



Designation: G 79 – 83 (Reapproved 1996)<sup>e1</sup>

## Standard Practice for Evaluation of Metals Exposed to Carburization Environments<sup>1</sup>

This standard is issued under the fixed designation G 79; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

<sup>e1</sup> NOTE—Editorial changes were made throughout in October 1996.

### 1. Scope

1.1 This practice covers procedures for the identification and measurement of the extent of carburization in a metal sample and for the interpretation and evaluation of the effects of carburization. It applies mainly to iron- and nickel-based alloys for high temperature applications. Four methods are described.

<i>Method A</i>	Total Mass Gain
<i>Method B</i>	Metallographic Evaluation
<i>Method C</i>	Carbon Diffusion Profile
<i>Method D</i>	Change in Mechanical Properties

1.2 These methods are intended, within the interferences as noted for each, to evaluate either laboratory specimens or commercial product samples that have been exposed in either laboratory or commercially produced environments.

1.3 No attempt is made to recommend particular test exposure conditions, procedures, or specimen design as these may vary with the test objectives.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- E 3 Methods of Preparation of Metallographic Specimens<sup>2</sup>
- E 8 Test Methods for Tension Testing of Metallic Materials<sup>2</sup>
- E 10 Test Method for Brinell Hardness of Metallic Materials<sup>2</sup>
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>2</sup>
- E 23 Test Methods for Notched Bar Impact Testing of Metallic Materials<sup>2</sup>
- E 139 Practice for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials<sup>2</sup>

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee G-1 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.05 on Laboratory Corrosion Tests.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 03.01.

E 290 Test Method for Semi-Guided Bend Test for Ductility of Metallic Materials<sup>2</sup>

G 1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens<sup>3</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *carbon potential*—the amount of carbon available for reaction in an environment. This amount depends upon the chemical balance of the carburizing and decarburizing agents in the system such as carbon monoxide, hydrogen, carbon dioxide, water vapor, methane, and nitrogen.

3.1.2 *carburization*—the absorption of carbon atoms into a metal surface at high temperatures. The carbon may remain dissolved or form metal carbides. This may or may not be desirable.

### METHOD A—TOTAL MASS GAIN

### 4. Summary of Method

4.1 This method provides a relatively fast, simple, and inexpensive technique for comparing material or environmental variables. The total mass gain of the sample during exposure is considered as a first approximation of total carbon pickup.

### 5. Significance and Use

5.1 This method has an advantage over the other three, which are destructive single-determination techniques, in that successive measurements at selected time intervals can be made without destroying the sample. If unwanted reactions (such as sulfidation and oxidation, which are usually minor under intentionally carburizing conditions) are not important, a mass gain plot versus time can provide some additional insight about carburizing rate or intermittent variables, or both.

### 6. Interferences

6.1 The mass change of a sample may not be entirely the result of carbon pickup. The environment may contain some other corroding species, such as oxygen, that may react with

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 03.02.

the metal surface to form corrosion products which also affect mass change. This type of data also gives no indication of carbon distribution within the material which may be of more importance than total pickup. Considering its limitations, this method is best used in combination with at least one of the other methods described in this practice or when considerable knowledge and understanding exist as to how materials usually perform in the particular conditions of the exposure environment, or both.

**7. Procedure**

7.1 This method assumes the use of a sample that can be readily measured to obtain exposed surface area and weighed both before and after exposure to obtain mass gain per unit surface area, that is, grams per square metre. See Practice G 1.

**8. Discussion of Results**

8.1 The successful application of this technique depends primarily upon the ability to measure small mass changes. All weighing should be done to the nearest 0.1 mg. Section thickness is also important in order to approximate an “infinite” solid thus allowing carbon diffusion from one surface to be unaffected by diffusion from any other surface. A minimum section thickness of at least 12 mm is necessary, particularly with cylindrical samples, for short time exposure in most carburizing environments. When calculating carburization rate, it must be assumed that carburization as measured by mass gain is not linear with time.

**METHOD B—METALLOGRAPHIC EVALUATION**

**9. Summary of Method**

9.1 The sample is cut, polished, and etched to accentuate the carbide structure. The extent of carbon penetration sufficient to form insoluble carbides is then measured directly on a magnified area.

**10. Significance and Use**

10.1 The carbon penetration number refers to the point at which insoluble carbides are first formed. It does not indicate the total depth of carbon penetration. Metallographic measurement of carbon penetration can be used by itself for evaluation of materials. It can be particularly useful when combined with total mass gain data to give some indication of the solubility and mobility of carbon in the exposed material as suggested by the following:

Mass Gain	+	Penetration	=	Solubility	and	Mobility
low		low		low		low
low		high		low		high
high		low		high		low
high		high		high		high

**11. Interferences**

11.1 The major limitation of this method lies in the fact that it is sometimes very difficult to differentiate visually between carbides that have formed from carbon diffused into the metal from the exposure environment and those that formed from carbon inherent in the composition of the alloy. An example of

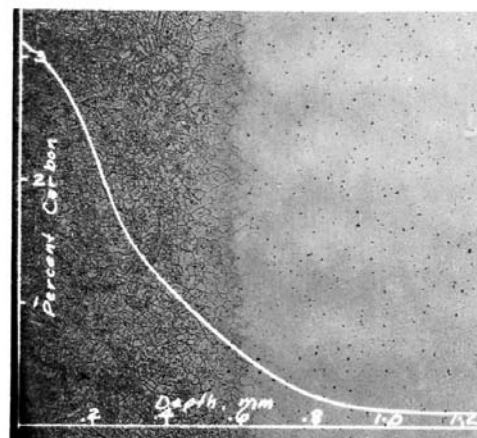
this situation is illustrated by comparing the relatively distinct carburized layer boundary in Fig. 1 with the more diffuse area in Fig. 2. This is particularly true of nominally high carbon-content alloys. In these cases, the depth of carbon penetration becomes a judgment based on density of the precipitated phase.

**12. Procedure**

12.1 Success with this method requires that close attention be paid to Methods E 3. The sample is first cut so that the final viewing axis will be perpendicular to the direction of carbon diffusion. After polishing, the specimen is usually etched with a suitable acid mixture to delineate carbides. Some particularly useful etchants are listed in Table 1. The sample is viewed at a magnification of between 50× and 100×. The depth of carbide precipitation is then determined with the microscope’s measuring recticle or other system such as a glass screen and appropriate scale. For example, the sample shown in Fig. 1 appears to have a carbide precipitation depth of about 0.6 mm. Carbon penetration may in some cases be very uneven due to intergranular or other localized acceleration of diffusion. The penetration depth shall thus be taken as at least the average of three measurements each in several areas. Some measure of variability is also necessary such as a standard deviation or other indication. In all cases preview the entire mounted specimen prior to measurements so that any areas of nonuniformity can be identified. It is helpful to compare photomicrographs of exposed samples with a standard that has received the same temperature and time exposure but without the external carbon potential. Alternatively, if the exposed sample has a large enough cross section, the surface carbide density can be compared with the unaffected core area.

**13. Discussion of Results**

13.1 Comparisons of carbon solubility and mobility indications are most accurate and meaningful when the boundary between the carburized and uncarburized areas is uniform and well delineated. When this boundary is vague or highly variable, results can be misleading. Statistical analysis cannot necessarily salvage vague measurements. It is best to avoid this technique unless the measurements can be made easily and unequivocally.



**FIG. 1 Microstructure of Carburized Sample with Superimposed Carbon Diffusion Profile (75×)**