

# Minimox®

## Reduction Of Carburization of 330 Stainless Steel With Minimox® Self-Protective Alloy Treatment

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### Summary

*Minimox-treated and oxidized 330 alloy successfully reduced carbon uptake at 593°C during pack carburization experiments.*

The corrosion process of carburization occurs by ingress of carbon into high alloy steels and subsequent internal carbide formation. This action embrittles the steels and causes crack formation and loss of oxidation resistance.

At first consideration, the use of a non-continuous dispersion of nanoparticles would not be expected to reduce carbon uptake. However, after Minimox-treated surfaces are oxidized, the oxide that forms is uniform with an ultrasmall grain size. As discussed in the literature,<sup>1,2</sup> "If alloys can form a continuous oxide scale on their surface, carbon diffusion through the oxide scale is slowed and carbon accumulation in the alloy diminishes."

Therefore, if a uniform oxide significantly reduces carbon uptake, alloy treatment with Minimox and subsequent oxidation is anticipated to further reduce this degradation when compared to oxidation without Minimox solution treatment. This supposition is based upon the fact that Minimox-assisted thermal oxides are more impervious than traditional thermal oxides.

Alloy 330 coupons were partially coated with Minimox® solution, followed by oxidization at 600°C for 10 hours to form a substantial, uniform oxide layer. The samples were then subjected to pack carburization experiments at 593°C (the temperature where carbon activity is highest) for 600 hours.

One side of the test coupons were machined to a 220 finish while the second side remained the mill finish Figure 1 shows the partially treated coupon after oxidation. Figure 2 shows a parallel sample after the pack carburization testing. For comparison, Figure 3 shows an untreated/unoxidized sample after carburization.

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<sup>1</sup>K. Natesan, Z. Zeng, and D. L. Rink, "Metal Dusting Research at Argonne National Laboratory," MTI Meeting at Orlando, FL, February 20-22, 2006.

<sup>2</sup> Natesan & Zeng, "Metal Dusting Degradation and Mitigation in Structural Alloys," *Hydrocarbon World*, **5(1)**, (2010) 35-38.

Technical  
Bulletin

Carburization  
Reduction  
330 Stainless  
Steel

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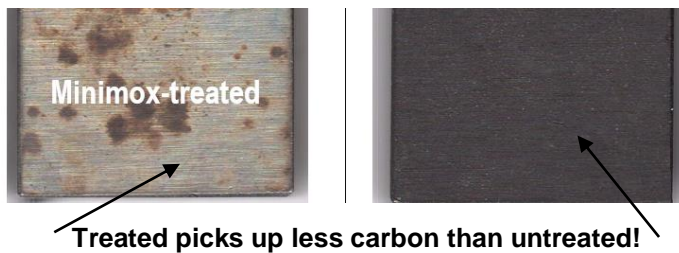
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Steel

Machined surfaces ↓		
		
Mill-finish surfaces ↓		
		
Figures 1a, 1b. Bottom half of each of these coupons is Minimox treated. Coupons were oxidized at 600°C, 10 hrs.	Figures 2a, 2b. Partially Minimox-treated & oxidized coupons after carburization test.	Figures 3a, 3b. 330 stainless after carburization, without Minimox or oxidation.
<b>When Figure 2 is compared to Figure 3, Minimox treatment and oxidation significantly reduces carbon uptake.</b>		

Although not perfect (some oxidation was noted, but not carburization), Minimox-treated and oxidized 330 stainless certainly takes up less carbon than untreated.



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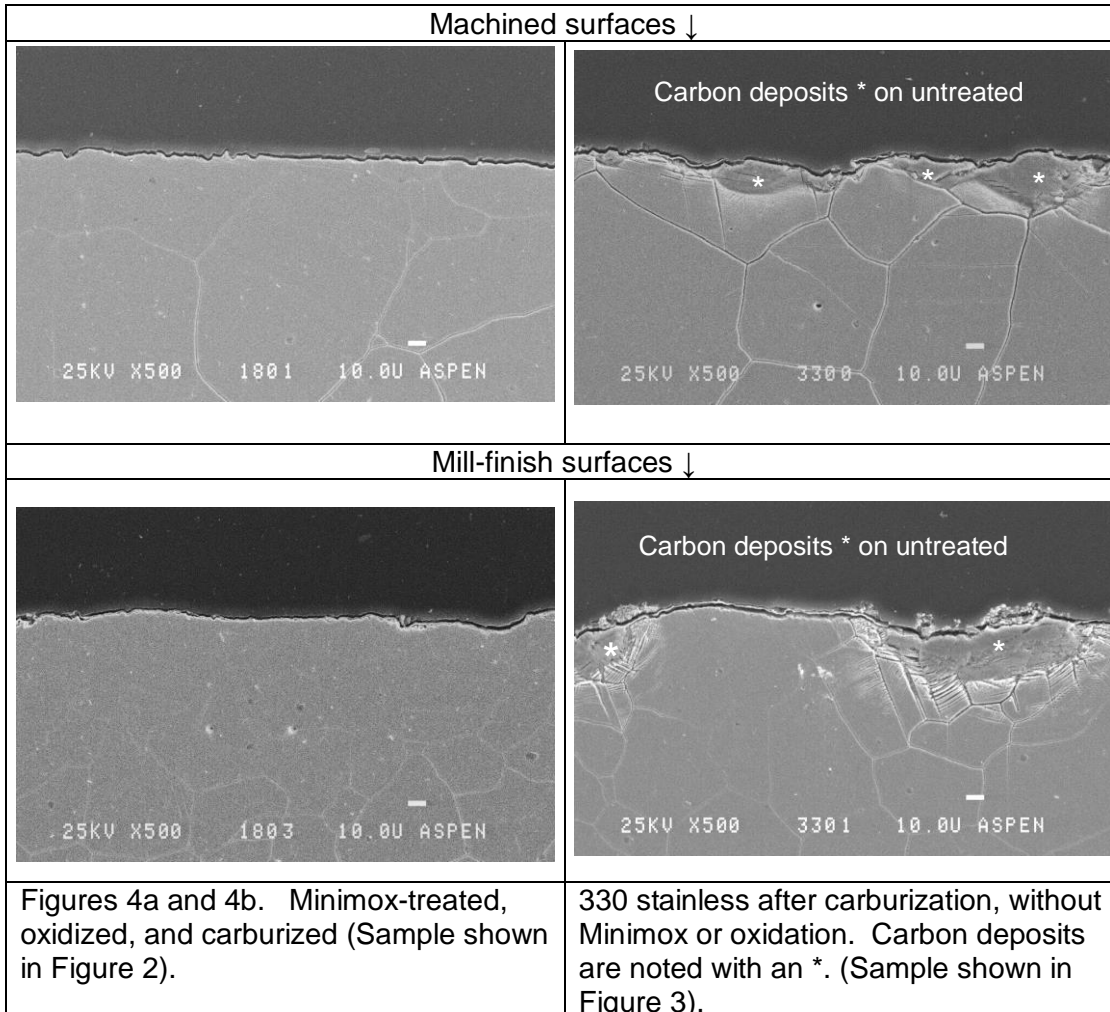
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These samples were mounted and polished in cross section to look at the depth of carbon ingress.



**On the untreated samples, carbon deposits to depth of approximately 30µm, i.e. over 1 mil, were common. No significant carbon deposits were found on the Minimox-treated and oxidized samples.**

Similarly, Minimox-treated and oxidized 601 alloy exhibited reduced loss in metal dusting experiments. Please see our additional Technical Bulletin on this subject:

<http://minimox.com/wp-content/uploads/2014/03/Minimox-Dusting-Reduction.pdf>

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