

AUTOMOBILE STEEL WHEELS

The Road to Dual Phase

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Hayes Lemmerz International

AUTOMOTIVE STEEL WHEELS

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- **Automotive Wheels Have Been Manufactured From Many Materials Through Out The History Of The Automobile:**
 - **Wood**
 - **Steel (Casting, Sheet or Wire)**
 - **Aluminum (Casting, Forging, or Sheet)**
 - **Magnesium**
 - **Composites (FRP)**
 - **Combinations of the Above**



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- **From The Early Days Steel Has Been A Predominant Choice For Wheel Materials:**



Pressed Steel Wheel

Circa 1910



Early Wire Wheel

Circa 1920

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- **The Age of Steel (1935 – 1980s): During This Period Steel Wheels Dominated The Automobile. By 1935 Wheel Diameters Had Decreased From 36” To 16” And Rim Widths Increased From 3” to 6”. The Processes Of Stamping The Center (Disc) And Rolling The Rim Were Well Suited For High Volume Low Cost Production.**



- **Hot Rolled Low Carbon Steel Grades Were Predominant For Wheels Prior To The 1970s And Continue To Be Used Primarily on Rims Today:**
 - **Discs:**
 - **Rimmed 1012/1015 HRLC**
 - **High Formability – Low Alloyed Outer Surface**
 - **Converted to Continuous Cast 1012/1015 HRLC**
 - **Rims:**
 - **Mechanically Capped 1008/1010 HRLC**
 - **Converted to Continuous Cast 1008/1010 HRLC**
 - **Still the Predominant Steel Alloy for Rims**

- **The Early To Mid 1970s Brought The Need To Reduce Weight And Led To The Introduction Of Higher Strength Steels Into Wheels:**
 - **North America: 955X / 960Y HSLA Grades**
 - **Precipitation Hardening w/Cb Additions for Grain Refinement**
 - **Europe: Dual Phase Grades**
 - **DP550 – Initially Si Chemistry**
 - **Japan: SAPH 45 – 60 HSLA Grades**
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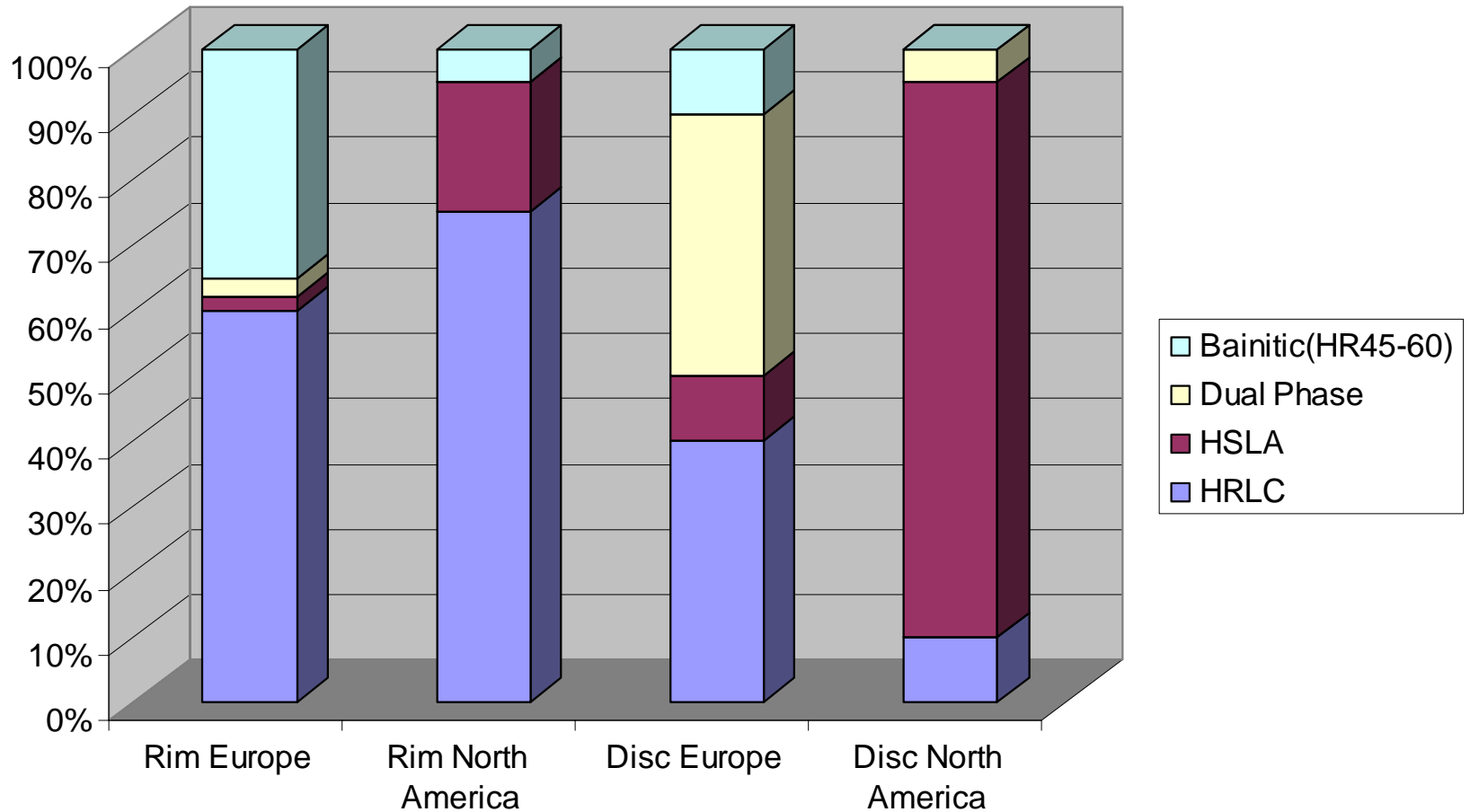
- **This Demand For Higher Strength Steels Along With A Need To Maintain Formability Led To The 1st Attempted Use Of Dual Phase Steel For Wheels In North America:**
 - **Mid 1970s – SAE980X Continuously Annealed Dual Phase**
 - **Motor Wheel Corporation: AMC Wheel**
 - **Kelsey Hayes: Cadillac Wheel**
 - **Both Attempts Discontinued – Production Steel Problems**
 - **Material Property Inconsistencies**
 - **Surface Cosmetics due to High Si Levels**

- **The 980X Experience Resulted In North American Wheel Manufacturers And OEMs Reluctant To Pursue Dual Phase Steel For Wheels:**
 - **Micro-Alloyed HSLAs became the Standard for North American Light Weight Steel Wheel Applications**
 - **Dual Phase / Bainitic Steels became the Standard for European Light Weight Steel Wheel Applications**

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2002 MY Steel Grade Usage - Automotive Wheels

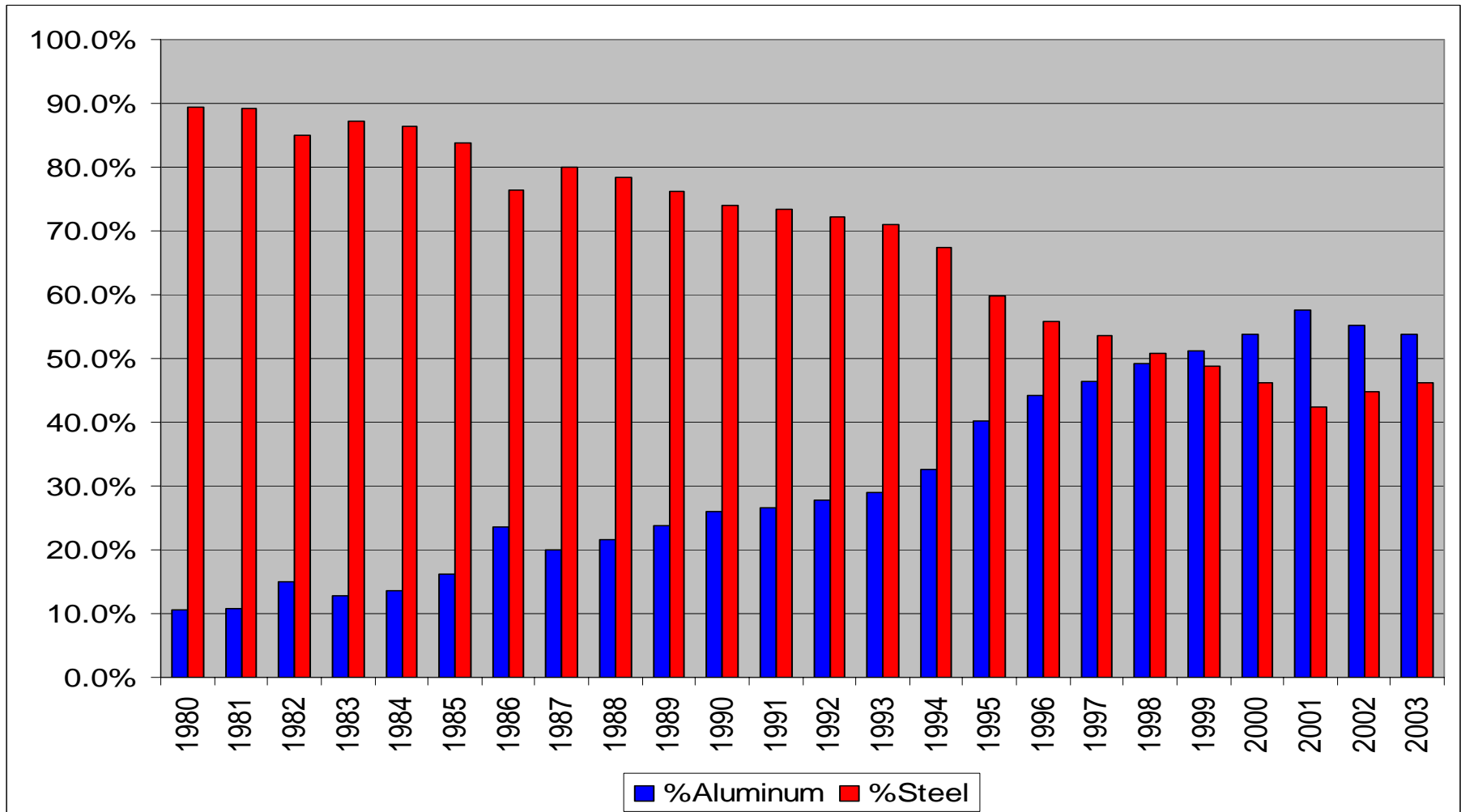


- **Renewed Interest in Dual Phase:**
 - **Aluminum Wheel Penetration**
 - **Advantages of Styling and Weight**
 - **Need for Improved Formability**
 - **High Vent Wheel Development**
 - **Renewed Need for Weight Reduction**
 - **Dual Phase Development for Ford “Impact” Program**
 - **Development of Cr Based DP Chemistry**
 - **Increased Availability**

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Wheel Material Usage 1980 - Present



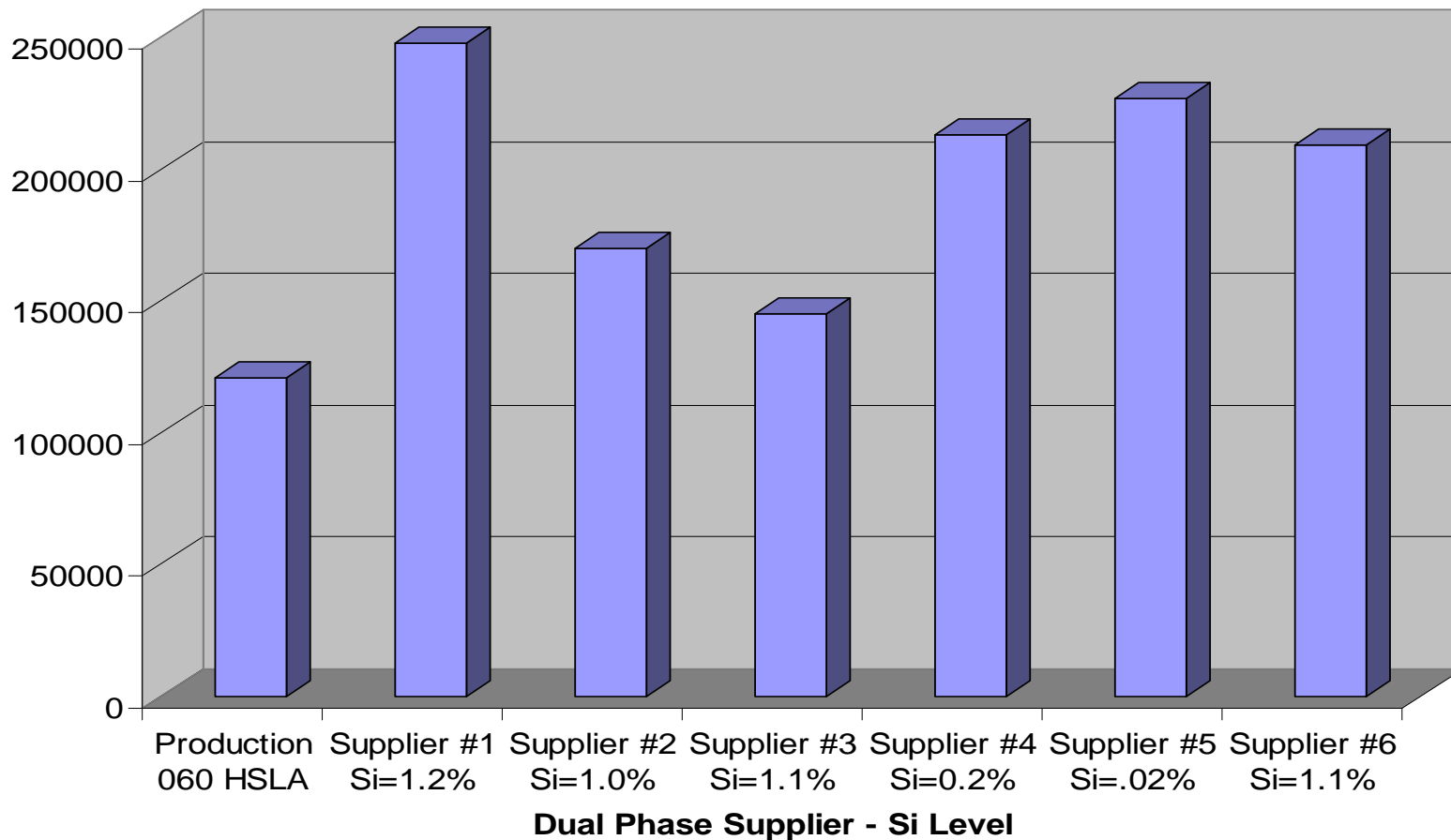
- **1999: Hayes Lemmerz Began An Investigative Study Into Utilizing Dual Phase In Steel Wheels:**
 - **Trial DP Steels from 7 Global Suppliers:**
 - **2 North American**
 - **1 South American**
 - **2 European**
 - **2 Asian**
 - **Chemistry:**
 - **Si (4 Suppliers)**
 - **Cr (3 Suppliers)**

- **Attributes Evaluated (Dual Phase vs HSLA):**
 - **Fatigue Strength**
 - **Higher Base Tensile Strength**
 - **87 ksi min. vs 75 ksi min.**
 - **Greater Work Hardening**
 - **Paint Bake Hardening**
 - **Formability**
 - **Lower Yield to Tensile Ratio**
 - **0.60 - 0.70 Typical vs 0.80 – 0.90**

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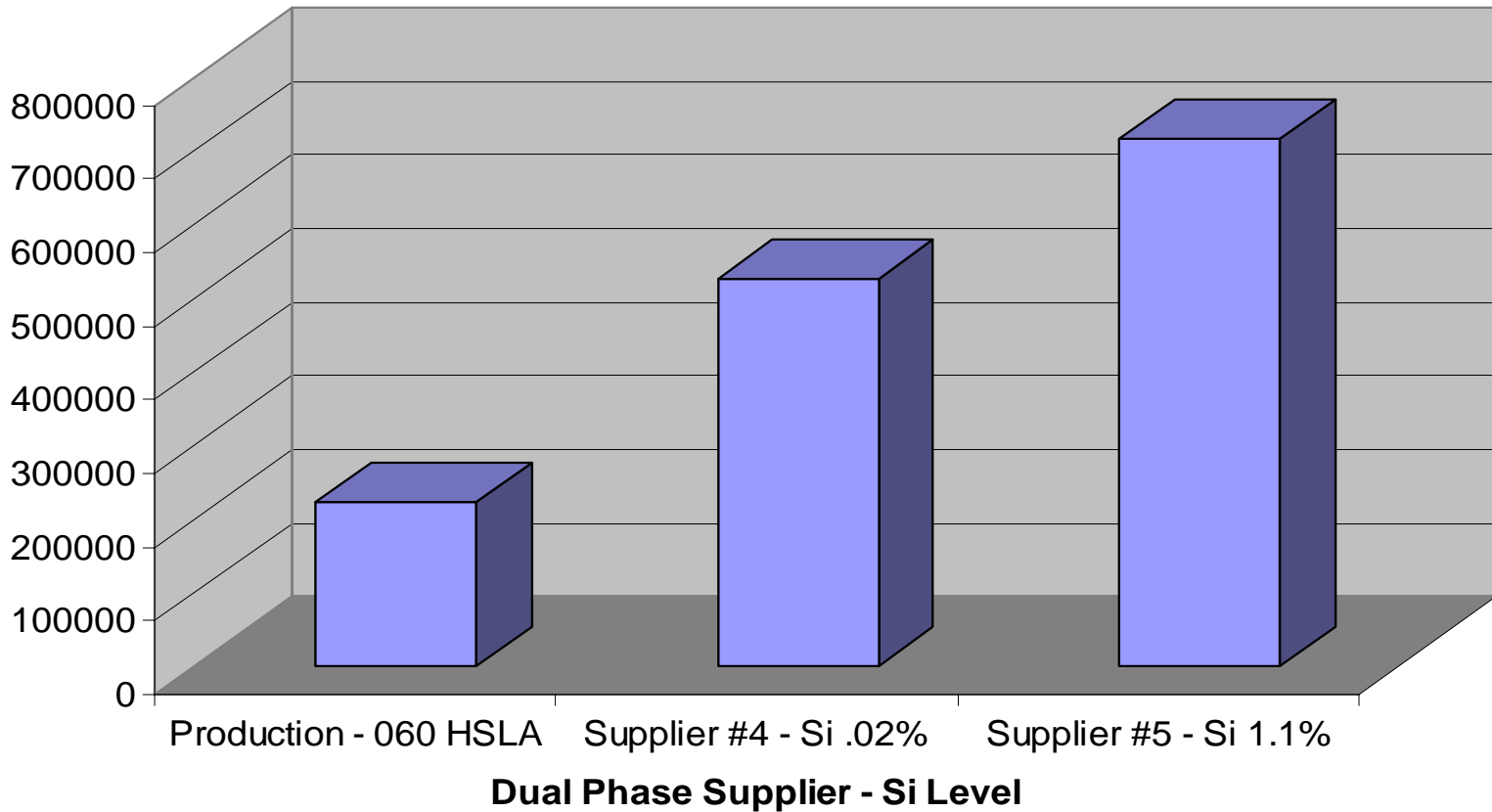
**Average Rotary Fatigue Life Comparison
15x6 Drop Center Wheel**



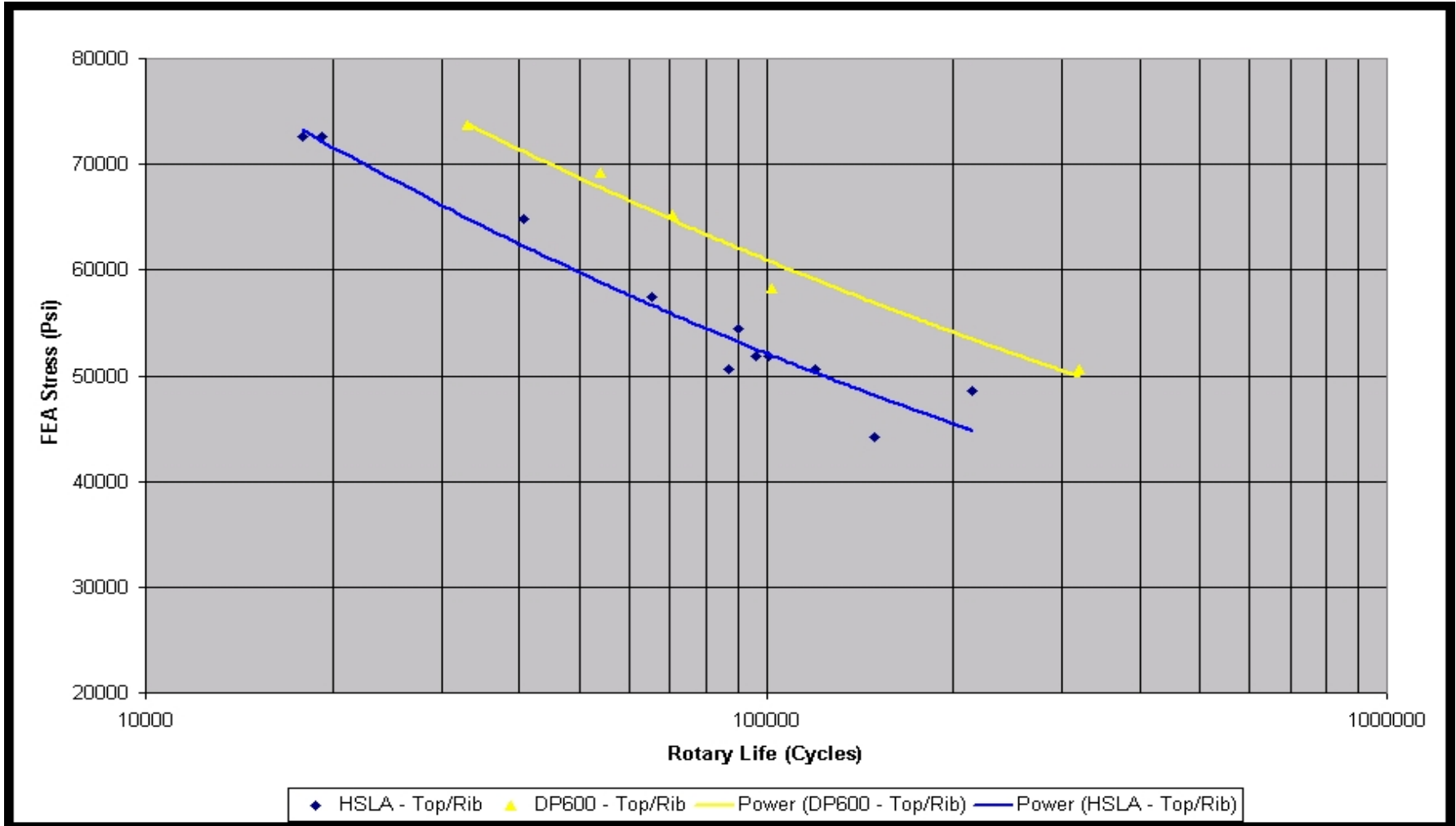
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**Average Rotary Fatigue Life Comparison
15x7 Full Face Wheel**



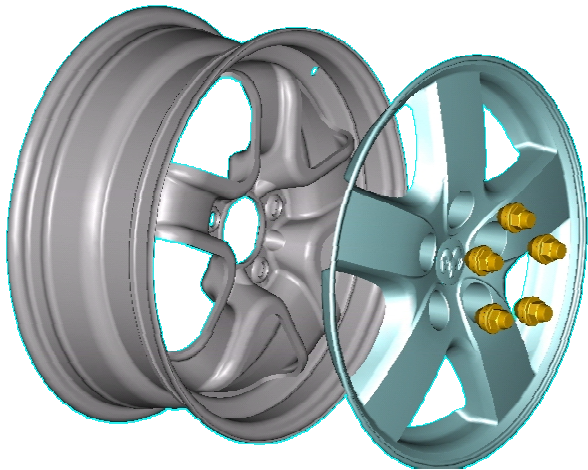
Wohler Curve Comparison – Dual Phase vs HSLA



- **Evaluation Results: Benefits Confirmed**
 - **Fatigue Performance Improvement**
 - **Typically 50% or Greater Increase**
 - **Allows for 10% Gauge/Mass Reduction**
 - **Formability**
 - **Reduced Forming Scrap**
 - **Reduced Leuder (Strain) Lines**

- **Evaluation Results: Concerns**
 - **Cosmetics**
 - **“Tiger” (Silicon) Stripes**
 - **Formability**
 - **Higher Work Hardening (n-values)**
 - **Redesigned Die Operations**
 - **More Forming Up Front**
 - **Consistency**
 - **Heat to Heat Variation (1970’s Experience)**
 - **Availability and Cost**

- **Going Forward:**
 - **2006 MY Production Dual Phase Programs**
 - **Flex Wheel Programs**
 - **Cr Chemistry Dual Phase Specified**
 - **2 Suppliers Identified**
 - **Additional Steel Suppliers to be Evaluated**



- **I'd Like to Acknowledge the Following Contributors:**
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 - **Usinor**
 - **Usiminas**
 - **Personnel**
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