## 1.0 SCOPE

This specification establishes photomicrograph standards for guidance in maintaining acceptable microstructures in carburize hardened parts. The primary constituent in a carburize hardened microstructure shall be composed of martensite (tempered as required). This specification establishes measurements for the secondary constituents in the martensitic matrix.

## 2.0 APPLICATION

**For metallographic rating purposes, only printed copies from Design Control A556 are to be used. Reproduction of the photomicrographs in this specification for metallurgical inspection purposes is strictly prohibited.** Original copies are available through T&SD Heat Treat Engineering, Design Control A556. This specification is applicable to all standard carburize and hardening combinations of heat treatments except 1E2204 carburize in combination with 1E0288 induction hardening.

## 3.0 ACCEPTANCE STANDARDS

**3.1** Unless otherwise qualified, microstructure quality levels for each micro-constituent requiring control are designated in the carburize hardening specifications or by precedence in a commodity specification. Quality levels are designated as acceptable, borderline, and rejectable. Borderline level implies tentative acceptance of immediate production quantities provided action is taken to bring subsequent parts produced up to acceptance levels. Photographs in this specification are polished samples of carburize hardened structures, lightly etched with nital, and observed at 500 magnifications.

**ON-LINE VIEWERS NEEDING BETTER RESOLUTION OF PHOTOS THAN AVAILABLE ON SCREEN SHOULD CONTACT DESIGN CONTROL.**

**3.2** The photomicrographs are identified alpha numerically. The letter designates the micro-constituent under evaluation (see Figure 1) and the number indicates the relative quantity or depth present.

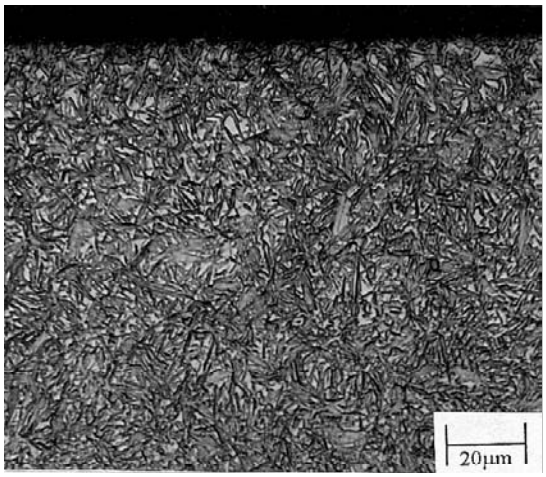
| | |
|---|---|
| A | Series Retained Austenite |
| C | Series Carbide Networks |
| B | Series Surface Bainite/Pearlite |
| BB | Series Subsurface Bainite |
| M | Series Microcracks |
| O | Series Oxides |
| F | Series Ferrite |
| D | Series Decarburization |
| DC | Series Direct Quench Carbides |

Figure 1

## 4.0 REFERENCES

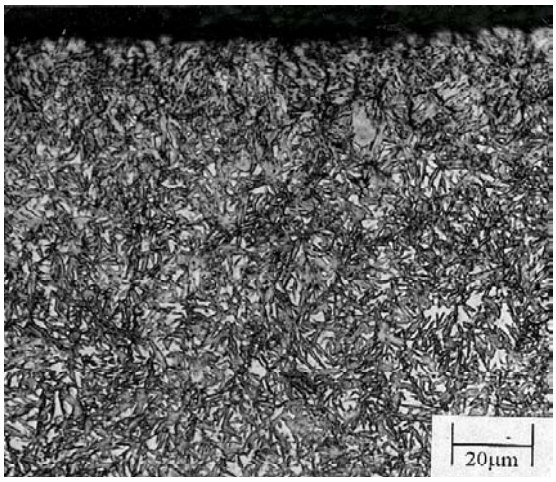
Caterpillar Specifications 1E0288, 1E2204

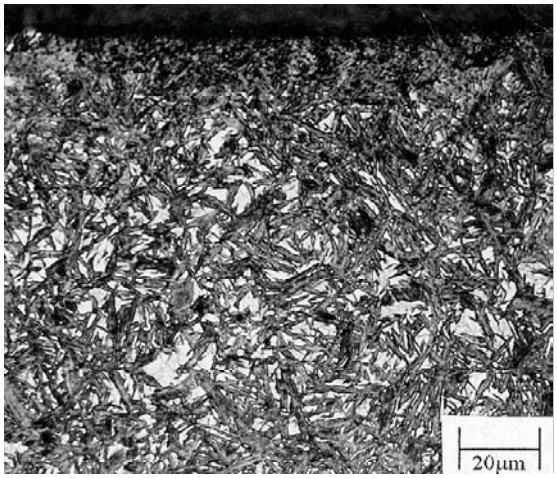
## RETAINED AUSTENITE (500 MAGNIFICATIONS)




A1
24%

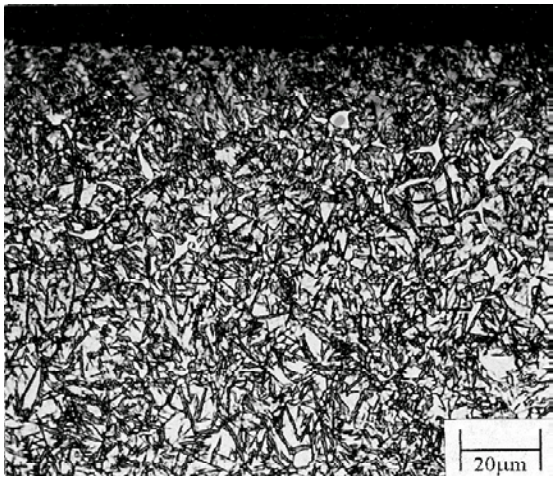
A2
30%

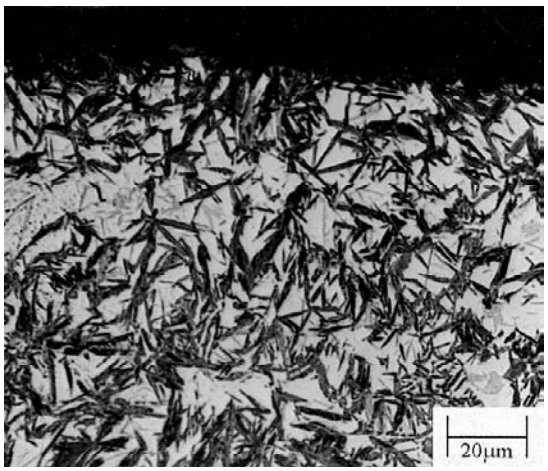



A3
36%

A4
48%




A5
55%

**Note:**

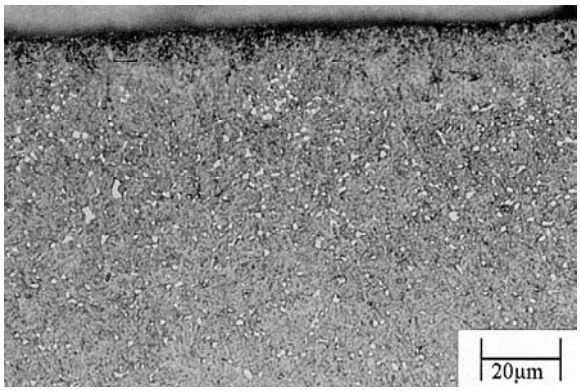
1. Designated percentages of retained austenite were obtained from x-ray diffraction. Optical estimates will tend to be lower.

2. These photomicrographs are direct quenched microstructures. Reheat hardened structures will at times be more refined, making optical estimations difficult.

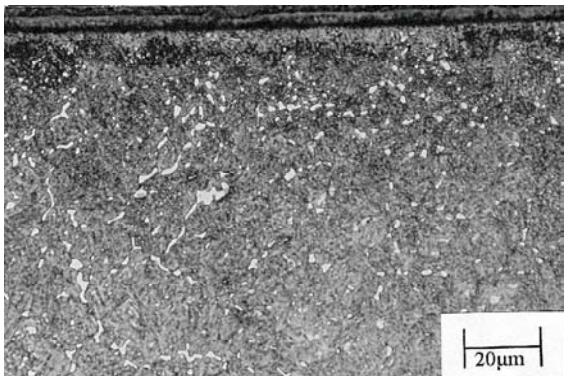
3. Unless otherwise specified, final acceptance of retained austenite shall be upon conformance to surface hardness requirements.

## NETWORK CARBIDES (500 MAGNIFICATIONS)

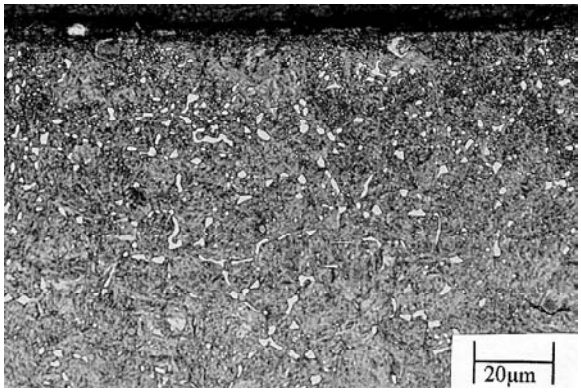
C1



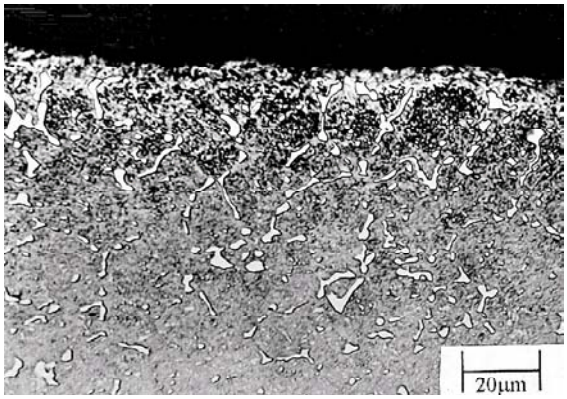

C2



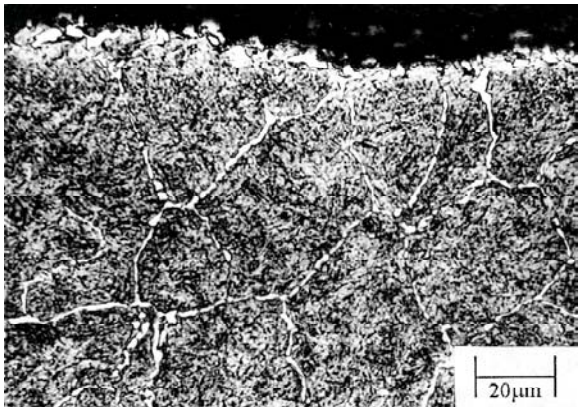

C3



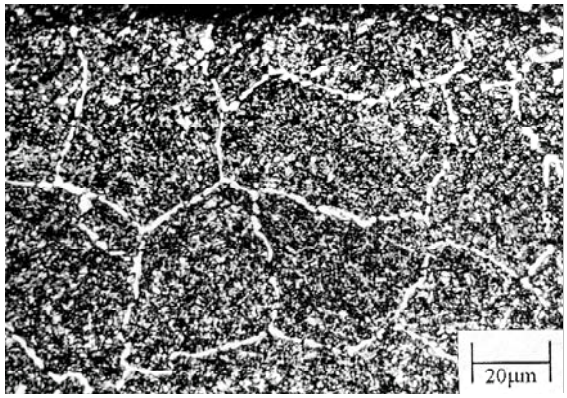

C4




C5



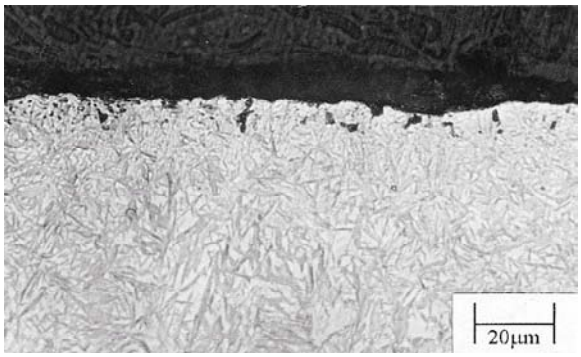

C6



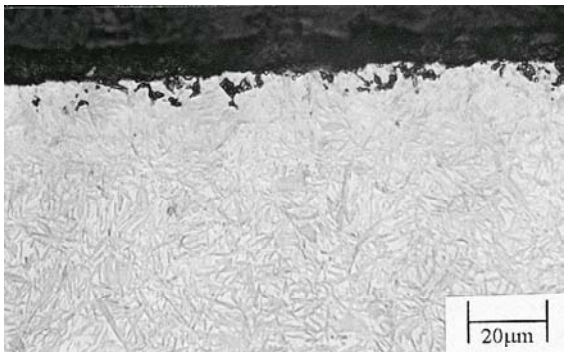

**Note:** Carbide ratings should be based on shape and tendency to form a carbide network, not on size or depth.

## SURFACE BAINITE/PEARLITE (500 MAGNIFICATIONS)

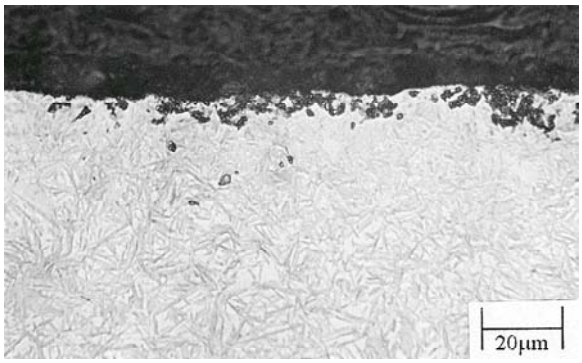
B1



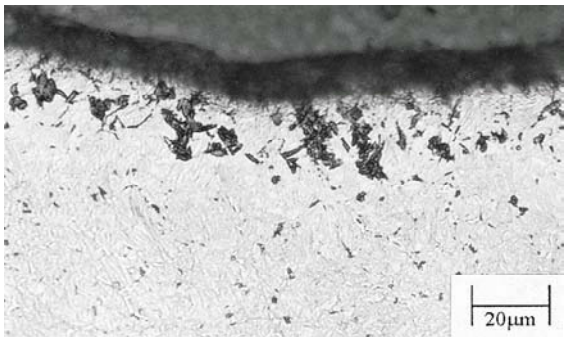

B2



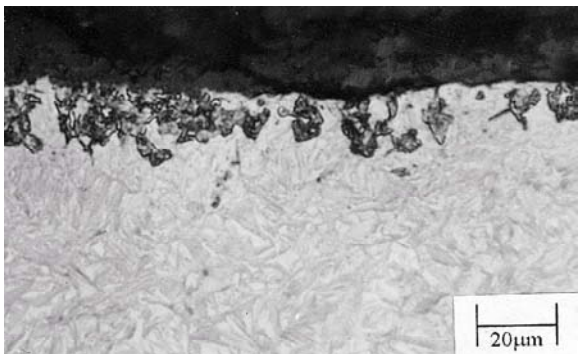

B3



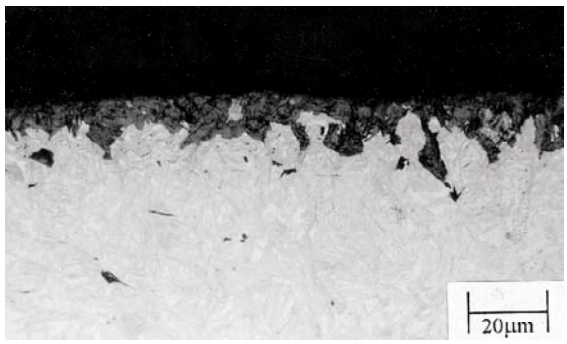

B4

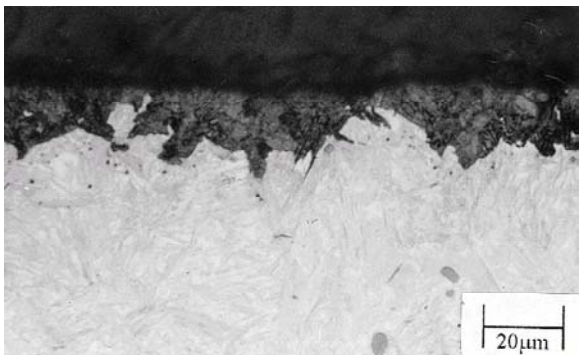



B5




B6

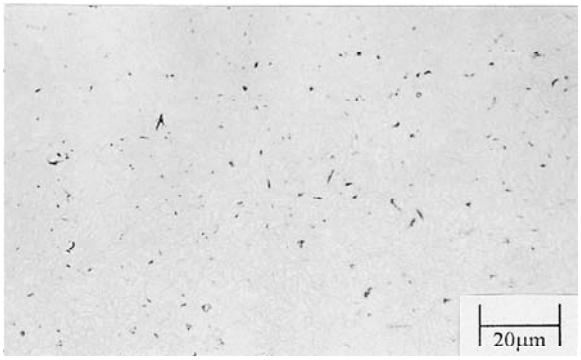


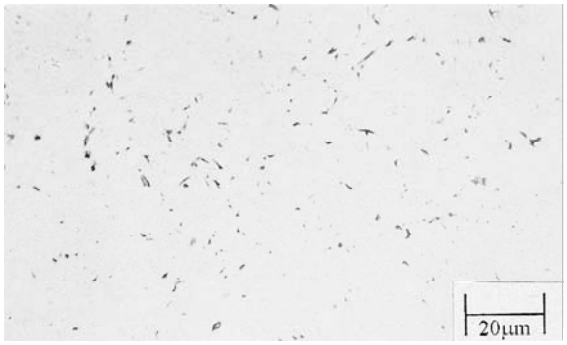

**Note:** Bainite/Pearlite ratings should be based on tendency to form a continuous layer, not on the depth of individual islands.

## SUBSURFACE BAINITE (500 MAGNIFICATIONS)

BB1

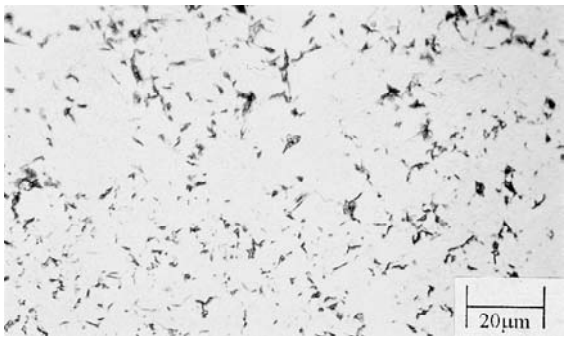



BB2

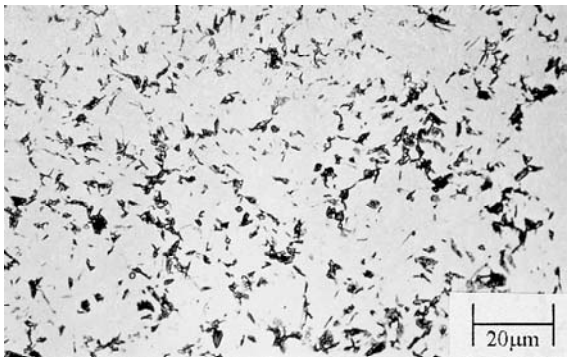



BB3


BB4




BB5




BB6


BB7


**Note:** Subsurface bainite ratings should be based on tendency to form a continuous layer, not on the depth of individual islands.

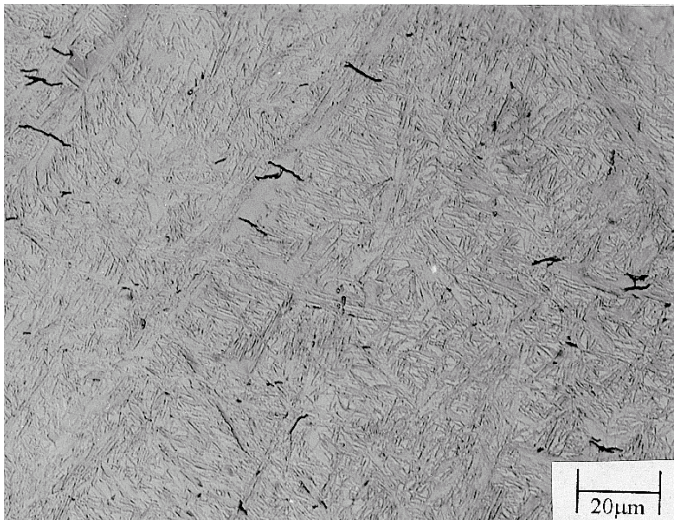
## MICROCRACKS (500 MAGNIFICATIONS)

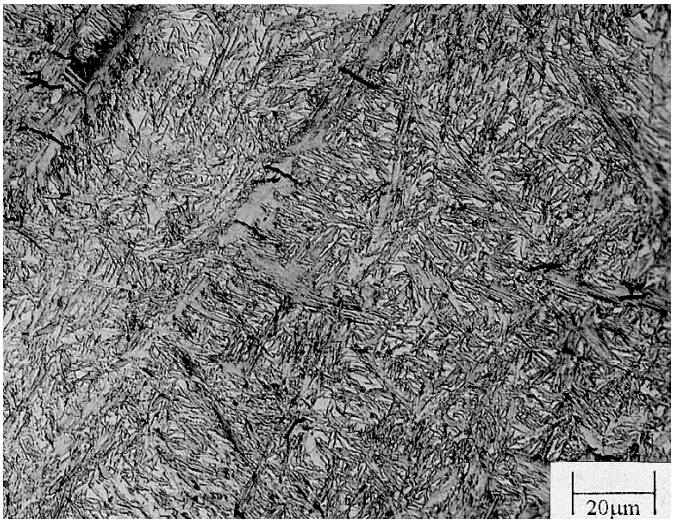

M1

**Note:** A specimen shall be rated as M1 or higher under either of the following conditions:

1. Seven or more microcracks are visible in any field at 500X.

2. The longest microcrack in any field at 500X is 4 mm or longer.



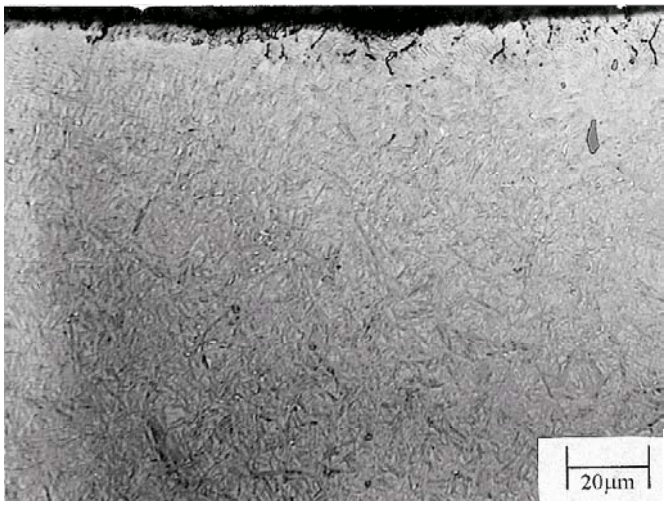




M2 M2[1]

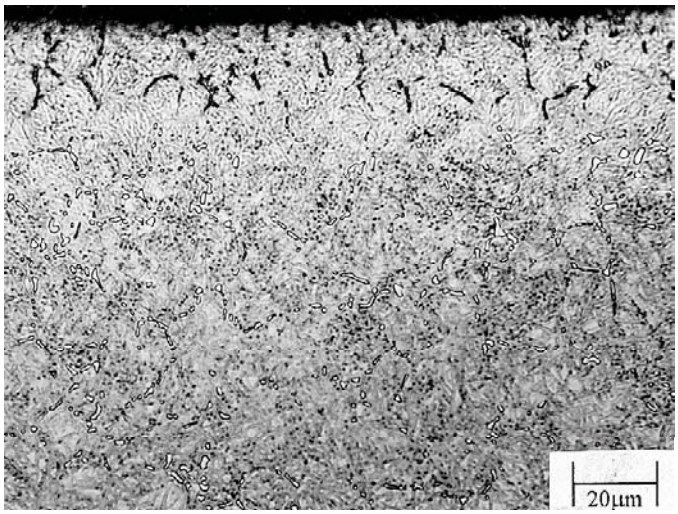
**Note:** M2 is an example of resolution of microcracks by light etching. M2[1] is an example of masking of microcracks by dark etching, which improves resolution of martensite and retained austenite but tends to obscure resolution of microcracks. M2 and M2[1] are from the same sample and field.

## OXIDES (500 MAGNIFICATIONS)

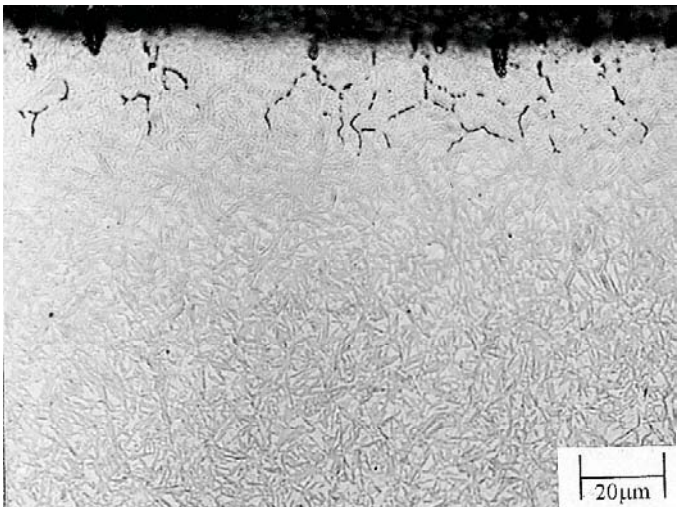

O1 (4 micrometers)




O2 (12 micrometers)



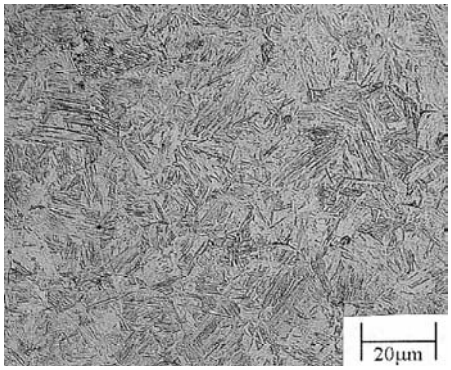

O3 (24 micrometers)




O4 (32 micrometers)

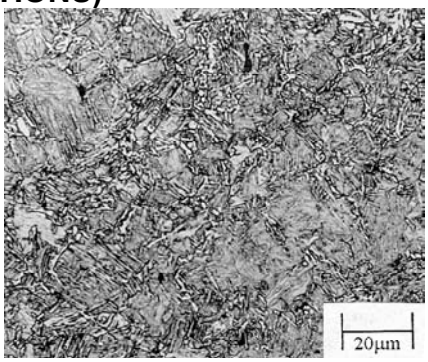
**Note:** Oxide rating should be based on depth rather than continuity.

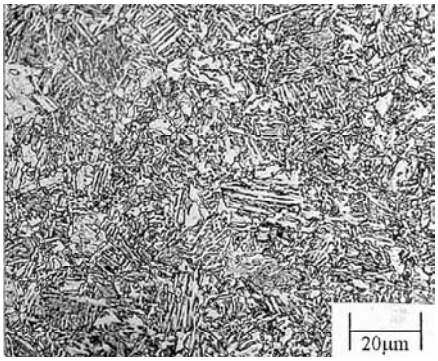
## CORE FERRITE (500 MAGNIFICATIONS)




F1 43 HRC

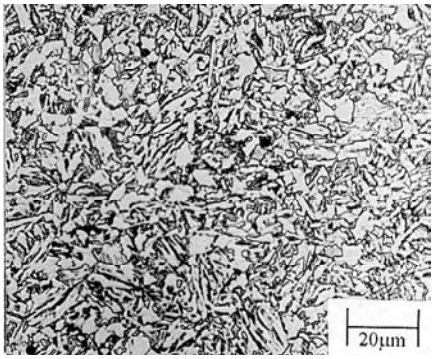
F2 38 HRC

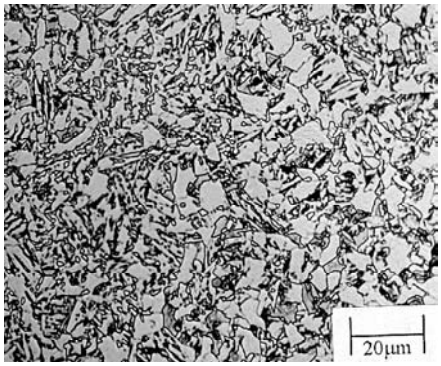



F3 30 HRC

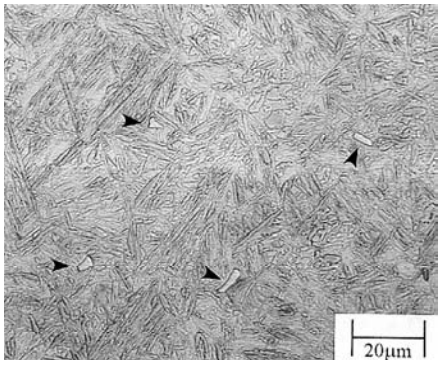
F4 25 HRC




F5 20 HRC

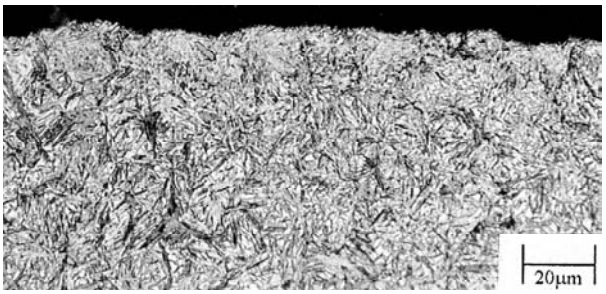
**NOTE:** F1 – F5 show transformation ferrite formed upon cooling from a fully austenitic condition. F6 and F7 show islands of undissolved or blocky ferrite, evidence of incomplete austenization prior to quenching.




F6

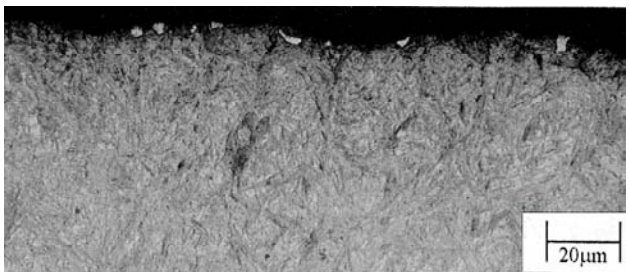
F7

## DECARB (500 MAGNIFICATIONS)

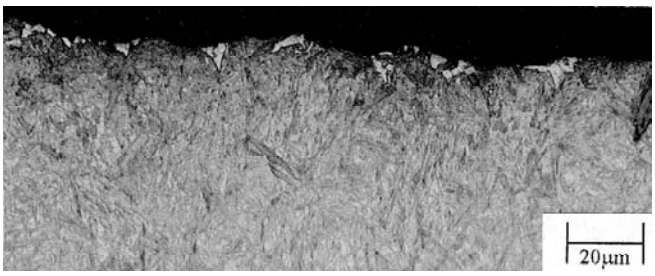


D0 - No Ferrite

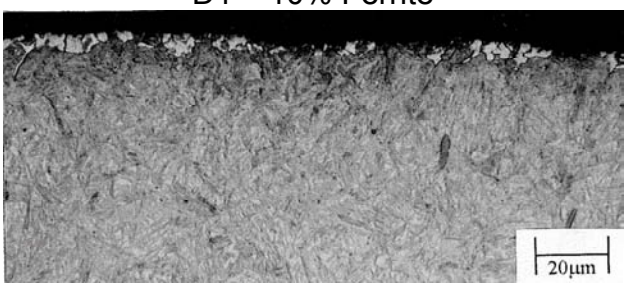
**NOTE:** The D1 rating should be used to indicate percent surface ferrite for levels of decarburization less than a continuous surface layer. D2-D4 represents various depths of continuous surface ferrite layers.



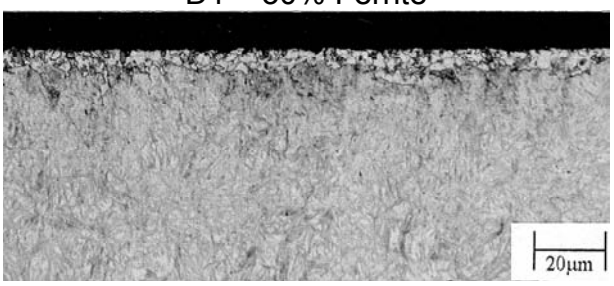
D1 – 10% Ferrite



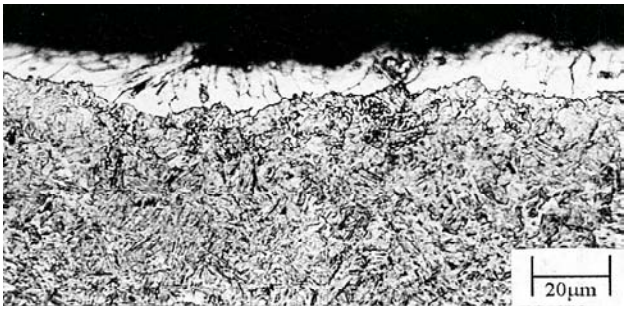
D1 – 30% Ferrite



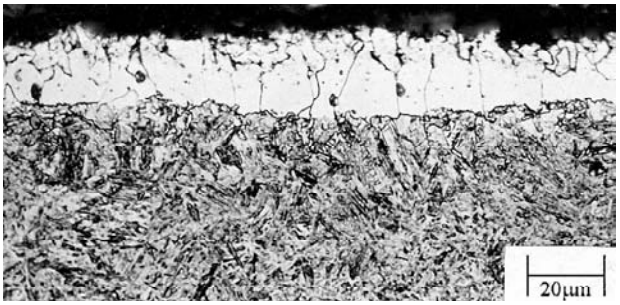
D1 – 50% Ferrite



D2 – 100% Ferrite



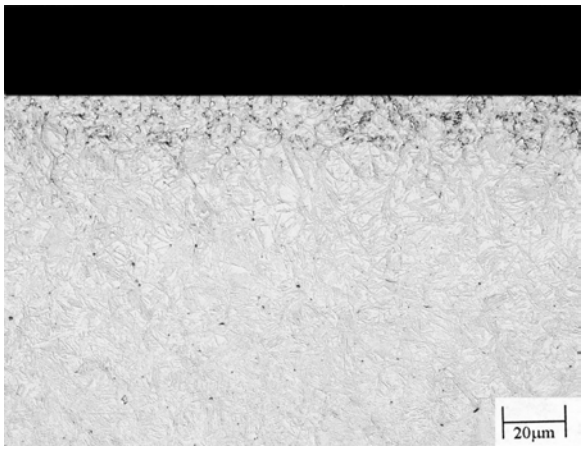
D3



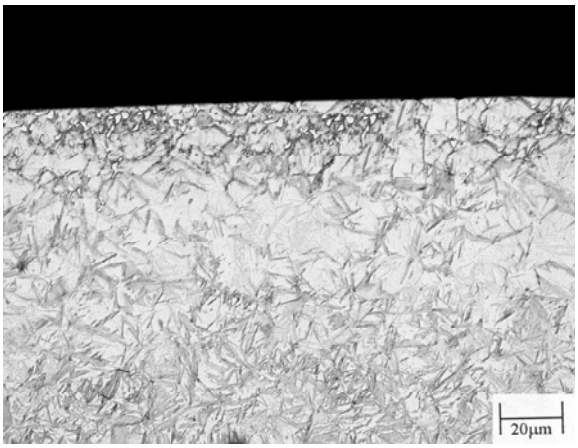
D4

## DIRECT QUENCH CARBIDE (500 MAGNIFICATIONS)

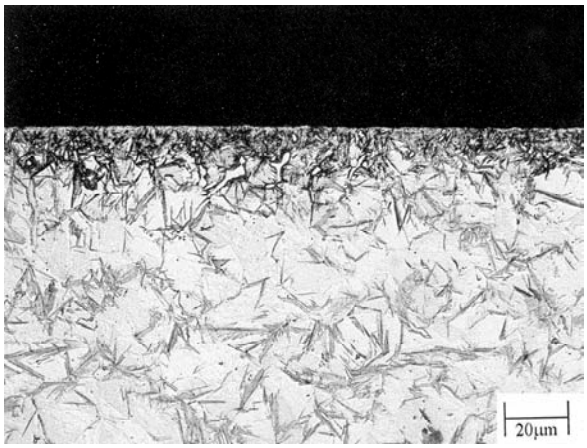
**DC1**



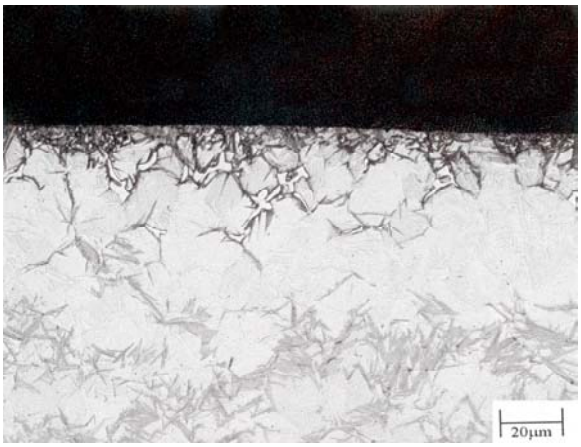

**DC2**




**DC3**




**DC4**




**DC5**