

# COBRA-AHS™

## ADVANCED HIGH-SPEED COMPUTER OPTIMIZED BALL & ROLLER BEARING ANALYSIS



**COBRA-AHS** is a bearing analysis program that computes the behavior of up to five (5) bearing rows on a flexible or rigid shaft loaded in 5 DOF. The program has a modern menu-driven Windows interface with a multi-tabbed worksheet format, allowing users to interactively change input data and quickly generate results. COBRA-AHS Full Edition is integrated with ANSYS FEA to perform fit-up and temperature-distribution analyses, including iterative thermal/dimensional interaction.

### PROGRAM CAPABILITIES INCLUDE:

Up to 5 Bearings on flexible or rigid shaft  
Up to 10 Applied Loads in 5 DOF  
Up to 20 Shaft Sections  
Tapered and hollow shaft sections  
Pre-defined defaults for many inputs  
Housing and Shaft Distortion inputs  
Housing and Shaft Sleeves option  
Crowned Rollers w/ Lamina  
Bearing Preload  
Bearing heat generation & cage forces

Internal Clearance & End-Play  
STLE Fatigue Life Adjustments  
Misalignment, Location Offsets  
Hybrid Bearings, Duplex Bearings  
Lubricant Film Thickness  
Lubricant Effects on L10 Life  
Library of Lubricants  
Interactive Roller Edge Stress  
Analysis w/ Contour Plot Outputs

Interactive Sensitivity Studies  
Interactive Duty Cycle Analysis  
Up to 2000 Duty Cycle Conditions  
Skid Estimates for Ball and  
Cylindrical Roller Bearings  
Input in SI or US units  
Results in SI and US units  
Copy Results & Plots to Clipboard  
Print Results & Plots  
Automatic Update of Results & Plots

### 4 BEARING TYPES:

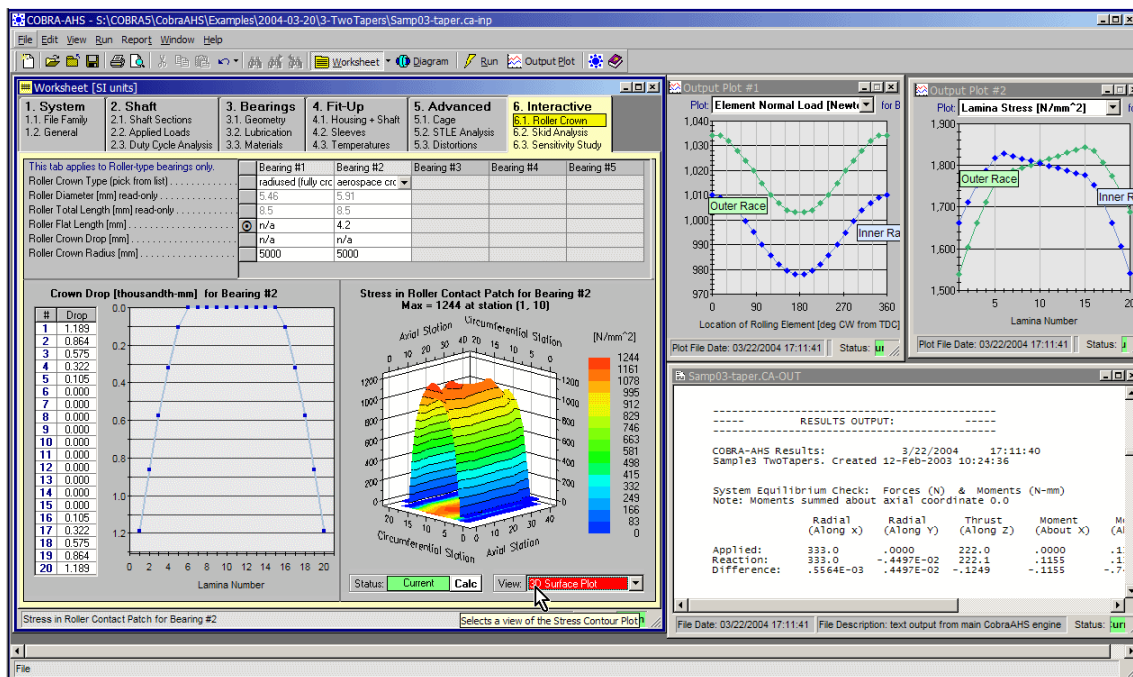
Radial (Conrad) Ball, Angular Contact Ball Cylindrical Roller, Tapered Roller

### 3 EDITIONS AVAILABLE:

**Baseline:** analysis capabilities equivalent to Jones Code, plus more output options and modern Windows user-interface

**Intermediate:** all Baseline features plus: interactive Roller Crown Design Cell with Edge-Stress estimation (see below)

**Full:** all Intermediate features plus: ANSYS integration for temperature distributions and more rigorous Fit-Up analysis



Worksheet [SI units]

1. System 2. Shaft 3. Bearings 4. Fit-Up 5. Advanced 6. Interactive

1.1. File Family 2.1. Shaft Sections 3.1. Geometry 4.1. Housing + Shaft 5.1. Cage 6.1. Roller Crown  
 1.2. General 2.2. Applied Loads 3.2. Lubrication 4.2. Sleeves 5.2. STLE Analysis 6.2. Skid Analysis  
 2.3. Duty Cycle Analysis 3.3. Materials 4.3. Temperatures 5.3. Distortions 6.3. Sensitivity Study

Shaft Rigidly  
 Shaft is rigid. COBRA analysis will treat the shaft as rigid regardless of Shaft Material Properties and Shaft Section Dimensions.  
 Shaft is flexible. COBRA analysis will compute shaft flexibility based on Shaft Material Properties and Shaft Section Dimensions.

Shaft Material Properties  
 Young's Modulus [MPa] 205878 Density [gm/cm<sup>3</sup>] 7.6  
 Poisson's Ratio 0.29 Thermal Expansion Coeff. [1/degC] 0.000123

Shaft Section Dimensions

Section Ident.	Section #	Section Length [mm]	Axial Location [mm] of Left End of Section	Dia. at Left End of Section		Dia. at Right End of Section	
				ID [mm]	OD [mm]	ID [mm]	OD [mm]
1	1	75	0	60	0	60	
2	2	85	75	60	0	60	
3	3	150	160	60	0	60	
4	4	150	310	60	0	60	

USE DEFAULT VALUE?  
 COBRA's default value for Poisson's Ratio is: 0.29  
 Click 'OK' to paste this value into your worksheet.

Note: COBRA-AHS uses a standard right-handed orthogonal coordinate system. Co-  
 \*X axis points vertically up. \*Y axis points out of the page. \*Z axis points towards the right.  
 Shaft Sections are numbered consecutively (starting with #1) from left to right.

Poisson's Ratio of Shaft Material - double-click (or press F5) to enter default value (0.3 for steel) Status: **Saved**

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	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Bearing Type (pick from list)	Angular Contact	Angular Contact	Cylindrical Roller	Angular Cont	(not present)
Duplex Bearing# (pick from list)	<no duplex>	<no duplex>	<no duplex>	<no present>	<no present>
Duplex Bearing Spacers (click cell to edit)	n/a	n/a	n/a	Angular Contact Ball Bearing	Conrad/Radial Ball Bearing
Location [mm] from origin	150	171	430		Tapered Roller Bearing
Bearing Nominal I.D. [mm]	60	60	60		
Bearing Nominal O.D. [mm]	95	95	85		
Width of a Single Row [mm]	20	20	13		
Number of Elements (min 3, max 30)	18	18	26		
Pitch Diameter [mm]	77.5	77.5	72.5		
Element Diameter [mm]	11.11	11.11	7		
Contact Angle or Cup Angle [degrees]	25	-25	n/a		
Outer Race Curvature/Osculation	0.52	0.52	0		
Inner Race Curvature/Osculation	0.52	0.52	0		
Shim Thickness [mm]	0	0	n/a		
Roller Length [mm]	n/a	n/a	8.5		
Roller End Spherical Radius [mm]	n/a	n/a	10000		
Flange Layback Angle [deg]	n/a	n/a	0		
Roller Included Angle [deg]	n/a	n/a	0		
Dynamic Capacity Reduction Factor (lambda)	n/a	n/a	0.66		
Dynamic Capacity [N] post-1930	36716	36716	45466		
Diametral Clearance [mm]	0	0	0.01		
Axial Preload [N]	0	0	n/a		
Axial Preload Spring Rate [N/mm]	0	0	n/a		
Axial Offset along Z-axis [mm]	0	0	n/a		
Radial Offset along X-axis [mm]	0	0	0		
Radial Offset along Y-axis [mm]	0	0	0		
Initial Tilt about X-axis [mm/mm]	0	0	0		
Initial Tilt about Y-axis [mm/mm]	0	0	0		

Bearing Type - click down-arrow to pick from list; bearing is "not present" if this is not specified Status: **Unsaved**

Worksheet [SI units]

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	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Lubricant Type (pick from list)	MIL-L 23639	MIL-L 23639	MIL-L 23639		
Lube Density [g/cm <sup>3</sup> ]	1.0102	1.0102	Mineral Oil (Shell Turbo 33)		
Lube Thermal Expansion Coefficient [1/C]	0.000745	0.000745	MIL-L 7808		
Lube Thermal Conductivity [W/m C]	0.152	0.152	PolyPhyEther MCS 293		
Lube Viscosity @40C [cSt]	28	28	MIL-L 23639		
Lube Viscosity @100 C [cSt]	5.1	5.1	user-defined lubricant		
Pressure Coefficient of Viscosity [mm <sup>2</sup> /N]	0	0	0		
Lube Operating Temperature [C]	65	65	65		
Element CLA Roughness [microns]	0.08	0.08	0.08		
Inner Race CLA Roughness [microns]	0.1	0.1	0.1		
Outer Race CLA Roughness [microns]	0.1	0.1	0.1		
Outer Race Flange CLA Roughness [microns]	n/a	n/a	0.1		
Roller End Face CLA Roughness [microns]	n/a	n/a	0.08		
Element-to-Race Friction Coefficient	0.1	0.1	0.1		
Flange Roller-End Friction Coefficient	n/a	n/a	0.1		
Lube Flow Rate [liters/min]	2	2	2		
Lube Churning Factor [%]	3.4062%	3.4062%	3.8151%		

Notes:  
 If you select a pre-defined Lubricant Type, then COBRA-AHS will enter default values for lubricant properties. If you select "user-specified lubricant", then you must specify the lubricant's properties. However, "Pressure Coefficient" may be left unspecified, in which case the COBRA-AHS engine will calculate it and display on the Results' page.  
 Click the black dot (or press F5) in the table above to enter COBRA's estimated or default value for these parameters.

Lubricant Type - pick from the list, or enter a name and all properties for your own lubricant Status: **Open**

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Perform STLE Analysis?

	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Reliability [%]	99.00%	99.00%	95.00%		
Inner Race Material (pick from list)	M50 NIL steel	M50 NIL steel	AISI 52100 steel		
Outer Race Material (pick from list)	M50 NIL steel	M50 NIL steel	AISI 52100 steel		
Element Material (pick from list)	M50 NIL steel	M50 NIL steel	AISI 52100 steel		
Mating Practice (pick from list)	VIM-VAR	VIM-VAR	AISI 52100 steel		
Metallurgy (pick from list)	Forged Rings	Forged Rings	M-1 or M-2 steel		
Inner Race Hardness (Rockwell C)	60	60	M10 or M50 or T-1 steel		
Outer Race Hardness (Rockwell C)	62	62	M42 or W849 steel		
Element Hardness (Rockwell C)	58	58	86-42 or CR7 steel		
Rework (pick from list)	Reworked @ L11	Reworked @ L11	AISI 440C steel		
Stressed Volume Removed in Rework [%]	8.00%	8.00%	M50 NIL steel		
Operating Temperature [degC]	100	100	AISI 4720 steel		
Water Content [ppm]	45000	45000	AISI 6720 steel		
Filter Rating [microns]	4	4	9310 or CBS 600 steel		
Shaft I.D. at bearing location [mm]	0	0	alumina, hot pressed		
Inner Race Mean O.D. [mm]	66.4	66.4	alumina, cold pressed		
Inner Race Tight Fit [mm]	-0.052	-0.052	silicon carbide		
Approximate Maximum Hertz Stress [N/mm <sup>2</sup> ]	1380	1300	tungsten carbide		
Residual Shear Stress at Crit. Depth [N/mm <sup>2</sup> ]	200	200	silicon nitride		

Notes on the 'Perform STLE Analysis' box in upper left:  
 - If checked, then you must specify all STLE parameters (on this Tab) for all Bearings. STLE analysis will be performed when you click 'Run'.  
 - If not checked, then the table of STLE parameters (on this Tab) is locked (read-only). STLE analysis will not be performed when you click 'Run'.

Element Material (pick from list) Status: **Open**

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	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Bearing Type (read-only)	Angular Contact	Angular Contact	Cylindrical Roller		
Number of Elements	18	18	26		
Element Diameter [mm]	11.11	11.11	7		
Contact Angle [deg]	25	-25	n/a		
Roller Length [mm]	n/a	n/a	8.5		
Outer Race Shape (pick from list)	0	0	elliptical		
Out-Of-Round Magnitude [mm]	0	0	elliptical		
Lube Temperature [degC]	65	65	elliptical		
Initial Load Estimate [N]	0	0	3-point OOR		
Skid Adjustment Factor (dimensionless)	1	1	1		

Results for Bearing #3 Status: **Current** Calc

```

# COBRA-AHS 6.0 ROLLER BEARING SKID ANZ
# InputFileSpec=
# InputFileDate=
# BrgType=
ARRAY 4 7 T
# RadialLoad[N] %Epicyl %Slip
.1200E+04 .9798E+00 .2018E-
.1050E+04 .9680E+00 .3200E-
.9000E+03 .9479E+00 .5210E-
.7500E+03 .9047E+00 .9531E-
.6000E+03 .8164E+00 .1846E-
.4500E+03 .6490E+00 .3510E-
  
```

Outer Race Shape (click down-Arrow to pick from list) Status: **Saved**

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Sensitivity Study #1

Input  
 Item: Bearing  
 Bearing #: 1  
 Parameter: Contact/Cup Angle  
 Units: N/mm<sup>2</sup>  
 Number of Steps: 5  
 Step Size: 2  
 Nominal Value: 25  
 Minimum Value: 21  
 Maximum Value: 29

Results  
 Plot: Max. Hertz Stress [N/mm<sup>2</sup>] for Bearing #1

Run Sensitivity Study #1 Status: **Current** Last Run: 2/13/2003 18:04:37

Select data to plot - click down-Arrow to pick from list Status: **Saved**

# Integration with ANSYS FEA FOR DIMENSIONAL/THERMAL INTERACTION

Available in COBRA-AHS Full Edition only

**Worksheet [SI units]**

1. System	2. Shaft	3. Bearings	4. Fit-Up	5. Advanced	6. Interactive
1.1 File Family	2.1 Shaft Sections	3.1 Geometry	4.1 Housing + Shaft	5.1 Cage	6.1 Roller Crown
1.2 General	2.2 Applied Loads	3.2 Lubrication	4.2 Sleeves	5.2 STLE Analysis	6.2 Skid Analysis
	2.3 Duty Cycle Analysis	3.3 Materials	4.3 Temperatures	5.3 Distortions	6.3 Sensitivity Study

**Perform Fit-Up? (check if Yes)**

	Bearing #1	Bearing #2	Bearing #3	Bearing #4	Bearing #5
Shaft I.D. [mm] at bearing center	0	0	0		
Shaft O.D. [mm] at bearing center	60	60	60		
Bearing Inner Race Mean O.D. [mm]	66.39	66.39	65.5		
Bearing Outer Race Mean I.D. [mm]	88.61	88.61	79.5		
Housing I.D. [mm]	95	95	85		
Housing O.D. [mm]	110	110			
Shaft Fit [mm]	-0.054	-0.054	-0.025		
Housing Fit [mm]	0	0	0.01		
Young's Modulus of Shaft [MPa]	205878	205878	205878		
Young's Modulus of Housing [MPa]	205878	205878	205878		
Poisson's Ratio of Shaft	0.29	0.29	0.29		
Poisson's Ratio of Housing	0.29	0.29	0.29		
Density of Shaft [gm/cm <sup>3</sup> ]	7.6	7.6	7.6		
Density of Housing [gm/cm <sup>3</sup> ]	7.6	7.6	7.6		
Thermal Expansion Coeff. of Shaft [1/degC]	0.0000123	0.0000123	0.0000123		
Thermal Expansion Coeff. of Housing [1/degC]	0.0000123	0.0000123	0.0000123		
Ignore rolling-element loads in Fit-Up calculation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Diametral Clearance [mm] input on Tab 3.1	0.001	0	0.01		
Diametral Clearance Change [mm] per Thk. Ring	-5.319584E-02	-5.716077E-02	-2.170152E-02		
Diametral Clearance Change [mm] per Ansys	-6.923575E-02	-6.363988E-02	-1.945928E-02		

Run Ansys to calc Diam. Clearance Change

Diametral Clearance Change Option  
 use value calc'ed by Thick-Ring Theory     use value calc'ed by Ansys

**Notes:**  
 If you check the 'Perform Fit-Up' box, then you must specify all Fit-Up parameters (on Tabs 4.1, 4.2, and 4.3).  
 Shaft Material Properties are displayed read-only on this Tab, and are deemed to be identical for all Bearings.  
 Go to Tab 2.1 'Shaft Sections' to edit the Shaft Material Properties.  
 Click the black dot (or press F5) in the table above to enter COBRA's estimated or default value for these parameters.

Click this button to run Ansys to calc Diametral Clearance Change using finite-element analysis    Status: **Open**

**Ansysis FitUp Analysis Options**

Select the FitUp Analysis method to calculate Diametral Clearance Change of Bearing #2

1. Structural only (single-pass)  
 2. Thermal only (single-pass)  
 3. Structural+Thermal (single-pass)  
 4. Iterative Structural+Thermal (multi-pass)

Convergence Criterion ... **0.0001**

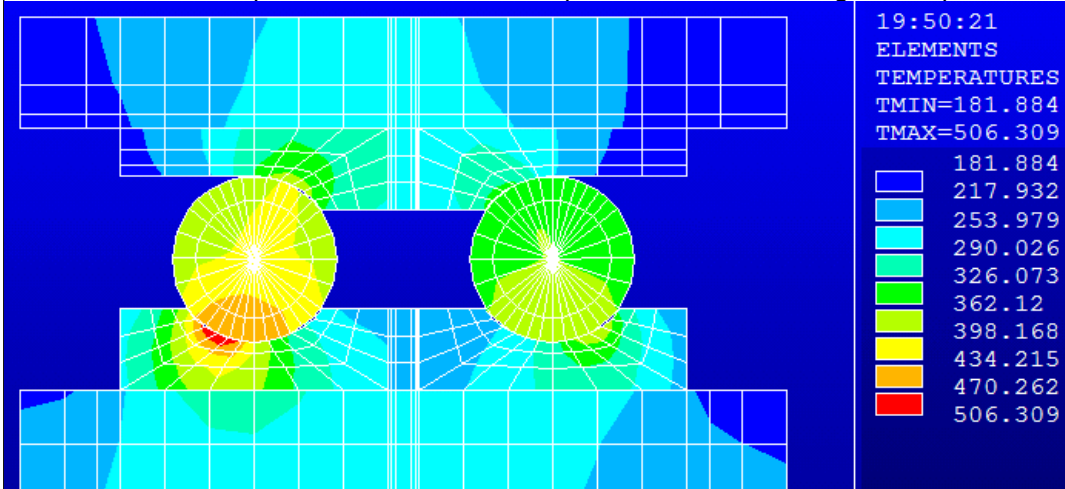
Iteration Limit ... **50**

Damping Factor ... **0.4**

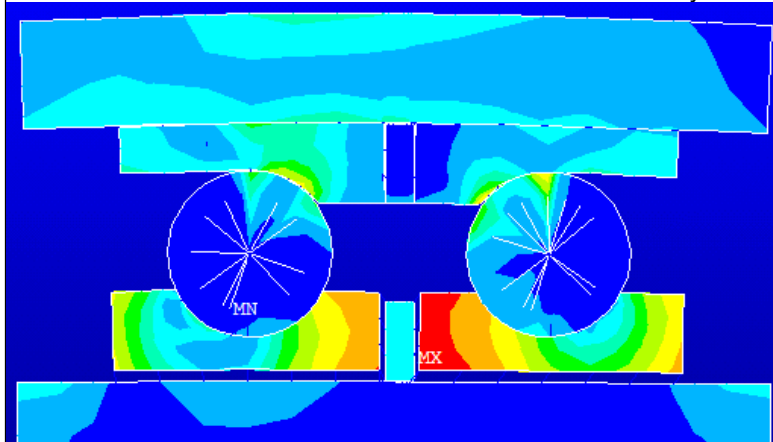
**Run**    **Cancel**

AnsysisEngineOption=1

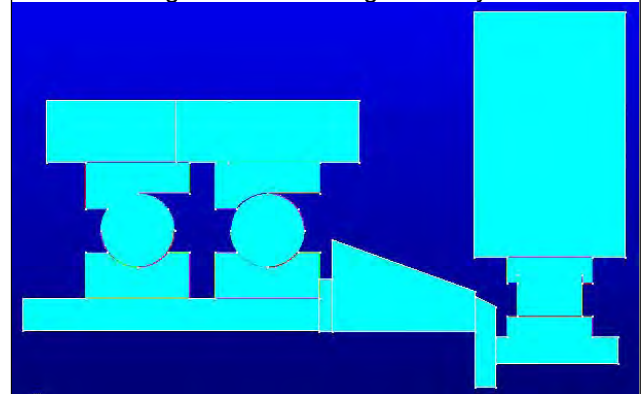
## ANSYS Plot of Temperature Distribution of Duplex Pair of Ball Bearings with Spacers



## ANSYS Plot of VonMises Stress and Deformed Geometry



## ANSYS Diagram of 3-Bearing Rotor System

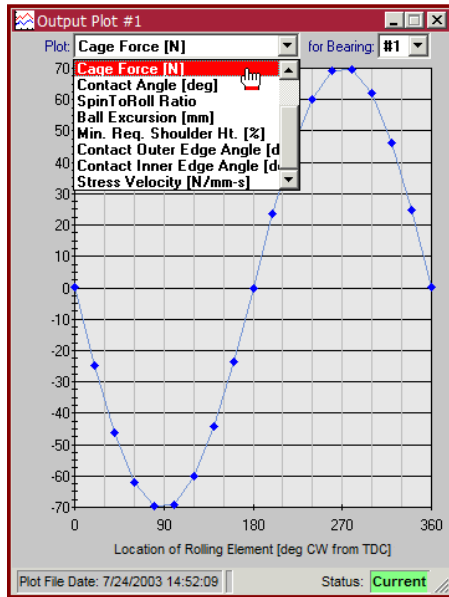
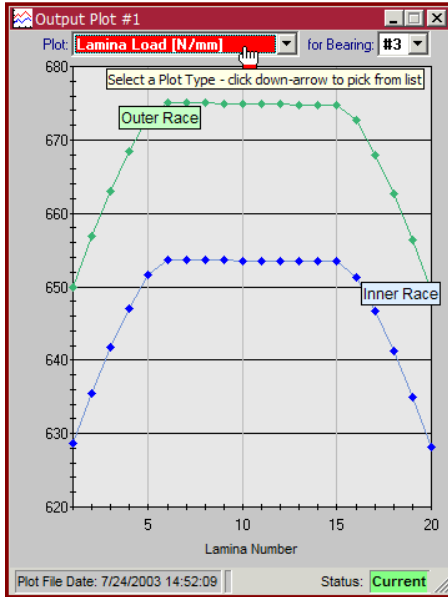
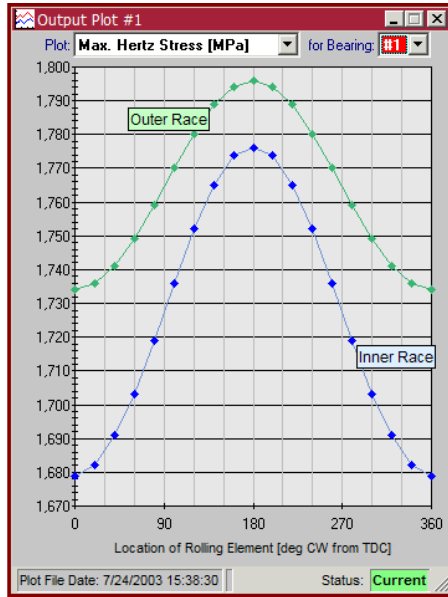
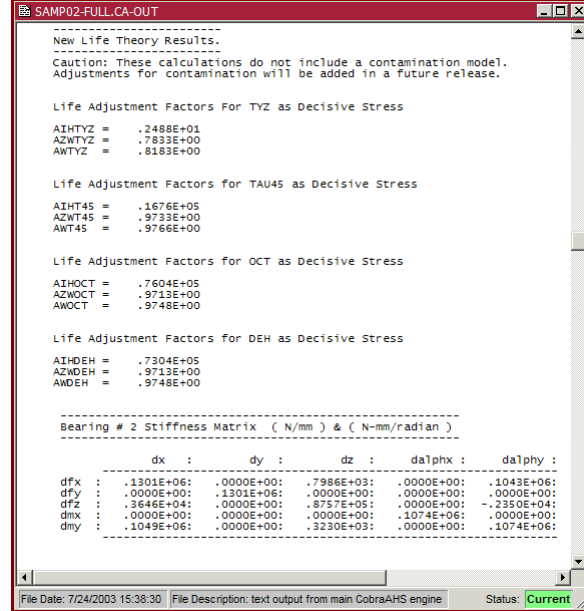
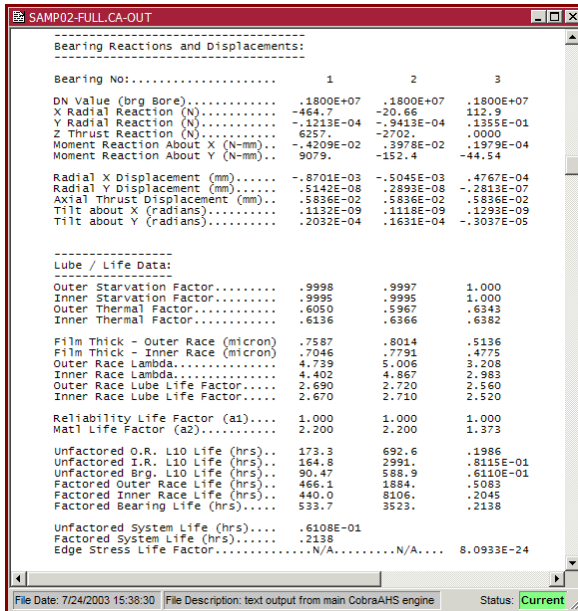


**PROGRAM RESULTS INCLUDE:**

Bearing Reactions & Load Sharing  
 Radial & Axial Spring Rates  
 Angular Spring Rate  
 Dynamic Capacity  
 System L10 Life, Bearing L10 Life  
 Bearing Stiffness Coefficients

Load Zones  
 Hertz Contact Stress  
 Sub-Surface Shear Stress  
 Operating Contact Angle  
 Element Loads  
 Contact Ellipse Dimensions

Required Shoulder Heights  
 Lubricant Film Thickness  
 Life Adjustment Factor-Lubrication  
 Individual Element Outputs  
 Per Bearing Plots of 11 parameters  
 Heat Generation



**SYSTEM REQUIREMENTS:**

IBM-compatible PC; 32-bit or 64-bit Windows Operating System (Windows 7, 8, 10); CD drive  
 40 MB hard disk space; 192 MB RAM installed (256 MB preferred); 800x600 pixel screen resolution; 16-bit color display

**PACKAGE INCLUDES:**

Installation CD; End-User License; Example Problems; Printed Manual; Release Notes, USB Hardware Security Key  
 Free Technical Support for 1 year. Fee-based support available thereafter.