

Particle

5/16

Particle Identification

- ❖ *Particle Classifications*
- ❖ *Particle Types (Wear Mechanisms)*
- ❖ *Particle Sources*
- ❖ *Severity of Wear*

PREDICTOL

Particle Classifications

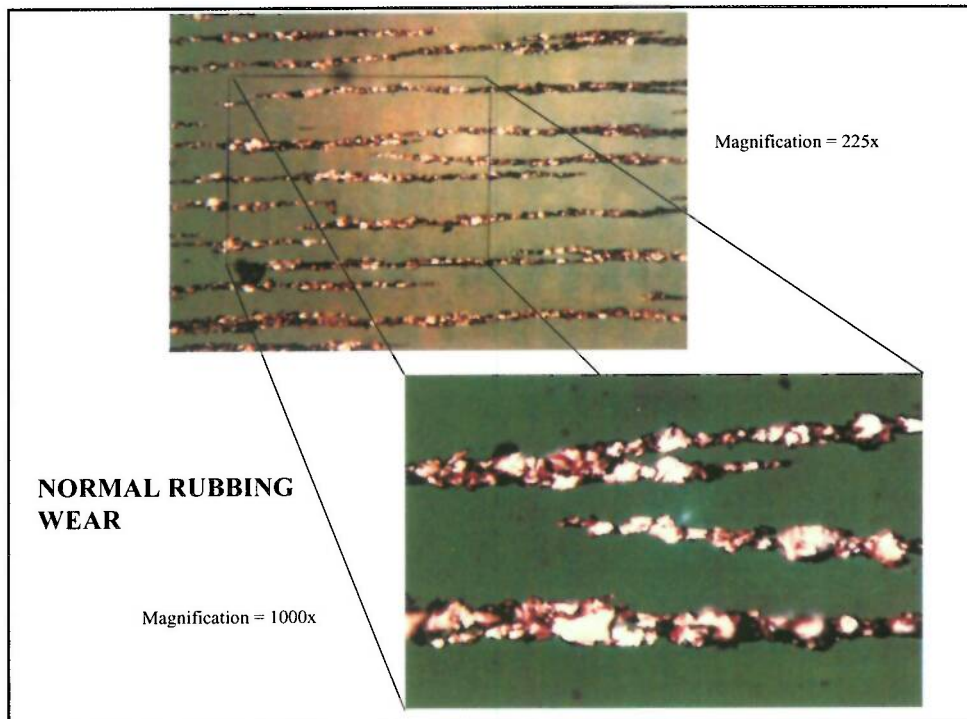
- ❖ **FERROUS** - MAGNETIC, PARAMAGNETIC; Fe, Fe₂O₃, Fe₃O₄; STAINLESS
- ❖ **NON-FERROUS** - COPPER ALLOYS, ALUMINUM, BABBITTED METALS, ZINC, CHROME, ETC.
- ❖ **CONTAMINANT** - FLUIDS; DUST, DIRT, EXTERNAL PROCESS; MANUFACTURING DEBRIS; FILTER MATERIAL; FRICTION POLYMERS; ORGANIC MATTER

only measure $\geq 15 \mu$ particles

Particle Types

Normal Rubbing Wear

- ❖ *Wear Generated During Normal Operation*
- ❖ *Appears Usually As Ferrous Strings With Particle Size < 15 Microns*
- ❖ *Low Concentration of Particles*

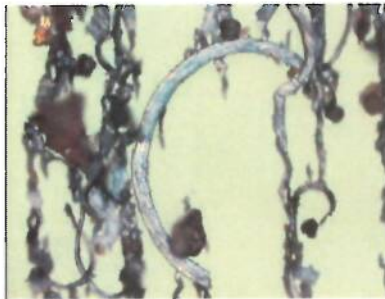


Particle Types

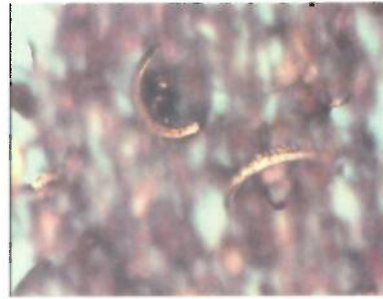
Cutting Wear

- ❖ *Indicative of Misalignment or Presence of Abrasive Contaminants*
- ❖ *Appears As Long, Curly Strips of Material With Aspect Ratios Ranging From 5:1 to 50:1 (Length to Width)*
- ❖ *Never Considered Normal*

CUTTING WEAR



Low Alloy Steel



Copper Alloy



High Alloy Steel

Particle Types

Bearing Wear

- ❖ *Rolling Fatigue Wear*
- ❖ *Appears As Flat Platelets With Perforated Surfaces and Irregular Edges Under the Microscope*

gúnos → DESGASTE DE ROLAMIENTOS

BEARING WEAR



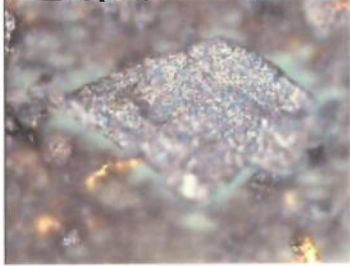
Copper Alloy



Low Alloy Steel



Steel Prior to Heat Treatment



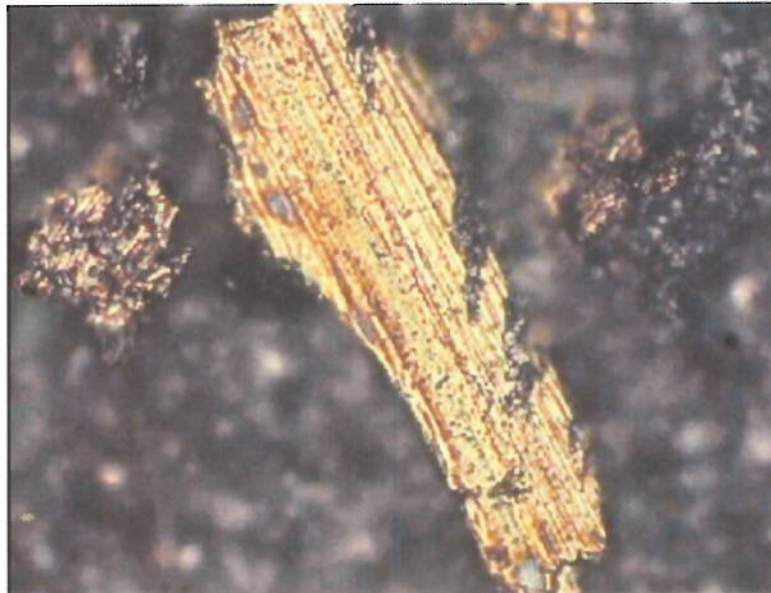
Lead/Tin Babbitt Metal

Particle Types

Severe Sliding Wear

- ❖ *Excessive Speeds/Loads on Critical Contacts Within the Equipment*
- ❖ *Appears As Rectangular Particles With Striations **Parallel** to the Direction of Elongation*

SEVERE SLIDING WEAR



Particle Types

Gear Wear

- ❖ *Combined Rolling and Sliding Wear*
- ❖ *Appears As Flat Platelets*
 - *Fatigue Spall - Similar to Bearing Wear Debris*
 - *Adhesive Wear - May have striations or other surface features*
 - *Scuffing and Scoring - Similar to Severe Sliding Wear Debris*

GEAR WEAR



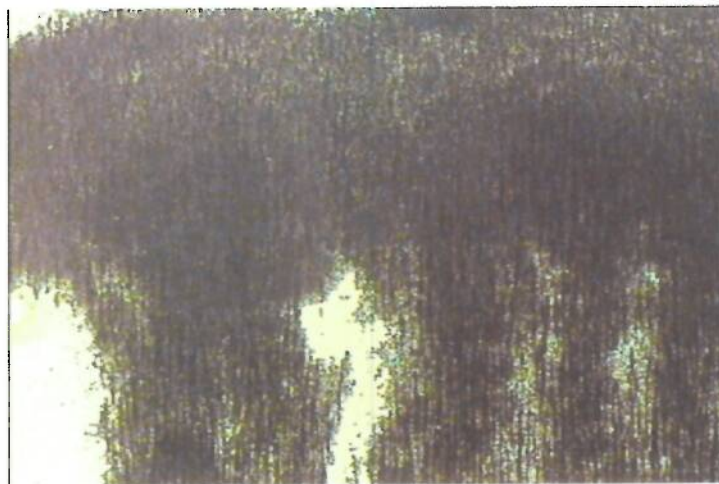
*not parallel
to length*

Particle Types

Corrosive Wear

- ❖ *Due to Acidic Attack on the Internal Surfaces of Equipment*
- ❖ *Appears As Small Particles <1 Micron in Size Which Align Themselves on the Outside Edges of a Ferrogram*

CORROSIVE WEAR



Particle Types

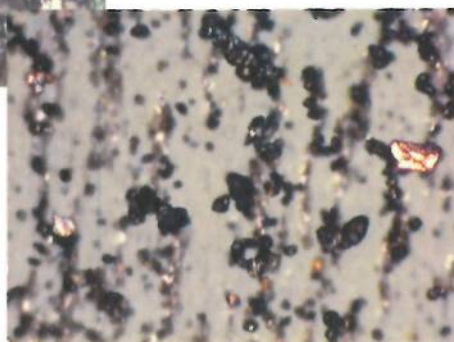
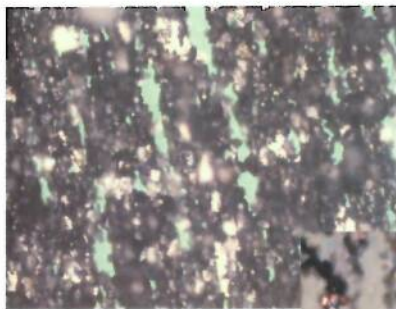
Black Oxides

- ❖ Due to High Temperatures at Critical Contacts Within a Unit
- ❖ Appear As Black Particles Which Align in the Ferrous Strings
- ❖ Indicative of Boundary Lubrication Condition

→ INSUFFICIENT LUBRICATION

METAL TO METAL CONTACT.

BLACK OXIDES



WITH MAGNIFICATION IS POSSIBLE TO SEE THIRD DIMENSION.



Particle Types

Red Oxides ($\alpha\text{Fe}_2\text{O}_3$ & $\beta\text{Fe}_2\text{O}_3$)

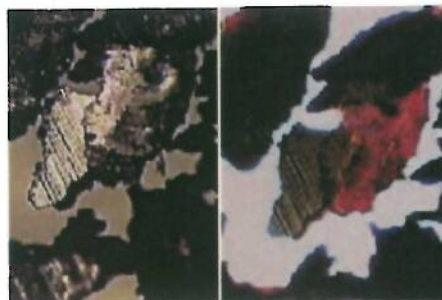
- ❖ *Alpha Crystalline Form of Hematite Caused by Water in Oil*
- ❖ *Appear As Orange/Red Particles Which Are Paramagnetic & Deposit Over Entire Length of Ferrogram*
- ❖ *Beta Crystalline Form of Hematite Caused by Insufficient Lubrication*
- ❖ *Appear As Gray, Shiny Particles in White Reflected Light & Dull Reddish-Brown in White Transmitted Light*

RED OXIDES
($\alpha\text{Fe}_2\text{O}_3$)



UNDER POLARIZED LIGHT

RED OXIDES
($\beta\text{Fe}_2\text{O}_3$)



REFLECTED LIGHT

TRANSMITTED LIGHT

Particle Types

Spheres

- ❖ *Spherical Particles Usually 5-10 Microns in Size; Indicative of Bearing Fatigue Prior to a Spalling Condition*
- ❖ *APPEAR AS BLACK CIRCLES WITH SHINY CENTERS UNDER THE MICROSCOPE*

SPHERES



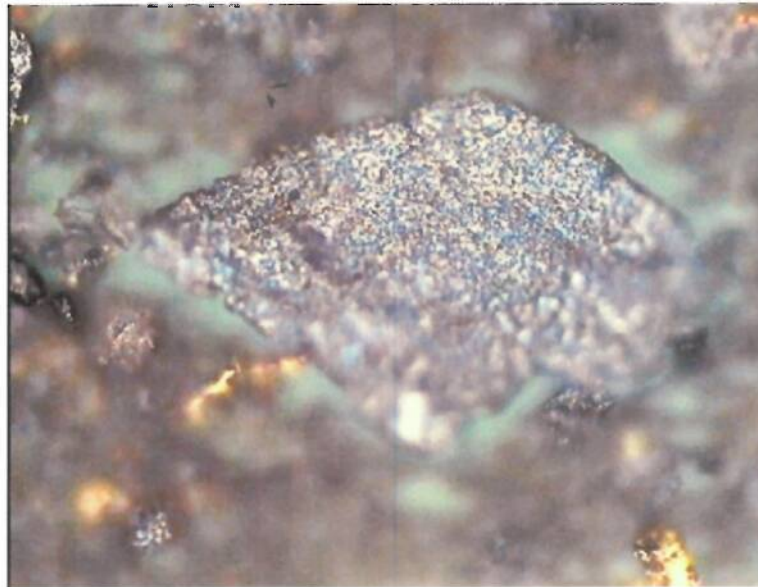
Particle Types

Nonferrous Wear

- ❖ **COPPER ALLOY** - YELLOW COLOR BEFORE AND A VARIETY OF COLORS AFTER
- ❖ **ALUMINUM ALLOY** - WHITE COLOR; WILL DISSOLVE IN NaOH SOLUTION
- ❖ **STAINLESS STEEL** - SLIGHTLY MAGNETIC; SLIGHT STRAW COLOR WHEN HEATED
- ❖ **LEAD/TIN BABBITT** - WHITE COLOR; BECOMES A MOTTLED BLUE/PURPLE WHEN HEATED
- ❖ **COPPER/LEAD BABBITT** - YELLOW COLOR; BECOMES YELLOW WITH BLUE/PURPLE MOTTLING WHEN HEATED

not from a regular pattern (non-ferrous)

BABBITTED SURFACE WEAR

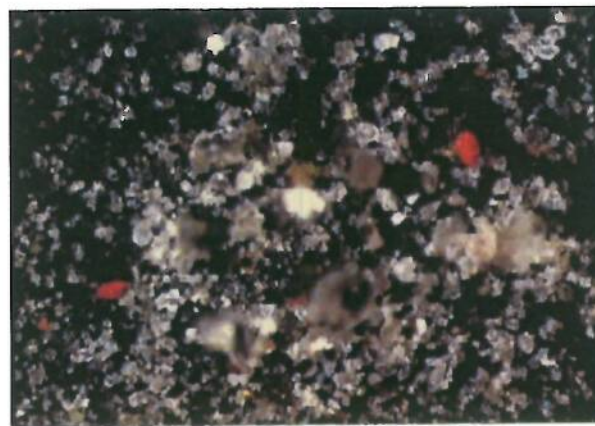


Particle Types

Sand/Dirt Particles

- ❖ *Contaminants Introduced Through Breather Elements, Seals, Cylinder Heads, Etc.*
- ❖ *Appear As Transparent, Translucent, or Opaque Crystalline or Birefringent Material; Deposits Over the Length of the Slide; Easily Seen Under Polarized Light*

SAND AND DIRT



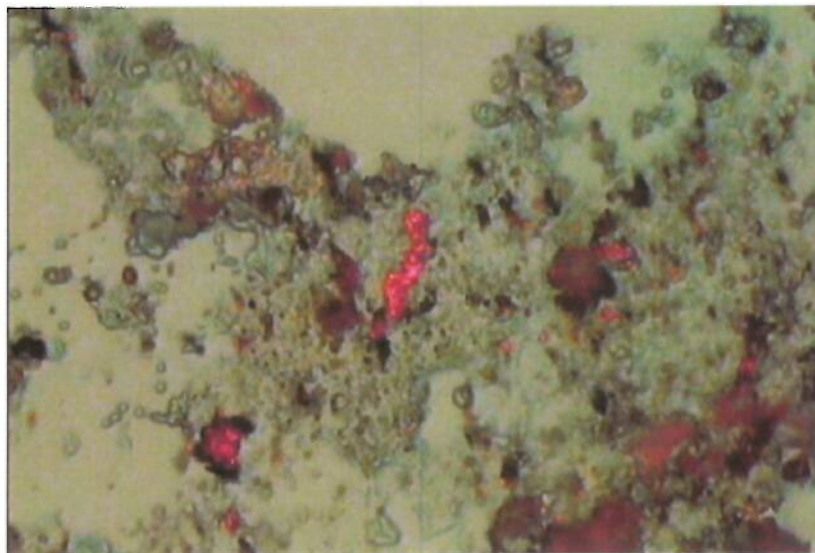
UNDER POLARIZED LIGHT

Particle Types

Friction Polymers

- ❖ *Amorphous Matrix Surrounding Wear Debris Formed As Lubricant Is Subjected to Excessive Loads or Stress*
- ❖ *Appears As Transparent or Translucent Mass Around Wear Debris on Slide*

FRICITION POLYMERS

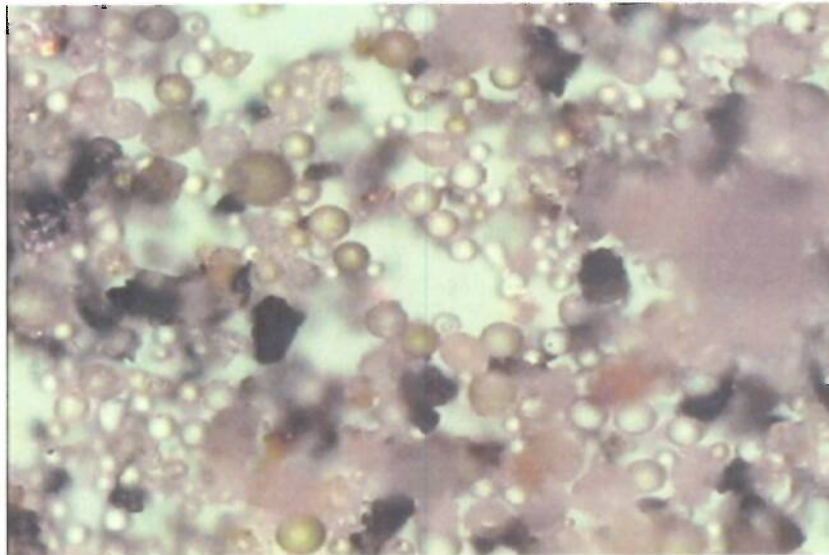


Particle Types

Contaminant Spheres

- ❖ *Spheres That Are > 10 Microns in Size; Translucent Usually Flyash, Opaque Typically Welding Debris*
- ❖ *Appear As Gray Circles With Translucent Centers (Flyash) or Black With Shiny, Opaque Centers*

FLY ASH



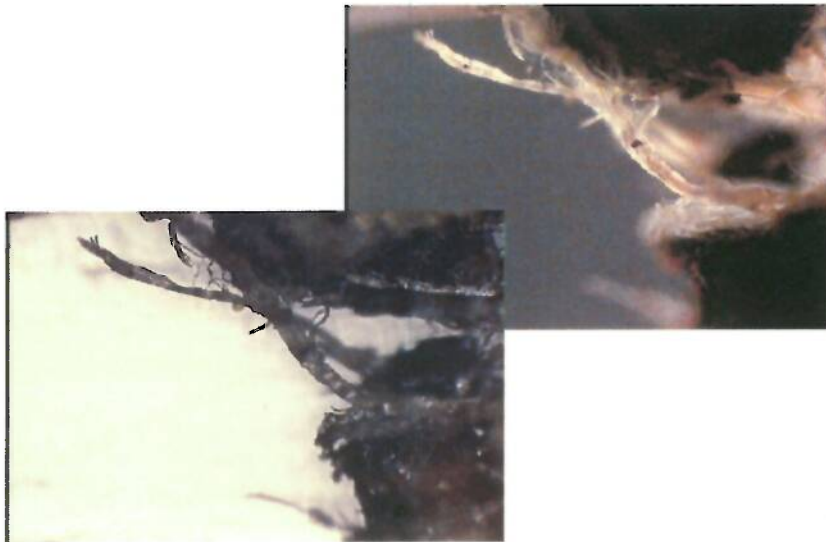
Particle Types

Fibers

- ❖ *Inside Contamination From Deteriorating Oil Filter, or Outside Contamination From Airborne Asbestos or Fiberglass Insulation*
- ❖ *Appear As Long, Straight or Curly Transparent Particles With Aspect Ratios of 5-50:1 or Greater*

asbestos

FIBERS



Particle Types

Evidence of Water Contamination

- ❖ *Circular deposition patterns that are empty in the center*
- ❖ *Water droplets that evaporated or were washed away*
- ❖ *Most likely visible water in the sample bottle (depending on demulsibility)*

Water Contamination

