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Operating and Trouble Shooting of Hot Black Oxide Baths for Steel Alloys

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What is Black Oxide?

Mild Steel

- Black oxide process converts metallic iron surface Fe^0 to Fe_3O_4 (magnetite) by controlled oxidation.
- Fe_3O_4 is a complex of FeO (ferrous oxide) and Fe_2O_3 (ferric oxide).
- Red Rust is Fe_2O_3

What is Black Oxide (cont.)?

Stainless Steel

- Magnetite
- CrO_2 chromium dioxide black
- $CrOH_3$-H_2O chromic hydroxide (black)
- Ni oxide
- Sulfides of Fe, Ni, and Cr

Why Black Oxide?

- Attractive black finish
- Increased corrosion resistance
- No dimensional change
- Lubricating qualities
- Economy and ease of application

Functional uses of Black Oxide:

- Absorbent base of rust preventives
- Reduced coefficient of friction
- Adhesion promoter for organic coatings
- Improved bonding of rubber
- Reduced eye fatigue – anti reflective
- Light and heat absorption
- Anti-galling properties
- Metal forming after blackening

Typical Process for Steel and Stainless Steel

1. Alkaline Clean
2. Rinse
3. Acid Pickle (activate):
    a) Mild Steel – only when scale, rust or oxides are present.
    b) Stainless Steel – all alloys, 2-7 minutes.
4. Blacken:
    a) Mild Steel - @285°F. rolling boil
    b) Stainless Steel - @255°F. rolling boil
5. Rinse
6. Sealer

Typical Blackening Times

Mild Steel	Stainless Steel
Low carbon: 10 min.	Need contact with mild steel
High carbon: 10-15 min.	300 series: 5-7 min. max
Tool steel: 30-60 min.	400 series: 2-5 min. max
Examples: A-3, H11,S7, etc.	pH 17-4: 2-5 min. max
Heat Treated Steel: 15-20 min.	Ductile and cast iron: 2-7 min.

Base Metal Effect of Mild Steel

- Rust: Must be removed. Rust in equals rust out
- Scale: Must be removed
- Surface smut: De-smut prior to blackening
- Matte Finish: Results in a matte black
- Polishes Finish: Bright shiny black
- Heat Treated: Scale common, prone to smutting
- Induction Hardened: May produce off-color results. Require longer activation and blackening times
- Tools Steel: Usually require extended blackening times

Trouble Shooting Hot Black Oxide for Mild Steel

Problem

Loose, red oxide that wipes off

Causes and Corrective Action

- Transfer time too long
- Rectifier needed (too much coloidal iron present)
- Temperature too high
- Solution dries on

Trouble Shooting Hot Black Oxide for Mild Steel

Problem

Red iron oxide that does not wipe off

Causes and Corrective Action

- Transfer too long
- Temperature too high
- Heat treat scale present
- High silica alloy (>3%)
- High Carbon Alloy (>1%)

Trouble Shooting Hot Black Oxide for Mild Steel

Problem

Red cast/ back ground

Causes and Corrective Action

- Galvanic problems
- High chrome alloy
- Need longer immersion time
- Temperature too high

Trouble Shooting Hot Black Oxide for Mild Steel

Problem	**Causes and Corrective Action**
Green cast / brown	• Temperature too low • Add salts • Increase temperature at boil • Rust present prior to black

Trouble Shooting Hot Black Oxide for Mild Steel

Problem	**Causes and Corrective Action**
Blotchy black uncoated areas	• Poor cleaning • Nesting • Transfer time too long • Increase part agitation • Improve cleaning

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Trouble Shooting Hot Black Oxide for Mild Steel

Problem	**Causes and Corrective Action**
Smutty black (rubs off)	• Carbon on surface • Tool steel alloy • Too long of an acid pickle • Return to cleaner to desmut

Trouble Shooting Hot Black Oxide for Mild Steel

Problem	**Causes and Corrective Action**
No blackening	• Chrome contamination • Oxidizers depleted • Loss of boil • High surface area

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Base Metal Effect on Stainless Steel

• 200 and 300 Series	Non magnetic; 3-5 minute activation required. 5-7 minutes blackening. Blackens best in contact with mild steel.
• 302 and 303 Alloys	Sometimes require special activation step.
• 309 and 310 Alloys	Requires 3-hour activation.
• 400 Series and PH Series	Magnetic; May require pre-passivation. 2-7 minutes activation. 5-7 minutes blackening.

Trouble Shooting Hot Black Oxide for Stainless Steel

Problem	**Causes and Corrective Action**
No blackening	• Contact with mild steel • Surface not activated • Increase pickle time • Surface oxides – requires passivation • Bath damaged by overheating

Trouble Shooting Hot Black Oxide for Stainless Steel

Problem

Smutty black

Causes and Corrective Action

- Too much pickle time
- Over activation
- Bath requires skimming
- Bath need desludging
- Parts need passivation
- Temperature to high

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Trouble Shooting Hot Black Oxide for Stainless Steel

Problem

Iridescent colors

Causes and Corrective Action

- Temperature too low
- Temperature too high
- Needs contact with mild steel
- Bath damage by overheating

Trouble Shooting Hot Black Oxide for Stainless Steel

Problem

Blotchy and uncoated

Causes and Corrective Action

- Poor cleaning
- Nesting
- Need Contact with mild steel
- Poor surface finish
- Increase agitation
- Improve cleaning

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