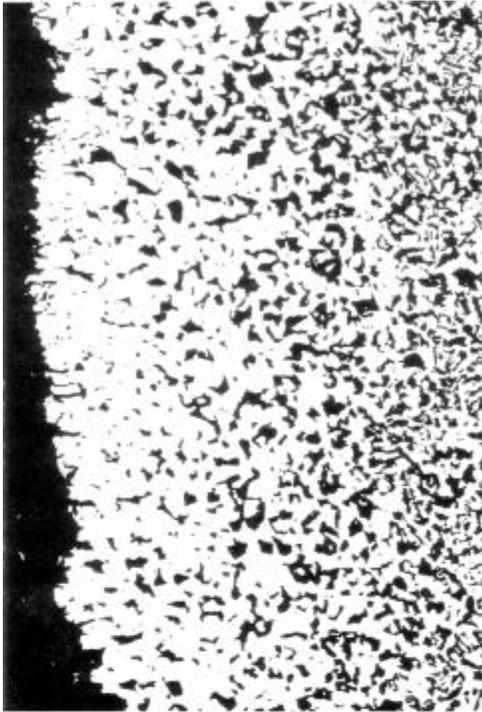


FIGURE 1—TYPE 1 DECARBURIZATION

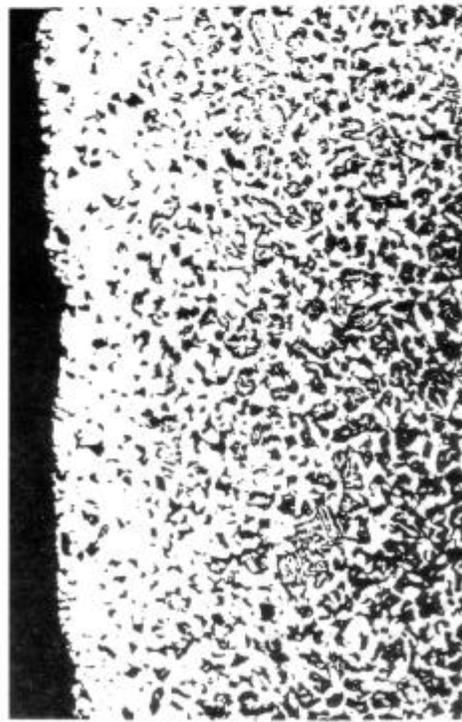
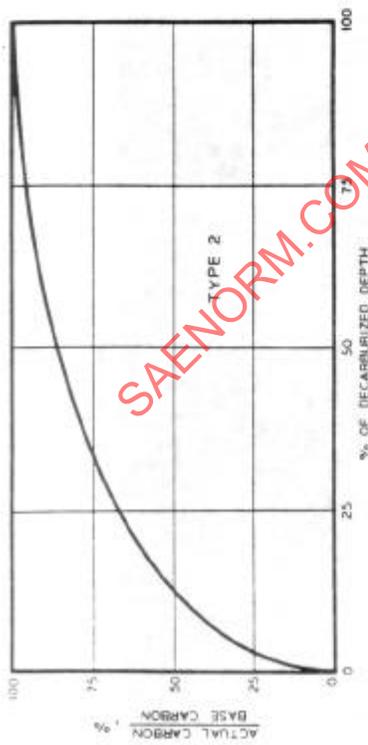
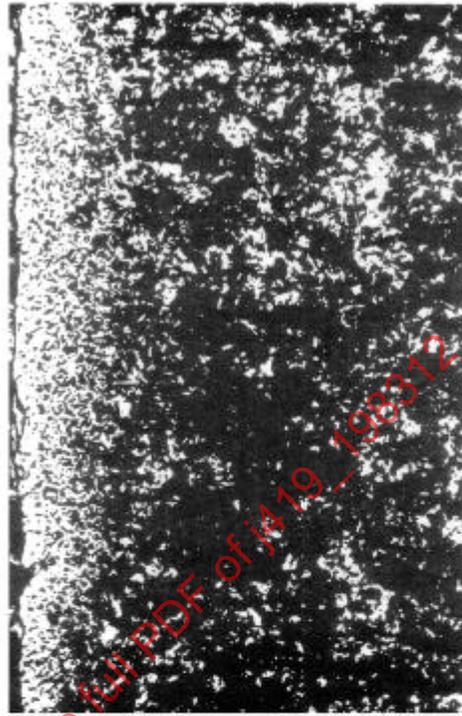
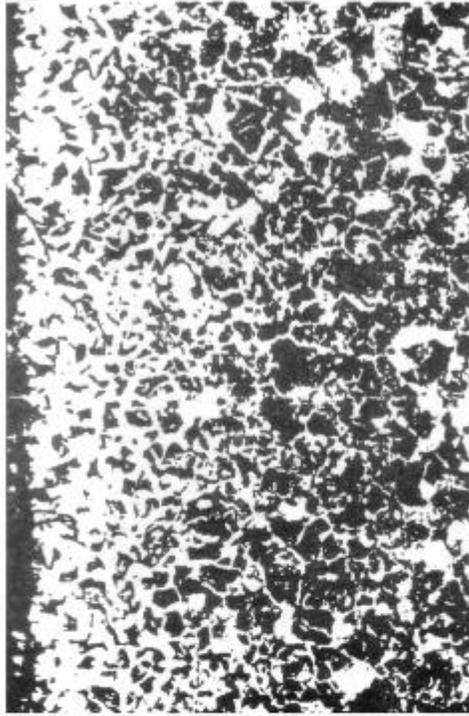
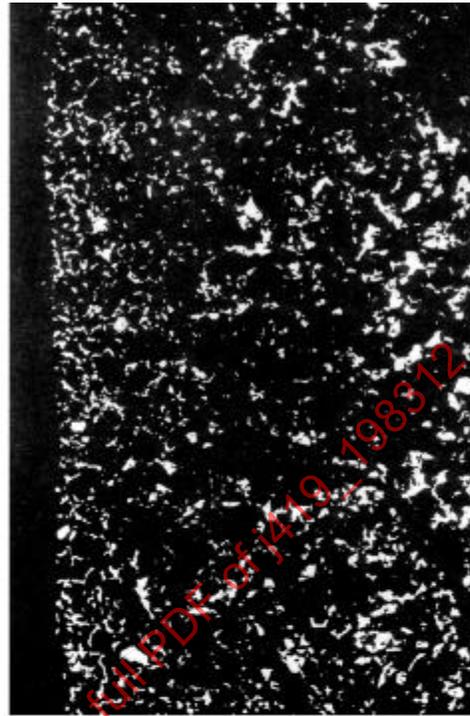
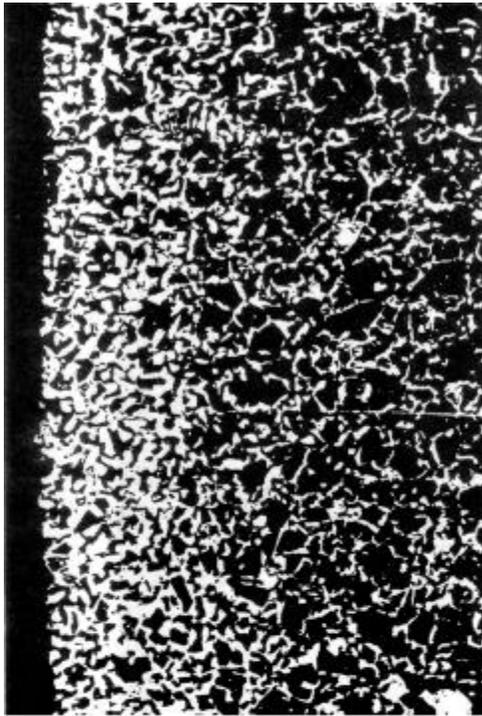
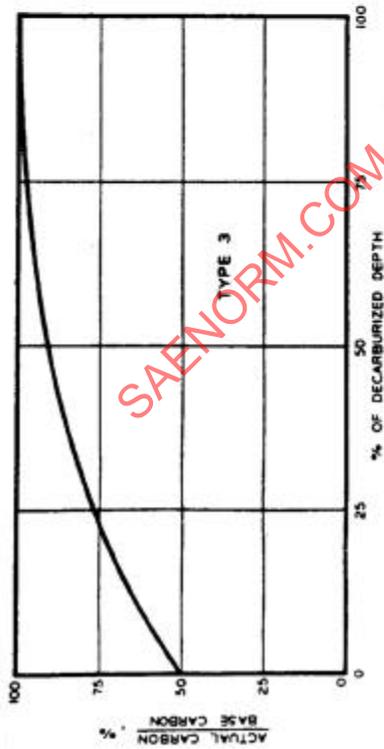


FIGURE 2—TYPE 2 DECARBURIZATION



Magnification 100 X—Nital Etch



TYPE 3 DECARBURIZATION CURVE

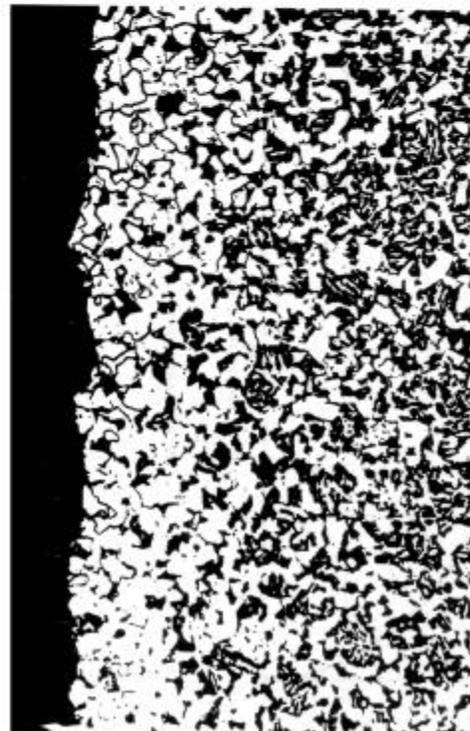


FIGURE 3—TYPE 3 DECARBURIZATION

- 5.1.2 PREPARATION—In mounting the specimen for grinding and polishing, protection from rounding the surface to be examined is essential. The specimen should be mounted in a clamp or in a plastic mount, the latter being the preferred method. An additional method of protection is to deposit (by electroless or electroplating) a metallic coating of 0.03–0.08 mm (0.001–0.003 in) on the specimen before mounting.

After mounting, the surface should be ground and polished in accordance with good metallographic practice.

Etching in a 3% nital (concentrated nitric acid in alcohol) is usually suitable for showing changes in microstructure caused by decarburization.

- 5.1.3 MEASUREMENT—Magnification for examination can be agreed on between purchaser and producer. However, it is recommended that 100X magnification be used. If the microscope is of a type with a ground glass screen, the extent of decarburization can be measured directly with a scale. If an eyepiece is used for measurement, it should be an appropriate type containing a cross hair or a scale.

5.2 Hardness Methods

5.2.1 CROSS SECTION MICROHARDNESS TRAVERSE

- 5.2.1.1 *Specimen*—Sample to be checked should be cut at right angles to the surface. If cross section is too large, a portion of suitable size including surface to be checked should be cut before examination.

- 5.2.1.2 *Preparation*—The specimen shall be hardened by quenching from equipment under conditions which minimize further change in carbon distribution. The time at temperature should be minimized to avoid excessive carbon diffusion. In the case of finished parts, which have been previously quenched and tempered, no further treatment is necessary. For sections up to 13 mm (1/2 in), the entire cross section is normally mounted in plastic. After mounting, the surface should be ground and polished in accordance with good metallographic practice.

- 5.2.1.3 *Measurement*—A series of microhardness impressions made by pyramidal or Knoop indentors should be extended from the surface until the hardness of the base metal is obtained.

5.2.2 LONGITUDINAL TRAVERSE (TAPER OR STEP GRIND)

- 5.2.2.1 *Specimen*—A specimen containing the surface on which decarburization is to be measured is prepared so that it can be manipulated on a superficial hardness tester.

- 5.2.2.2 *Preparation*—If the specimen is not in the hardened condition, it is recommended that it be hardened by quenching from heating equipment under conditions which avoid further change in carbon distribution.

For the taper grind specimen, a shallow taper is ground through the decarburized layer, see SAE Recommended Practice, Methods of Measuring Case Depth—SAE J423. The angle is chosen so that hardness readings spaced equal distances apart will represent the hardness at the desired increments below the surface. Unless special anvils are used on the hardness tester, a parallel section should be prepared so that indentations will be at right angles to the tapered surface.

For the step grind procedure, flats are ground at predetermined intervals below the original surface. These flats should have sufficient area to allow several hardness readings to be taken on each flat.

- 5.2.2.3 *Measurement*—A superficial hardness tester such as a Rockwell Superficial or Vickers Tester using a light load should be employed in making the hardness measurements. The depth of decarburization is defined as the distance measured from the nearest original surface to the point at which no increase in hardness is found.