

THE COMPLETE SOFTWARE PACKAGE FOR

- Rotor Dynamics
- Torsional Vibration
- Fluid-Film Bearings
- Rolling-Element Bearings
- Lubricant Performance
- Tools / Utilities

Workstation and Enterprise Licensing Available

Please contact *Dr. Andreas Laschet* as RBTS' consultant and representation for the regions **Europe, Middle East, Africa** with the following communication details:

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Advanced Rotating Machinery Dynamics тм RM THE COMPLETE SOFTWARE UTILIZED WORLDWIDE Heart Pumps & **Blood Bearings** LPC HP IP LPA LPB Generator Turbine Turbine Turbine Turbine Turbine \geq \leq ~ \leq ∇ $\dot{\nabla}$ Axial length = 4.62519E+004 mm From Heart Pumps to Turbine-Generator-Sets

ARMD is the most complete software package available to help you evaluate any bearing, rotor/bearing system, or mechanical drive train. Using leading edge technology and a host of valuable capabilities,

ARMD has been proven effective and accurate in the design, analysis and trouble shooting of rotating machinery by machinery manufacturers, equipment packagers and end users around the world.

ARMD consists of five main modules:

- Rotor Dynamics
- Torsional Vibration
- Fluid-Film Bearings
- Rolling-Element Bearings
- Lubricant Performance
- Vtilities & Support Tools

With a variety of features, including:

- A user-friendly interface
- > Advanced project and file management system
- Graphics/text capabilities
- Inter-module communication and data exchange

All of which operate seamlessly in an integrated environment.





Rotor Dynamics (**ROTLAT**[™])

The rotor dynamics lateral vibration analysis package ROTLAT is a finite element based software for performing damped and undamped naturalfrequencies / critical-speeds, mode shapes, stability, unbalance response, and time-transient response. Tabs ROTLAT consists of four sub-modules: ROSTAB, ROTORMAP, ROSYNC, and RORESP integrated by ROTLAT's user interface. The user interface controls the sub-modules to provide a complete rotor/bearing system dynamic analysis environment integrating the rotating assembly with its support bearings, wear-Tool rings, seals, aerodynamic effects, support structural Strip flexibilities, etc.

ROTLAT incorporates advanced modeling features and capabilities including the following:

- Rotor of various configurations:
- Solid, Hollow, Tapered & Stepped.
- Shaft material damping.
- Gyroscopic effects (discs with angular degrees of freedom).
- Element geometry, stiffness diameter, or element stiffness (i.e. flexible connections or plates).
- Bearings of all types: Cylindrical, Conical, Tilting Pad & Rolling Element with/without moment stiffness or tilting-pad pitch degrees of freedom.
- Bearing models linked to rotating assembly at any station.
- Bearings vertical elevation for accurate bearings load computation of multi-bearing systems.
- Springs: wear-rings, seals, aero-dynamic effects, squeezefilm dampers, etc.
- Springs models linked to rotating assembly at any station.
- Bearings support systems; casing and foundations.
- Static foundation/pedestal flexibility (mass, stiffness and damping).
- Dynamic (frequency dependent) foundation flexibility.
- Discs: couplings, impellers, sleeves, etc.
- Moment release (pin-joint) at shaft stations.
- Multiple unbalance forces at any location and phase orientation along the shaft.
- External excitations and body forces: sinusoidal, step, ramp and pulse type functions.

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NATURAL FREQUENCY, MODE SHAPE & STABILITY

- Natural frequencies & mode shapes
- Damped and undamped simulation
- Stability parameters (damping ratio, logarithmic decrement)
- Rotor orbit direction (forward/reverse precession)
- Critical speed map
- Stability map / Campbell diagrams
- Bearing reaction forces
- Shaft weight, deflection, centerline slope
- Shaft moment, shear, & fiber stress diagrams

Synchronous UNBALANCE & STEADY-STATE RESPONSE

- Multiple unbalance planes/forces
- Various types of external excitations & body forces including sinusoidal/harmonic
- Magnitude and phase (Bode plot)
- Dynamic forces and moments
- Vibratory amplitudes and orbits
- Forces and moments transmitted to bearing and foundation
- Foundation vibratory amplitudes
- Rotor shape plots (amplitude & phase)
- API Amplification factors



- Gravitational and external forces: Multiple sinusoidal, step, ramp, pulse and unbalance
- Vibratory amplitudes time history
- Rotor orbits
- Dynamic forces and moments
- Dynamic stresses
- Transmitted forces and moments
- Pedestal vibratory amplitudes









Page



Torsional Vibration (TORSION[™])

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0.0 1st Order Excit

C Steady State Tor

Harmonic Order

The torsional vibration package uses a finiteelement based formulation for performing damped and undamped torsional natural frequencies, mode shapes, steady-state and time-transient response of mechanical drive trains. TORSION consists of three sub-modules TORNAT, TORHRM and TORRSP integrated by TORSION's user interface. The user interface controls the sub-modules to provide a complete torsional vibration analysis environment.

TORSION accepts/imports models generated with the rotor dynamics package "ROTLAT" and has the same advanced modeling features and capabilities including the following:

- Modeling of multi-shaft/multi-branch systems
- Coupling torsional stiffness and damping
- Gear tooth flexibility
- Element stiffness/mass/inertia diameter
- Torsional springs to ground
- Various types of external excitations
- Synchronous motor start-up torque
- Load torgues from such equipment as compressors, pumps, fans, mills, etc.
- Electrical faults for motor and generator

Steady State Harmonic Torques Time Transient Torques Harmonic Torque Import Files

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User specified time varying torques

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Many more...

Harmonic Torque Branch Location

C Applied Torque Tables

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NATURAL FREQUENCIES & MODE SHAPES

- Damped and undamped simulation
- Natural frequencies

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Torsional Twist Mode

Mode 8

Mode 7

Mode 6

Mode 5

- Growth factors and damping ratios
- Vibration mode shapes
- Critical speed map / Campbell diagrams

2 High Speed

Pinion-Compressor

Bull

Gear

2nd Order

1 st Order

Rotational Speed (RPM) (E+04)

Mode '

- - 1st Order

- 2nd Order

600-rpm

<u>c</u>

STEADY STATE RESPONSE

- Vibratory amplitudes (displacement, velocity and acceleration)
- Dynamic torques
- Dynamic stresses
- Dynamic heat dissipation



TIME-TRANSIENT RESPONSE

- Dynamic shaft-torque time-history
- Dynamic stresses
- Fatigue life

Sample of synchronous motor-gearbox-compressor timetransient startup and calculated system response torques.



Motor Startup Average Torque



High Speed Shaft Torque



Time varying excitations include:

 \triangleright Electrically induced exciting torques, associated with generator and induction motor operation, can be considered in the time-transient response simulation module.

Generator

Type 1: 3-phase short circuit Type 2: Line-to-Line short circuit Type 3: False-coupling short circuit

Induction Motor

Type 4: Start from standstill (across the line start) Type 5: 3-phase short circuit at terminals Type 6: 2-phase short circuit at terminals Type 7: High-speed automatic reclosing

User torque table (.csv \geq file format) representing time-varying exciting torque at any location (e.g. simulation of clutch engagement).

Frequency, Mode Shapes & Respons hree Branch System. High Speed ion-Cor Electric Motol 3-phase short circuit excitation Gear 12 13 Time (s) C:\Users\Public\Documents\ARMD\TORSION\TorrspV57 Gtype1 3phase short sample.TRG Elm #006 Elm #00 Forque (in-lb) (x 10^4) 1.0 S 0.5 0.0 -0.5 Fundamental -1 (**Torsional Twist Mode** 0.0 1.0 2.0 3.0 Time (s) Generator **3-Dimensional Presentations** Torsional Twist Mode HIP

Bearings Fluid-Film Lubricated Journal & Thrust Bearings with Fixed or Tilting-Pad Configurations Practically any Bearing or Bearing System Available in the Industry can be Analyzed



Results including

The ARMD software package has the capabilities of evaluating both fluid-film and rolling-element bearings. Practically any bearing or bearing system available in the industry can be modeled and evaluated with one of the bearing solution modules Modeled Bearing

Details _ The FLUID-FILM bearing modules (JURNBR, HYBCBR, TILTBR, and THRSBR) solve the lubrication problem in two dimensions eliminating any approximation typically associated with one Scroll through dimensional analysis or with look-up table methods. cases.

Complete performance predictions of hydrodynamic, hydrostatic, and hybrid lubricated journal, conical and thrust bearings operating in the laminar and/or turbulent regime can be generated.

Simulation capabilities include such effects as misalignment, pressurized boundaries or grooves, cavitation, surface deviations (structural deformation), lubricant feed circuitry with specified pressures or

restrictors	Single Case Lube Details	-
(capillary,	Lubricant Conditions	-
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	Supply Temperature 120.0	
valve),	Flow Type Grooved ~	Heat Content Non-Grooved Triangular
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geometry	Groove Feeding System	
and	Chamfer Type Triangular 🗸	
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,		Preload	0.4	Speed	20000.0	Grv. Angle	0	0.0 No. of Pads	5.0
ed. Complete Bearing Performance Results including bearing system and individual pac heat balance.		Min.Film T Power-Loss Load Capace Supply-Oil Supply Fid Film-Temp Viscosity Heat Conte Groove Tem Max. Temp. Indivi Surface Ve	hick> 9.8 > 2.5 hity> 4.9 119. .w Rate> 6. (avg.)> 176. 1.01 int> 3. 1.01 1.01 3. 1.01 1.01 1.01 3.	316E-04 591E+01 955E+03 997 (D. 1604 (G) 056 (D. 7E-06 (R. 622 (BTI 7E5 (D. 347 (D. 1t5 Belot 3E+04 (Ft	(Inch) ECC (HP) Side (Lbf) Inle eg.F) >>> pm) KXX eg.F) KXX eg.F) DXX eg.F) DXX eg.F) DXX eg.F) DXX eg.F) DXX eg.F) DXX eg.F) DXX	= 0.6344 (-Leakage (t-Flow (STIFFNESS ; KXY> ; KYY> DAMPING (1 ; DXY> ; DYY> ected Pres	<pre>& Angle = 27 QF -> 1.710 QI -> -1.540 (Lbf/Inch) 3.883E+06 1.690E+00 Lbf-Sec/Inch 1.637E+03 1.420E-04 </pre>	0.00 (Deg) 12E+00 (Gpm) 19E+01 (Gpm) 1.229E+00 6.829E+06 	Generated text output
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The FLUID-FILM bearing modules incorporate numerous templates for common bearings used in industry. In addition, bearing configurations that can be evaluated with the various solution modules include but not limited to:

Fixed Geometry Cylindrical and Conical Journal Bearings (JURNR & HYBCBR)

Ο

0

Plain surface 0

0

Tapered land 0 Lobe or canted lobe

Multi-recess

- Multi-groove 0
- Pressure dam 0
- Elliptical or lemon 0
- Rayleigh step or pocket 0

Fixed and Tilting-Pad Geometry Thrust Bearings (THRSBR)

- Plain surface 0
- Multi-groove 0
- Step land 0
- Step pocket 0
- 0

- Tapered pocket Ο
- Tilting pad Ο
- Compound taper Ο
- 0

Tapered land

Any configurable pad surface



- Central pivot Ο
- Offset pivot 0
- Evenly spaced pads 0
- Grouped pads 0
- Load between pads 0
- Load on pad
- Any load direction Ο
- Any preload 0
- Leading/trailing edges taper Ο

ок

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Fluid-inertia force effects 0



6 Pad Load Between Pads 6 Pad Load On Pad

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Help

Help



Rolling-Element Bearin

The ROLLING-ELEMENT bearing module [COBRA] predicts the performance of up to six bearings of different types mounted on a shaft and experiencing radial, thrust and moment loading. Bearing types include:

- Conrad (radial) ball
- Angular contact ball
- Cylindrical roller
- Tapered roller
- Spherical roller

The program allows the evaluation of misalignment, offsets, preload, clearance, or end-play on bearing performance. Bearing preload from spacer grinding or shimming, as well as preload springs is included. Individual bearings can be made to "float". Results include:

- Ball load distribution
- Stress distribution
- Bearing reaction loads & displacements
- System reaction loads & displacements
- Hertz contact stress
- B10 life
- Contact angles
- Spring/stiffness rate

COBRA File Edit RUN Page Window Help C-Users/Public/Documents/ARMD58/COBRA/Sample1.dat System Bearings Lubrication Initial Conditions & Materials Results Descriptive Title
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Inrust Load along Z-axis [IDS, Appld -2.000E+03 1.000E+03 5.000E+02] Guess -3.000E-03 2.000E-03 1.000E-0
Reactn 2.010E+03 -1.007E+03 -4.452E+02 Soln -1.375E-02 1.658E-02 1.931E-0
Life Adjustment Factors: Bearing No. 1 2 3 4
Reliability: 1.000E+00 1.000E+00 1.000E+00
Lubrication: 2.333E-01 2.333E-01 2.100E-01 6.000E+00 +
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Results (shown above) are current w/r/t worksheet data.

Lubricant Module (VIS

The LUBRICANT module [VISCOS] calculate dependent properties of lubricating fluids. Th requires the user to specify lubricant publishe to select them from the built-in lubricant datab

0.35220E+03

Brand Name --> DTE 797 Turbine Oil

0.44359E+02

Kinematic

Viscosity

Centistoke=

(M²/s)*E+6

0.11245E+03

0.98266E+02

0.86276E+02

0.76089E+02

0.8577

0.8562

20 10

50

100

VISCOS generates, as a function of temperature, such parameters as:

*** Units of Measure for this Run are --> US (English)

Centinoise=

(Pa-s*1000)

0.96961E+02

0.84583E+02

0.74131E+02

0.83685E-05 0.57699E+02 0.67391E+02 0.31217E+03

API Gravity [@ 60øF/15.556øC] = 0.32600E+02 ISO Grade Number ->

TABLE WAS GENERATED FOR THE FOLLOWING LUBRICANT

1st Viscosity point (Centistoke) = 0.32000E+02

2nd Viscosity point (Centistoke) = 0.54000E+01

Computed SUS sec.@ 100øF/37.778øC = 0.16509E+03

Absolute - Viscosity

0.94654E-05 0.65261E+02

- Absolute viscosity
- Kinematic viscosity
- Saybolt universal viscosity
- Specific gravity
- Weight density
- Specific heat
- Heat content

Supplier --> MOBIL

Temperature

60.000

64.000

68.000

72.000

76.000

F .

Degrees

<

Thermal conductivity

Last line of problem description

Computed SUS sec.@ 210øF/98.889øC =

(Rens)

Lb-Sec/In^2

0.14063E-04

0.12268E-04

0.10752E-04

Viscosity Data COS] calculates temperature ting fluids. The program ricant published properties or lubricant database. on of as: Image: Suppler Difference (Suppler Difference) Suppler Difference (Social Projection) Image: Suppler Difference (Social Projection) Image: Suppler Difference (Social Projection) Image: Difference (Social Projection)				-			_							
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Absolute Viscosity (Rens) data-base that can be accessed		Absolute Viscosity	ty (Rens)			data-l	base	that can b	be accesse	d				
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50 100 150 200 2 Lubricant Temperature (Degrees F)		50			100	Lubrica	ant Tem	150 perature (Degree	sF)	200		250		
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		60 50												
0.45439E+03 0.8608 540	0.45439E+03 0.8608	10 40		-										

150

Lubricant Temperature (Degrees F)

200

Wear-Rings tool

ArmdWear is an ARMD utility for computing wear-ring/seal performance properties including dynamic coefficients (stiffness and damping) of incompressible fluids such as those found in boiler feed pumps.

The computation is based on Black and Jenssen "Effect of High Pressure Ring Seals on Pump Rotor Vibrations". The simulation in ArmdWear can be performed for a single point of operation or as a function of operating parameters such as Diameter, Length, Clearance, Pressure Drop, Speed, Fluid Viscosity or Density.

Wear-ring input data files can also be linked to ARMD rotor

models developed in the rotor dynamic package ROTLAT, for automatic wear-ring dynamic coefficients (stiffness & camping) calculations and inclusion in the rotor dynamic simulations.



Aerodynamic Cross Coupling tool

ArmdAeroCC is an ARMD utility for computing gas compressor Aerodynamic Cross Coupling Destabilizing Effects. The computation can be based on one of the following:

A- API 617 for centrifugal impeller.B- API 617 for axial flow rotor.C- ALFORD's equation.D- WACHEL's equation.

The simulation can be performed for a single point of operation or as a function of input parameters such as power, impeller diameter, impeller discharge clearance, ratio of discharge to suction densities, etc.

Created input data files can be linked to ARMD rotor models developed in the rotor dynamic package ROTLAT, for automatic aerodynamic cross-coupling coefficients calculations and destabilizing effects inclusion in the rotor dynamic simulations.



ARMD Documentation

ARMD package is supplied with a printed quick start manual that covers installation, sample cases, features, and capabilities. The package also has a comprehensive electronic user's manual that includes the following sections:

ARMD™	Introduction, Set-up, Installation and Operation	Brochure	Manual	
ROTLAT™	Rotor Dynamics Lateral Vibration	Overview	Manual	Samples
TORSION™	Torsional Vibration	Overview	Manual	Samples
JURNBR™	Cylindrical Fluid-Film Fixed Geometry Journal Bearings	Overview	Manual	Samples
HYBCBR™	Conical Fluid-Film Fixed Geometry Journal Bearings	Overview	Manual	Samples
TILTBR™	Fluid-Film Tilting-Pad Geometry Journal Bearings	Overview	Manual	Samples
THRSBR™	Fluid-Film Fixed and Tilting- Pad Geometry Journal Bearings	Overview	Manual	Samples
COBRA™	Rolling-Element Bearings	Overview	Manual	Samples
VISCOS™	Lubricant Temperature Dependent Properties	Overview	Manual	Samples



Purchasing Options

ARMD is constructed from various solution modules. It can be tailored to suit your needs and budget. You may purchase any combination of programs or all if you wish. Licensing is available as a single seat or multi-seat network configuration.

With your purchase, the package includes the software (CD or download), quick start manual, electronic user's manual, technology transfer and training session (optional), updates, maintenance, and support.

System Requirements

Microsoft Windows 10, 11 or higher (32 or 64 bit).

Remember, with RBTS, you get

more than just the software, you get the company with more than 50 years of experience in the areas of tribology and machinery dynamics.



The Worldwide Leading Software For Rotating Machinery Analysis

Advanced Rotating Machinery Dynamics



RBTS' software has gained international reputation for its:

Technical Capabilities
 User Friendliness

- Completeness
- Support & Service

YOUR PARTNER for Europe & Middle East & Africa

Support for other countries on request.

- Customer Engineering Support (Rotor Dynamics & Torsional Vibrations)
 - ARMD Software Support
- Training Courses & Seminars

Please contact: Dr. Andreas Laschet



Dr.-Ing. Andreas Laschet

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