

ARMD Packages: Detailed Information



Phone: +49 2268 901650 · E-mail: info@laschet.com · Web: www.laschet.com

Advanced Rotating Machinery Dynamics - Rotor/Bearings/Supports Lateral Vibration Analysis



Phone: +49 2268 901650 · E-mail: <u>info@laschet.com</u> · Web: <u>www.laschet.com</u>



The rotor dynamics lateral vibration analysis package uses a finite-element based formulation, for performing damped and undamped **natural frequencies**, **mode shapes** and **stability** (ROSTAB & ROTORMAP), **synchronous unbalance response** (ROSYNC), **steady-state response** (ROSSRP), and **non-synchronous time-transient response** (RORESP) of rotating machinery. The five sub-modules are 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-rings, seals, aerodynamic effects, support structural 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.
- Bearings of all types: Cylindrical, Conical, Tilting Pad & Rolling Element.
- Bearing models linked to rotating assembly at any station.
- Bearings vertical elevation for accurate bearings load computation.
- Springs: wear-rings, seals, aero-dynamic effects, squeeze-film 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/pedestal 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.
- The release of RBTS' **ARMD Version 6 Rotor Dynamics** is a major milestone in the product's development history, rolling out a **completely new and improved** graphical user interface for the package with enhanced numerical capabilities and analysis features. The software's front end was redesigned with our customers' and industry's input to incorporate the most logical, efficient, and productive techniques to model and analyze complex rotor/bearing systems for lateral vibrations.

ARMD ROTLAT users will immediately see the improvements as element, shaft, and system data are presented in a flatter format, with key fields and analysis options readily visible and accessible from the main data entry screens. Engineering productivity to design models is vastly improved as shafts and systems can be easily imported from usergenerated component template models. Furthermore, the ability to simultaneously run multiple instances of the program permits rapid side-by-side comparison of results.

By identifying new trends from industry standards, along with RBTS' involvement in turbomachinery standards revisions, new technical features were added to the software. Addition of equivalent element stiffness diameters, user specified stiffness for such elements as flexible coupling or disk plate, expanded user-defined forces application, better access to temperature dependent properties, seamless integration of modeled bearings and springs (such as wear-rings, seals, aerodynamic effects, squeeze-film dampers, etc.) all combine to provide more accurate modeling and better matching of analysis results to actual system empirical results.

New Enhanced Modeling, Usability and Technical Features:

Improved TAB layout. Redesigned for more direct and faster access to data input locations and results. Important functionality is brought forward into the TAB structure, thereby eliminating the need to select from drop down or pop-up menu lists.

þ								Syst	em									×	
Materials	Element	Discs	Bearing	gs Beari	ing Loads	Speed	ds Static	: Pede	stals D	ynamic Pe	edestals	Sprin	ngs: Seals & More	Elem	ent Stiffness	Station	Moment Re	elease	
		Material Number	Taper	Length	OD1	ID1	OD2	ID2	Use Stiffness Diam	Stiffness Diameter	User Specifi Stiffne	r ied ss	١	lame				^	
	49	1		18.7	250.0	0.0	250.0	0.0		0.0	None	~							
	50	9		7.9	257.8	0.0	257.8	0.0		0.0	None	~							
	51	9		15.9	281.7	0.0	281.7	0.0		0.0	None	~							
÷2 →N	œ	1							0	ptions									2
	D	escriptior	n Solve	ers Optio	ons Nat	ural Fre	equencie	es / N	lode Sh	apes (Inbalan	ce / S	Steady State Re	espons	se Time '	Transient	Simulation	1	
<u>_</u>													-						
Natural Frequencies and Mode Shape Options Soutput Options Coutput Options Cycles/Minute Output Options Row C Output Options Cycles/Minute Output Options Cycles/Minute Output Options Compute natural frequencies and mode shapes where the critical damping ratio is below Output Options Output Options Row C Output Options Compute natural frequencies and mode shapes where the critical damping ratio is below Output Options																			
							App	lied	Loads	;							- 0	×	
defined	Applied L	oads																	
	Station	D	irection		Load		Frequen	су	Phas	e Angle	Star	t Time	e End Tim	e	Name			^	1
14	44	Force in	۱Y	~	217	79.3	23	310.0		76.776			0.0 100	0.00	Compresso	r Throw 3	Y 5th Ham	1.	1
15	44	Force in	١Y	~	389)1.9	26	640.0		-66.54			0.0 100	0.00	Compresso	r Throw 3	Y 6th Ham	ı.	1
16	44	Force in	١Y	~	516	3.3	19	0.086		48.908			0.0 100	0.00	Compresso	r Throw 3	Y 7th Ham	ı. 🗸	
	1								·i		·i		i.	ŕ				>	
8]						Ok			Can	cel		He	elp					2	,
aft statio	on numb	er																	

Multiple instances of ROTLAT. The newly developed package can now open simultaneously multiple instances of ROTLAT, so modeled shaft and components can be moved easily between different system models to allow fast, side-by-side comparison of model variations and analysis results. This functionality permits multiple instances of ROTLAT Version 6 or Version 5.8 to be accessible on your screens.



Many of the improvements incorporated into the ARMD ROTLAT Version 6 are specifically directed towards simplicity, increasing usability and increasing productivity as illustrated bellow: Auto Mathematical



- Evaluate Mathematical Expressions. When entering data to cells, data entry field has the ability to evaluate mathematical expressions, without having to launch a calculator app.
- > Whole Number. Display for improved legibility, defaulting to scientific notation when required.
- Auto Convert Units. Automatically computes the units conversion when modeling a system with different components using mixed SI and English units. Example: You have a few inch dimensions to enter amongst hundreds of mm values, just check the box for auto conversion.
- Automatic Cell Validation. Performed at data entry time. The program now reviews data grids for incomplete, invalid, or nonsensical entries, providing an error flag and correction recommendation. This applies to mass-elastic data fields, user defined torques, and required solver data inputs.
- Data validation error diagnostics quickly walks user through any model input errors. A mouse click navigates the user to the next error found.
- Row Tagging. Row marking/tagging for quick identification and rapid recall, advantageous for multishaft systems with very large numbers of elements.
- Round Function. Round function for data entry fields is accessible from the Tools menu, and can be declared for all data fields.

~	Enable Units Conversion from Expression Evaluator
	Enable Rounding Button
	Set Rounding Precision

Tool Strip/Bar and Buttons. Replaces hidden right-click menus to provide enhanced visibility of functions and features.



> Data Entry Grids. All data entry grids can be open simultaneously for ease of model building.

RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • info@rbts.com Page 5 of 18

- Data Entry Menus. All data entry menus are visible at the Grid Input page. Grids now feature selection check boxes and editing buttons where appropriate.
- Shaft Material Temperature. Material operating temperature is readily input and enabled, to capture the temperature dependent material properties and their effect upon rotating assembly dynamic characteristics. Particularly useful for shafts in high temperature applications like steam turbines, rolling mills or extruders.

_								(X)	aterial		Indend	
Q	þ					S	ystem	Τe	emperature	e	Library 🔨	- • ×
	Mat	terials	Elements Discs	Bearings Bear	ing Loads Speed	ds Static F	edestals	lynami	c Pedestals S	orings: Seals & More	Element Stiffness Station	Noment Release
			Young's Modulus	Shear Modulus	Density	Use Operating Temp	Operati Tempera	ng ture	Damping Factor		Name	Get Values From Library
		1	199950.0	79290.0	7833.4			0.0	0.0	Steel		
		2	199950.0	79290.0	3519.2			0.0	0.0	Motor Core Ends		
	►	3	199950.0	79290.0	2442.1	✓		100.0	0.0	Motor Core		
		4	199950.0	79290.0	7833.4			0.0	0.0	Compressor Steel		
) late	rial Yo	ung's Modulus of	Elasticity	Ok	:	Car	ncel	H	lelp	Check for Syst	em Errors

- Stiffness Diameter can be used to enter the equivalent mass-elastic properties of complex shaft sections, motor lamination stacks, shrunk on disks, etc. When selected, stiffness diameter is used to compute element stiffness while element geometry is used for computing element weight and inertia properties.
- Discs & Disc Calculator. Discs representing concentrated mass with/without inertia properties can be located at any station along the shafting system. A disc calculator is implemented in ROTLAT to compute weight, polar and transverse moments of inertia for user defined single or multiple disc geometries. Calculated weight and inertia properties are automatically placed in the appropriate cells in the Discs form.



Bearings can be located at any station along the shafting system. Bearings are the fundamental elements supporting the rotating assembly, and any internally generated or externally applied forces and moments. Their dynamic properties (stiffness and damping coefficients) can be manually specified or automatically generated when bearing models are linked to specified stations on the rotating assembly.

Q	D									Syste	em										×
ſ	Mater	ials	Elements	Discs	Bearings	Bearing	g Loads	Speed	ds Static	Pedes	stals Dyr	namic Pe	edesta	ls Springs	: Seals &	More Ele	ment Sti	ffness	Station	Moment Relea	ase
			Station	DOF	Ту	pe	Coef So	ficients urce	Inp	ut File	(e.g. Non	-dimensi	onal o	r other)	File Status	Browse to File	Edit File	Be Coef	aring ficients	Elevation	
	•	1	3	2	Fixed journ	nal	✓ Auto	~	Pinion01	AsDesi	ignedPres	ssureDar	nBeari	ing-M00V	Found			E	Edit	C	0.0
		2	17	2	Fixed journ	nal	X Auto	¥	Pinion01	AsDesi	ignedPres	ssureDar	nBear	ing-M00V	Found			E	dit	(0.0
Be	1 3 2 Fixed journal ✓ Auto ✓ Pinion01AsDesignedPressureDamBearing-M00V Found •••• Edit 2 17 2 Fixed journal ✓ Auto ✓ Pinion01AsDesignedPressureDamBearing-M00V Found •••• Edit 2 17 2 Fixed journal ✓ Auto ✓ Pinion01AsDesignedPressureDamBearing-M00V Found •••• Edit ✓ Manual Bearing ✓ ✓ ✓ ScrollRight Manual Bearing Øk Cancel Help ✓ Check for System Error Bearing Station Number Rolling Element ✓ Manual Static Pedestal Tilting Pad Manual Static Pedestal Dynamic Pedestal Tilting Pad Description														tem Errors	>>					
							Man	Jal Ϋ	i [F		•			-						
							Manu	Jal			Static Pe	edestal	Dy	namic Pede:	stal I	ilting Pad Inertia			Desc	ription	
							Linke	d		N	Vone) v	Nor	ne	¥	0	0				
										N	lone	~	Nor	ne	¥	0	0				
									V												>

Typically, a bearing has two degrees-of-freedom (X and Y directions, Z being the rotational axis) which is the default setting. ROTLAT can accommodate any number of degrees-of-freedom such as **4x4** for bearings with moment stiffness (Rolling-Element bearings or Thrust bearings). Similarly, for Tilting-Pad bearings where pad pitch degree-of-freedom are to be considered (full stiffness and damping coefficients **NxN**) the size is set to 2 + number-of-pads).

Bearings Loads. Bearing applied loads due to rotating assembly dead weight and/or externally applied forces and moments on the rotating assembly, can be automatically calculated or manually specified in the form. To automatically calculate bearing applied loads simply press the calculator button on the left side of the form.

œ					System					×
Materia	ls Elements Disc	s Bearings B	earing Loads	Speeds	Static Pedestals	Dynamic Pedestals	Springs: Seals & More	Element Stiffness	Station Moment Rele	ease
		Bearing 1 Load	Bearing 2 Loa	be						^
	Speed 5	87.43	83	3.4						
	Speed 6	99.78	94.	32						
	Speed 7	99.78	94.	32						
	Speed 8	113.32	106.3	28						\sim
B	earing Loads alculator But	s tton		Ok	C	ancel	Help	✓ Check	c for System Errors	Ê

Bearing load calculations may-or-may-not consider dead weight load and externally applied forces/moments, but also will take **bearing elevation** into account to properly compute bearings load magnitudes and directions for each of the bearings supporting the rotating assembly. Bearings **Elevations** are influential when indeterminate supports are considered with three or more bearings such as those installed in multi-rotor power generating units.

Speed Cases. Many speed cases can be considered in rotor dynamic evaluation with ROTLAT. Speed cases entry and bearing dynamic coefficients viewing are designed for efficiency with copy and deep duplicate functions (all linked values are duplicated).

Q	Þ										Syster	n										×
	Mater	ials E	lements	Discs	Bea	arings	Bea	aring Lo	oads Sp	eeds St	tatic Pedestals	Dynamic F	Ped	estals	Sprin	ngs: Se	eals & More	Elemer	nt Stiffnes:	s Sta	tion Moment Relea	se
		Enter	/Edit Sp	eeds:				[Dynami	c Coeffic	cients Seleo	ctor			Curre	ent C	oefficient	s at Se	lected S	peed	d and Location	
			Sp	eed	^				Station	т	уре С	Coefficients	^	Stiffn	iess Mat	trix:		B	earing Loa	ad:	122.0 lbf	
		9		18000.0			L.	-	2	Eword iou	imal A	uto .					x		у			
		10		18600.0			Ľ	-		Fixed jou				•	Kx		75606.37	1	22947.0			
		11		18800.0			-	2	1/	Fixed jou	umal A	uto		Ľ.	K		-564232.4	8	5345 52			
		12		19000.0											ry		001202.1		0010.02			
	•	13		19200.0										Dam	ping Ma	atrix:	Edit Coeffo	ients	Upd	ate All	Auto Coefficients	
		14		19400.0	*	Cut		C	trl+X												oofficiente	<u> </u>
		15		19600.0		Сор	у	C	trl+C								x		у	a	utomatically upda	ted
		16		19800.0		Past	te	C	Ctrl+V						Dx		111.4341		47.1215	fo	r linked bearings	
		17	<u> </u>	20000 0	w	Clea	ar			_			.		Dy		-43.68232	5	88.1042	W	hen button is pre	ssed
					Ŧ	Inse	ert Row		F3				× .									
I.	-				÷	Арр	end Ro	w Ct	trl+F3	Ok		Cancel	1		He	elp			🗸 Ch	eck fo	r System Errors	
Ŀ					×	Dele	ete Row	'	F4				1								2,111 21010	
S	peed				-	Dup	licate I	(ow	۲۵									R	PM			

Static Pedestal. Bearings support flexibility such as bearing housing, support structure, etc. can be considered in ROTLAT. These dynamic coefficients are normally defined in the horizontal X-direction and vertical Y-direction with their mass, stiffness and damping characteristics. Any defined static pedestal properties can be linked to any bearing in the system. ROTLAT not only accommodates these coefficients but also can accommodate cross-coupled coefficients as shown.

Q	Ð								System								• • ×		
	Mate	rials	Elements	Discs	Bearings	Bearing Loads	Speeds	Static P	edestals	Dynami	c Pedestals	Spri	ings: Seals & Mo	re E	lement Stiffness	Station Momen	t Release		
			Use Cross Coupling	w	eight X	Weight Y	Stiffne	ss X	Stiffness	Y	Damping X		Damping Y		[Description			
	•	1			50.0	50.0	100	0.0000	10000	00.0	0	.0	0.0	NDE					
	œ	System Materials Bements Discs Bearings Deceds Static Pedestals Dynamic Pedestals Sorings: Seals & More Bement Stiffness Station Moment Release															• ×		
	Materials Elements Discs Bearings Bearing Loads Speeds Static Pedestals Dynamic Pedestals Springs: Seals & More Element Stiffness Station Moment Release																		
Γ	Materials Elements Discs Bearings Bearings Coupling Static Pedestals Dynamic Pedestals Springs: Seals & More Element Stiffness Station Moment Release Use Use Cross Weight X Weight Y Stiffness XX Stiffness YX Stiffness YX Stiffness YY Damping XX Damping XX Damping YX Damping YX D															Damping YY			
			1 🗹		50.	0 50	.0 1(000000.0)	0.0		0.0	1000000.	.0	0.0	0.0	0.0	0.0	NDE
		/ :	2 🔽		100.	0 100	.0 2.000	000e+06	6	0.0		0.0	2.00000e+0)6	0.0	0.0	0.0	0.0	DE
	<	C													_				>
	-14								Ok		Canc	el		Help		✓ Che	ck for System Erro	ors	

Dynamic Pedestal. Similar to the static pedestal mentioned above, the dynamic pedestal defines the dynamic coefficients as a function of frequency bands calculated or measured in the field.

œ					Pedest	tal / Housing	Dynamic (fre	equency-depe	endent) Infor	mation for Pe	edestal 1			- 🗆 ×	
Γ		Minimum Frequency	Maximum Frequency	Weight X	Weight Y	Stiffness XX	Stiffness XY	Stiffness YX	Stiffness YY	Damping XX	Damping XY	Damping YX	Damping YY	Description	
	1 0.0 100.0 100.0 100.0 500000 0.0 0.0 500000 0.0 0.0 0.0 0														
	1 0.0 1000.0 100.0 100.0 500000.0 0.0 0.0 0.0 0.0 0.0 2 1000.0 2000.0 100.0 500000.0 0.0 0.0 0.0 0.0 0.0 0.0														
Þ	3	2000.0	3000.0	100.0	100.0	500000.0	0.0	0.0	500000.0	0.0	0.0	0.0	0.0		
	4	3000.0	4000.0	100.0	100.0	500000.0	0.0	0.0	500000.0	0.0	0.0	0.0	0.0		
	5	4000.0	5000.0	100.0	100.0	50000.0	0.0	0.0	500000.0	0.0	0.0	0.0	0.0		
Low	er limit o	of fre 🗸 Cross Cou	pling Enabled									СРМ			

Page 8 of 18

RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • info@rbts.com

Springs. Provides the means to introduce dynamic characteristics (stiffness and/or damping coefficients similar to bearings) affecting the rotating assembly. This option permits the user to specify dynamic effects such as those arising from Seals, Wear-rings, Impeller Aero-Dynamics, Impeller Hydraulics, Steam Whirl effects, etc. that may be stabilizing or destabilizing forces on the rotating assembly. Their dynamic properties (stiffness and damping coefficients) can be manually specified or for some elements (shown below) automatically generated when these elements are linked to specified stations on the rotating assembly.

¢	в							System							- • ×
	Mater	ials	Elements	Discs Bearing	gs	Bearing	Load	s Speeds Static Pedestals Dynamic Pedestals	Springs	: Seals & N	Nore E	ement Stiffnes	s Station M	oment Release]
		Da	ata ent	ry form for S	Spr	ings: V	Vea	ar-rings, Aerodynamic Cross Couplin	igs, Ma	gnetic	Pulls	and other	stiffness	s / damping	g locations.
			Station	Туре		Coeffici Sourc	ents ce	Input File	File Status	Browse to File	Edit File	Coefficients	Wear-ring Pressure Drop		Description
		4	9	Wear-ring	~	Auto	~	MultiStagrPumpImpellersWearRing-M00.win	Found			Edit	Edit	Stage #4	
		5	11	Wear-ring	~	Auto	~	MultiStagrPumpImpellersWearRing-M00.win	Found			Edit	Edit	Stage # 5	
		6	13	Wear-ring	Y	Auto	~	MultiStagrPumpImpellersWearRing-M00.win	Found	•••		Edit	Edit	Stage #6	
		7	15	Wear-ring	¥	Auto	~	MultiStagrPumpImpellersWearRing-M00.win	Found	•••		Edit	Edit	Stage # 7	
	•	8	57	Wear-ring	8	Auto	¥	MultiStagrPumpImpellersWearRing-M00.win	Found	•••		Edit	Edit	Stage #8	
		9	59	Moordee	Į,	Auto	4	MultiStagrPumpImpellersWearRing-M00.win	Found			Edit	Edit	Stage # 9	
		10	61	Wear-ring		Auto	4	MultiStagrPumpImpellersWearRing-M00.win	Found			Edit	Edit	Stage # 10	~
	<		-	User Specified Wear-ring				7	i	Ľ			i		>
	_ba1]			Aerodynamic Squeeze Film				Ok Cancel		Help]		✓ Check for	r System Errors	
	(1949) (1949)					Auto	V				-				<u>u</u> 2
S	tation	Num	ber			Manual									
						Linked									

Element Stiffness. The element stiffness feature (matrix tab shown below) permits user specification of elements stiffness matrices to be utilized in the shaft element form instead of being computed internally by the solvers from the specified element geometry. This feature allows the specification of element stiffness matrix for such elements as coupling, coupling connections, plate elements, discs, or any other flexible connection along the shafting system.

						Axisvmme	etric Non-t	apered Ele	ement						
	_ X	αχ	Y	αΥ _		X	αΧ	Ý	αγ	Ð	Use	r Specified El	ement Stiffne	ess Matrix	×
x	1,1	1,2	1,3	1,4	x	$\frac{12EI}{L^3}$	$\frac{6EI}{L^2}$	$-\frac{12EI}{L^3}$	$\frac{6EI}{L^2}$			Kox 2.905 Kox	900 <u>e+07</u>	Кхах 1.452900e+07 Кахау]
αχ	2,1	2,2	2,3	2,4	αχ	$\frac{6EI}{L^2}$	$\frac{4EI}{L}$	$-\frac{6EI}{L^2}$	$\frac{2EI}{L}$	-	Edit the	values above to p	roduce the effecti α x	ve stiffness matrix s	shown below: αy
Y	3,1	3,2	3,3	3,4	Y	_ <u>12EI</u>	<u>6EI</u>	12 <i>EI</i>	_ <u>6EI</u>	•	x αx	2.905900e+07 1.452900e+07	1.452900e+07 3.004100e+07	-2.905900e+07 -1.452900e+07	1.452900e+07 -1.551200e+07
						L^{3}	L^2	L^3	L^2		y ay	-2.905900e+07 1.452900e+07	-1.452900e+07 -1.551200e+07	2.905900e+07 -1.452900e+07	-1.452900e+07 3.004100e+07
αγ	4,1	4,2	4,3	4,4	αΥ	$\frac{6EI}{L^2}$	$\frac{2EI}{L}$	$-\frac{6EI}{L^2}$	$\frac{4EI}{L}$			ОК	Cancel	Help	Ľ

Station Moment Release. The station moment release permits specification of stations along the shafting system not to transmit moment forces across the station while transmitting full shear forces. This option lends itself to readily define a station reflecting shaft connections at universal joints,

a	∍							Syster	n				8
	Mater	ials	Elements	Discs	Bearings	Bearing Loads	Speeds	Static Pedestals	Dynamic Pedestals	Springs: Seals & More	Element Stiffness	Station Moment Release	
			Stati	on		Na	ame						
	•	1			6 Flexible	Connection							
l L		_											

RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • info@rbts.com Page 9 of 18

> 2-D GRAPHICS MODEL.

Real-time graphics update of the 2-D image corresponding to numeric data input in data grids provides visual confirmation of model correctness while building system models.



2-D Model auto resizing gives user the option to "fit-to-page" complete model. User can automatically view the model with the correct aspect ratio (Uniform Display Scale, shown below), thereby permitting rapid, visual model review. Shaft models can be **flipped from left** to right with a single button click.



Interrogate an element in the 2-D Model Viewer to see all defining element data in a side-bar data window.

Element selection with control keys within the 2-D model viewer permits easy identification of particular cells within large models. This is useful for models with closely spaced thin elements.

Rotated view option for copying the 2-D model graphic to the clipboard.

Metafile enabled copy and paste of system models and graphics for better report graphics.

Tool panel has been added on the 2-D display window for enhanced graphics control and better visibility of display options.

- Text Output Viewer. User selectable text output viewer that can be Word, Open Office Writer, Notepad, WordPad, or any other program which accepts text file input. Settings are specified in the ARMD Settings form from the help menu.
- One-click Quick Chart. This feature rapidly displays an X-Y graph of entered tabular data for visual verification of correctness. ARMD Graph software is still available for complete graphic analysis capabilities
- Selectable Output Units. Selectable Frequency Units between CPM or Hz, in accordance with the user's preference, or the industry standard format, can be set simply by checking a box in the options form. Also damping parameter (Damping Ratio or Log. Dec.) can be selected.
- Damped Modes. Users may eliminate graphical presentation of highly damped modes by simply checking a box and specifying damping ratio threshold.

	1			ARMD	Settings		-		×	
	General	2 DOF Layout	Recent Lists	Grid & M	aterial Colors	Model Colors an	d Fonts	Adva	nced	
		Application max	imized at startu	р	🗌 Alway	ys save data on s	olver run			
	5	j Do not aiways (Text Viewer	display solver ou	Jtput		gnas aunng data (entry			
	(WordPad		NotePad		Other				
	[C:\Program Files	(x86)\TextPad	5\TextPa	l.exe	Browse				
	F	Preferred units	ustomary/Englis	sh	0	SI/Metric				
	F	Preferred frequent	cyunits s / min (CPM)		0	Hertz (Hz)				
	F	Preferred damping Critica	g output units (F al Damping Rati	Rotordynar o	nics graphics o	only) Log Decrement				
	F	Restore Defaults Restore a	II settings to def	fault.	Restore	Defaults				
🗇 Optic	ons									x
Descripti	on Solvers	Options Natural Fre	equencies / Mode	Shapes U	nbalance / Stea	dy State Response	Time Tran	nsient Si	mulation	
Nat	tural Frequence Output Option	cies and Mode Shap Is	e Options							
	Cycles	:/Minute	Damping Ration	•	Compute na	tural frequencies an	d mode shi	apes wh	iere	
	⊖ Hertz		O Log Decreme	nt	the critical damp	oing ratio is below		0	.9	
	Critical	Speed/Stability Ma	p Condensed Outp	out	o				_	
	Stability Analy	sis Options			Untical Speed O	ptions	1.00	0000-	07	
	0				Deal Dearing St	unness	1.00	0000e+	12	
	Operating	speed. 2000	. 10		Final bearing ou	inness	2.00	0000000000		
	Number of	mode snapes to pio		[Speed (Only for	gyroscopic analysis)				
			Ok	Ca	ncel	Help				

- Critical Speed Map Options. Minimum and maximum support/bearing stiffness for critical speed map can be user specified and can include gyroscopic/speed effects.
- Amplification Factors. Amplification factors in accordance with API standards are computed for user specified stations by simply specifying the desired stations for this option.





RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • info@rbts.com Page 11 of 18

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





Generation of mode shapes as a function of support stiffness for Critical Speed maps and as a function of speed for Stability maps.



RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • info@rbts.com Page 14 of 18

ARMD[™] V6.2 – ROTLAT Package Synchronous UNBALANCE & STEADY-STATE RESPONSE



RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • info@rbts.com Page 15 of 18

Implement feature for scaled amplitude of vibration to be user specified in the below form "API Scaling" tab. For example, API 617 criteria for compressors states "vibration response at each vibration probe, for considered unbalance amount and for cases of interest, shall not exceed the mechanical test vibration limit AvI, of 25.4 micrometer (1.0 mil) or the equation shown below, which ever is less".



C:\Users\Public\Documents\ARMD62\ROTLAT\MOTOR.syg MOTOR SYNCHRONOUS UNBALANCE RESPONSE ANALYSIS RESULTS IN GRAPHICS FORM >> Per API 617 Normalized Amplitude <<.



Rotor Speed (RPM)

RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • info@rbts.com Page 16 of 18



0

0

TIME-TRANSIENT RESPONSE (Non-Synchronous)

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



RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • info@rbts.com Page 18 of 18

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/modules 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:

Personal computer with Microsoft Windows 8, 10, 11 or higher (32 or 64 bit).

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

For further information, please contact us.



Rotor Bearing Technology & Software 1041 West Bridge Street Phoenixville, PA 19460 USA

> Telephone: Facsimile: Web: Email:

610-415-0412 610-415-0413 www.rbts.com info@rbts.com

ARMD⁻ The Worldwide Leading Software For Rotating Machinery Analysis

Advanced Rotating Machinery Dynamics

ARMD is a well established software package used worldwide to perform complete rotating machinery dynamic analysis. ARMD employs a user-friendly interface and window environment with pulldown menus and context-sensitive help. ARMD integrates the most advanced and complete rotor dynamics, torsional vibration, and bearing analysis programs under one environment in a seamless fashion to give you the power to model your rotating machinery with ease, efficiency, and above all accuracy. Some applications in which ARMD has been utilized include rotating machinery such as a miniature air turbine for a dental drill, a large turbine generator set for a power plant, a small compressor for an air conditioner, a pump for an artificial heart, a fuel pump for a jet engine, an electric motor and spindle for a miniature computer hard disk, a canned pump for petrochemical processing plant, synchronous motor driven drivetrains, and a gear box for an Uranium enrichment plant.

Technical Capabilities

Completeness

- User Friendliness
- Support & Service

Rotor Bearing Technology & Software

1041 West Bridge Street Phoenixville, PA 19460, USA

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

Dr.-Ing. Andreas Laschet · Apolloniaweg 6 · 51515 Kuerten · GERMANY Phone: +49 2268 901650 · E-mail: <u>info@laschet.com</u> · Web: <u>www.laschet.com</u>



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





Dr.-Ing. Andreas Laschet

Engineering Service & Technical Consulting

Apolloniaweg 6 · 51515 Kuerten · GERMANY

Ph: +49 2268 901650 · E-mail: info@laschet.com · www.laschet.com



Dr.-Ing. Andreas Laschet · Apolloniaweg 6 · 51515 Kuerten · GERMANY Phone: +49 2268 901650 · E-mail: <u>info@laschet.com</u> · Web: <u>www.laschet.com</u>



The torsional vibration package uses a finite-element based formulation for performing damped and undamped torsional **natural frequencies** and **mode shapes** (TORNAT), **steady-state** (TORHRM) and **time-transient** (TORRSP) **response** of mechanical drive trains. The three sub-modules are 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 advanced modeling features and capabilities including the modeling of multi-shaft/multi-branch systems, coupling stiffness and damping, gear tooth flexibility, stiffness/mass/inertia diameter, torsional springs to ground, various types of external excitations, synchronous motor start-up torque, compressor load torque, user specified time varying torques, electrical faults for motor and generator, and many others.



The release of RBTS' **ARMD Version 6 Torsion** is a major milestone in the product's development history, rolling out a **completely new and improved** graphical user interface for the package with enhanced numerical capabilities and features. The software's front end was redesigned with our customers' and industry's input to incorporate the most logical, efficient, and productive techniques to model and analyze complex multi-shaft systems for torsional vibrations.

ARMD TORSION users will immediately see the improvements as element, shaft, and system data are presented in a flatter format, with key fields and analysis options readily visible and accessible from the main data entry screens. Engineering productivity to design models is vastly improved as shafts and systems can be easily imported from usergenerated component template models. Furthermore, the ability to simultaneously run multiple instances of the program permits rapid side-by-side comparison of results.

By identifying new trends from industry standards, along with RBTS' involvement in turbomachinery standards revisions, new technical features were added to the software. Addition of equivalent torsional stiffness diameters, better handling of shaft connections, expanded user-defined torques application, and better access to temperature dependent properties all combine to provide more accurate modeling and better matching of analysis results to actual system empirical results.

Among The Enhanced Modeling, Usability and Technical Features are:

Improved TAB layout. Redesigned for more direct and faster access to data input locations, and results. - Important functionality is brought forward into the TAB structure, thereby eliminating the need to select from drop down menu lists and mouse right-click drop down menu lists.

¢											System									• ×	
E	Iranche	s Material	s Eleme	nts Conne	ctions [)iscs Sp	rings														
	All Elen	nents Brar	nch 1 Eler	nents Bran	ch 2 Elen	nents															
			Material Number	Use Geometry	Taper	Length	OD1	ID1	OD2	ID2	Use Stiffness Diam	Stiffness Diameter	Stiffness	Damping	Inertia	Use Dyn Mag	Dynamic Magnifier		Name		
	È	1	1	~		11.0	7.5	2.36	7.5	2.36		0.0	0.0	0.0	0.0		0.0	MOTOR NDE			
	Ē	▶ 2	1	•		14.0	8.0	2.36	8.0	2.36		0.0	0.0	0.0	0.0		0.0				
	÷2	3	1	•		10.0	9.0	2.36	9.0	2.36		0.0	0.0	0.0	0.0		0.0				
	÷Ν	4	1		✓	20.0	9.0	2.36	11.0	2.36		0.0	0.0	0.0	0.0		0.0				
	© Options																				
	Des	Description Natural Frequencies / Mode Shapes Steady State Response Time Transient Response Output Options																			
	Co	ontrol / C	Constar	nt Speed	/ Start	up optio	ons	Mate	erial F	atig	ue / Lif	e Data	Gear	Backla	sh						
		<u> </u>												<u> </u>							
		Contr	ol para	meters										Constar	it spee	d / sta	artup and	d shutdown (options		
		Time	step s	ize for int	egratio	n (sec)				1.	00000	0e-04	(orm Tir a the fi	ne-Tra	insient F	Response at es:	fixed speed		
Ľ		Num	ber of s	simulation	n time s	teps:					12	0000		Com	P	redefir	ned exte	mal torque			
c	Ð								Appl	lied	Torqu	ie Tab	les							•	3
	Stead	ly State H	amonic	Torques	Time Tr	ansient 1	Forque	s													
	Prec	lefined Ex	temal To	orques S	peed-De	ependent	Torqu	Jes	User-S	peci	fied Exte	mal Ton	ques Sy	Inchronou	us Motor	Torque	es Elect	rical Torques			
		E	ranch S	Station	Start Ti	me					CSV	File			St	atus	Browse	Edit		Name	
	•	1	1	6		0.05 1	ly TDa	ita_01	.csv						Fo	und		Torque	data from CSV	file.	1
	<																			>	
l																					
L								Ok	,	1		Cance			Help						
	-121							5.	-		_									6	3
ſ	Jser S	pecified	Torque	File Nam	e																-

Multiple instances of TORSION. The newly developed package can now open simultaneously multiple instances of TORSION, so shafts and component models can be moved easily between different models, also allowing fast, side-by-side comparison of model variations and analysis results. This functionality permits multiple instances of TORSION Version 6 or Version 5.8 to be accessible on your screens.



Many of the improvements incorporated into the ARMD TORSION Version 6 are specifically directed towards simplicity, increasing usability and increasing productivity as illustrated bellow:

														Aut	C				Mathe	matical	
_														Conv	ert			e	expression	s evalua	itor
	Ð			тс	RSION	(C:\L	lsers\F	Publi	c\D	ocu	men	nts\AR	MD60)\TORS	SION/S	ampl	es\S	YNC-M	OT.TOI US)		1 X
	Fi	ile	Edit	System	Optic	ons /	Applied	Tord	ues	Ru	un	View	Tools	win	dow I	Project	: Н	elp		\checkmark	
	n n	lew (🗃 Op	en 🖬 Sa	ve 🐰	Cut 📔	Copy	🖺 Pi	aste	-	Syste	em Mo	del 📗	Conv	ert Unit	s Ins	ert Va	alue: =((1.5^2+1.8^2)	0-3.13	
			<u> </u>				, cop)				-					5 115			(1.0 2 1.0 2)) 0.10	
	¢										1	System		01:0							
Tabs	E	Branche	s Mate	erials Eleme	nts Conne	ctions	Discs S	orings						Stil	Thess			Eleme	ent		
1		All Eler	nents	Branch 1 Eler	ments Brar	nch 2 Elei	ments							Dia	imetei	K		Prope	rties		
				Material Number	Use Geometry	Taper	Length	OD1	ID1	OD2	ID2	Use Stiffness Diam	Stiffness Diameter	Stiffness	Damping	Inertia	Use Dyn Mag	Dynamic Magnifier	Na	ame	
				1 1	-		11.0	7.5	2.36	7.5	2.36		0.0	0.0	0.0	0.0		0.0	MOTOR NDE		
		F	•	2 1	•		14.0	8.0	2.36	8.0	2.36		0.0	0.0	0.0	0.0		0.0			
		÷2		3 1	~		10.0	9.0	2.36	9.0	2.36		0.0	0.0	0.0	0.0		0.0			
Tool		÷Ν		4 1	·		20.0	9.0	2.36	11.0	2.36		0.0	0.0	0.0	0.0		0.0			
Strip		÷		5 2			15.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0		0.0	MOTOR CORE		
		4		6 2			20.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0		0.0	MOTOR CORE		
		¥		/ 2	v		10.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0		0.0	MOTOR CORE		
		— -		8 I 9 1			10.0	9.0	0.0	9.0	0.0		0.0	0.0	0.0	0.0		0.0			
		<i>%</i> =	1	0 1			14.0	8.0	0.0	8.0	0.0		0.0	0.0	0.0	0.0		0.0			
_			1	1 1	I		10.0	8.0	0.0	8.0	0.0		0.0	0.0	0.0	0.0		0.0	MOTOR DE		
			1	2 3	~		27.0	7.0	0.0	7.0	0.0		0.0	0.0	0.0	0.0		0.0	LS COUPLING		
			1	3 1	~		21.0	7.5	0.0	7.5	0.0		0.0	0.0	0.0	0.0		0.0	LS GEAR SHAFT		
			1	4 1	-		23.0	16.0	0.0	16.0	0.0		0.0	0.0	0.0	0.0		0.0	LS GEAR		
	-	1								Ok			Cancel		Help			~	Check for System Er	rors	
	Inn	er Dia	meter o	f left-hand s	ide													incl	יו ו	🍾 Data	
																		N	o project open	valid	ation
			t	Mover	ow Up						H	Cha	nge m	nateria	l			-	Color rov	VS	
	Strip		Ē	Mover	ow Do	wn					47	Und	ock					≸≡	Get Sum	mary	
	00		÷2	Split E	ement						ж	Mar	k/unm	nark				11	Reverse	order of	
	F		÷N	Divide	eleme	nt inte	o N el	eme	ents	Mark/unmark elements							element on a branch			ıch	

- Evaluate Mathematical Expressions. When entering data to cells, data entry field has the ability to evaluate mathematical expressions, without having to launch a calculator app.
- > Whole Number. Display for improved legibility, defaulting to scientific notation when required.
- Auto Convert Units. Automatically computes the units conversion when modeling a system with different components using mixed SI and English units. Example: You have a few inch dimensions to enter amongst hundreds of mm values, just check the box for auto conversion.
- Automatic Cell Validation. Performed at Data Entry time. The program now reviews data grids for incomplete, invalid, or nonsensical entries, providing an Error Flag and correction recommendation. This applies to mass-elastic data fields, user defined torques, and required solver data inputs.
- Data validation error diagnostics quickly walks user through any model input errors. A mouse click navigates the user to the next error found.

- Row Tagging. Row marking/tagging for quick identification and rapid recall, advantageous for multi-shaft systems with very large numbers of elements.
- Round Function. Round function for data entry fields is accessible from the Tools menu, and can be declared for all data fields.

То	ols	
~	Ena	able Units Conversion from Expression Evaluator
	Ena	able Rounding Button
	Set	Rounding Precision

- Tool Strip/Bar and Buttons. Replace hidden right-click menus to provide enhanced visibility of functions and features.
- > Data Entry Grids. All data entry grids can be open simultaneously for ease of model building.

C TORSION (C:\Users\Public\Documents\ARMD60\TORSION\Samples\SYNC-MOT.TOI US)	
File Edit System Options Applied Torques Run View Tools Window Project Help	
🔁 New 😂 Open 📓 Save 🛛 🕉 Cut 🛍 Copy 🎕 Paste 📲 System Model 🗍 Insert Value:	
C System	C Applied Torque Tables
Desetes Metricle Elemente Consultant Distr. Contra	Steady State Harmonic Torques Time Transient Torques
All Classest Brooch Telements Connections Discs Springs	Predefined External Torques Speed-Dependent Torques User-Specified External Torques Synchronous Motor Torques Electrical Torques
All Clements Dranch / Clements Dranch / Clements	Fdit
fateria Use Iumbe ieometri Taper .ength OD1 ID1 OD2 ID2 tiffnes tamping nertia Dyn lagnifie Diam tamping nertia Dyn lagnifie	iranct Matior Poles Soints Zurve Torque
	▶ 1 1 6 4 10 1450000 % Snead % Avg % Osc ▲
E 2 1 ✓ 14.0 8.0 2.36 8.0 2.36 0.0 0.0 0.0 0.0 0.0 0.0	Torque Torque
+2 3 1 V □ 10.0 9.0 2.36 9.0 2.36 0.0 0.0 0.0 0.0 0.0 0.0 □ 0.0	1 0.0 150.0 74.0
Image: Heat of the second	2 300 1420 750
5 2 V 15.0 14.0 0.0 14.0 0.0 0.0 0.0 0.0 0.0 0.0 N	4 600 1310 800
	5 70.0 126.0 85.0
	e 800 1180 930 -
3= 9 1 ♥ 10.0 9.0 0.0 9.0 0.0 0.0 0.0 0.0 0.0 0.0	
	OK Cancel Help
Ok Cancel Help Check for an	Data Description of Assessed Taxanan dimensional and
	Percent of Average Torque
Element Material Number	Synchronous Motor Torque Magnitude
Coptions	🗢 System Model
Description Natural Frequencies / Mode Shapes Steady State Response Time Transient Response Output Options	e.e C:\Users\Public\Documents\ARMD60\TORSION\Samples\SYNC-MOT.TOI SAM0LE_DOOR_EM_NUMPER_2
Control / Constant Speed / Startup options Material Fatigue / Life Data Gear Backlash	14.0ID2: TWO BRANCH SYSTEM; MOTOR-GEAR-COMPRESSOR DRIVE TRAIN. 0 TO 12 SEC.
	0.0 TORSIONAL RESPONSE TO SYNCHRONOUS MOTOR START-UP OF DRIVE SYSTEM.
Control parameters Constant speed / startup and shutdown options	Shaft Inertia
Time step size for integration (sec) 1.00000e-04 Perform Time-Transient Response at fixed speed	(NR*) = 5.657223e-02
Number of simulation time steps: 120000	lbf-in ² =
Simulation and time (sec) 100.0 User Specified external torque	Shart Starries = 2. COMPRESSOR 2STG
Time interval for generating restart data (sec) 1.0 Electrical torque	Ibt/radian *
Restart control index (0 for start @ t-0 secs) 0 Gear Backlash	Disolay Station Number
Text/graphics output operation	Display Filled Symbols
rexugraphics output control parameters	☑ Display Scaled Discs
	Display Branch
	AI • I. STRUM-MOTOR
UK Cancer neip	Connection View:
	Stub •
	No project open

Data Entry Menus. All data entry menus are visible at the Grid input page. Grids now feature selection check boxes and editing buttons where appropriate.



This feature rapidly displays an X-Y graph of entered tabular data for visual verification of correctness. ARMD Graph software is still available for complete graphic analysis capabilities.



All Branches. All branch element data is presented on a single grid form allowing simultaneous access to all branch elements of a multi-branch system. This new presentation is much more user efficient for data entry and multi-branch model review.

æ							Sys	tem									
Brar	nches	Materials	Berner	nts Conr	nections D	iscs S	prings							tiffnoon			
AI	Eleme	ents Bran	ch 1 Elen	nents Br	anch 2 Elen	nents								liameter			
			Branch Number	Material Number	Use Geometry	Taper	Length	OD1	ID1	OD2	ID2	Use Stiffness Diam	Stiffness Diameter	Stiffness	Damping	Inertia	
	•	1	1	1	•		11.0	7.5	2.36	7.5	2.36		0.0	0.0	0.0	0.0	
)	*	2	1	1	✓		14.0	8.0	2.36	8.0	2.36		0.0	0.0	0.0	0.0	
	•	3	1	1	✓		10.0	9.0	2.36	9.0	2.36		0.0	0.0	0.0	0.0	
ý		4	1	1	✓	✓	20.0	9.0	2.36	11.0	2.36		0.0	0.0	0.0	0.0	
		5	1	2	•		15.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0	
		6	1	2	•		20.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0	
Bra # 1	nch	7	_ 1	2	✓		15.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0	
" ·		8	1	1	✓	✓	20.0	11.0	0.0	9.0	0.0		0.0	0.0	0.0	0.0	
		9	1	1	✓							on Cun		or Dours 0	11 _		
		10	1	1	✓		- <u>-</u> - SI	nart E	leme	ent Se	electi	on Sun	nmary f	or Rows 8 -			
		► 11	1	1	✓		Shaft	Leng	th =	54.0	incl	n 11. c					\sim
		12	- 1	3	✓		Shaft	Neig Iner	nt = tia	(WR ⁴)	4572	161 0222.04	lbf-ir	4			
		13	1	1	✓		Shaft	Stif	fnes	s = 1	.194	514e+08	in-lbf	/radian			
		14	1	1	✓		Total	Iner	tia	(WR ²)	= 3	10222.0	4 lbf-i	nº (Shaft +	Disc)		
		15	2	1	✓		<								,	>	
Bra	nch	16	2	1	✓						, ,					T	
# 2	+	17	2	3			20.0	3.2	0.0	3.2	0.0		0.0	5.500000e+06	0.0	0.0	
		18	2	1	✓		16.0	4.0	0.0	4.0	0.0		0.0	0.0	0.0	0.0	
		19	2	1	✓		10.7	4.5	0.0	4.5	0.0		0.0	0.0	0.0	0.0 🗸	
		٢														>	
						Ok		С	ancel			Help		✓	Check for (System Ei	
Eleme	ent Br	anch Nur	nber														

Stiffness Diameter. Can be used to enter the equivalent mass-elastic properties of complex shaft sections, motor lamination stacks, shrunk on disks, etc.

Lime-Transient 1		a Ciri	Edit	Torque Curve		×
User-Defined	Applied Torque Tables	-	Units			
Torques. User	Steady State Harmonic Torques Time Transient Torques			US	⊖ SI	
has complete	Branch Station Start Time CSV File					
freedom to	▶ 1 1 6 0.05 My TData_01.csv	Г		Time	Tomue	
specify, including			1	0.0005	58364.34643	
predefined			2	0.001	1125.967494	
external torques,	Ok Cancel		3	0.0015	-74694.25532	
speed dependent			4	0.002	-166022.0528	
torques, user-	User Specified Torque File Name		5	0.0025	-268783.8141	
specified external			6	0.003	-378169.2525	¥
torques, harmonic and electrical torque be prepared in a C	torques, synchronous motor torques, ues. User defined external torques can SV file and linked to the torsional model	_	Save	Save As Ca	Incel Help	
as shown here		Toro	iue Magni	tude	in-lbf	

Page 6 of 19

Shaft Material Temperature. Material operating temperature is readily input and enabled, to capture the temperature dependent material properties and the effects upon torsional modeling. Particularly useful for shafts in high temperatures applications like steam turbines, rolling mills or extruders.

æ	3					Sy	vstem	Motorial	Matari	
	Bran	ches	Materials Elemer	nts Connections	Discs Spring	S		Temperatur	e Library	
			Young's Modulus	Shear Modulus	Density	Use Operating Temp	Operating Temperature	Damping Factor	Name	Get Values From Library
	•	1	3.000000e+07	1.150000e+07	0.283		0.0	2.500000e-04	STEEL	
		2	3.00000e+07	1.150000e+07	1.000000e-06		0.0	2.500000e-04	Steel No mass	
		3	3.000000e+07	1.150000e+07	1.000000e-06		0.0	0.0025	Steel No mass	
					Ok		Cancel	He	Ip Check for System	n Errors
N	lateri	ial You	ng's Modulus of	Elasticity					PSI	

- Shaft Connections. Better handling of shaft connections for multi-speed systems. The reference shaft and its associated speed are selectable, allowing the analysts to see speed-based variable-stiffness effects upon the model.
- Shaft Connections Specification Form. Optional full linear connection display between shafts with the ability to specify stiffness and damping values, all on one form.

¢	Ð							Sys	tem					
	Branch	nes	Materia	als Elemer	nts Conne	ctions Dis	cs Spring	gs						
						т.	T		Marcal			Flex.	Select	
	M			Branch	Station	Branch	Station	Туре	Number	Stiffness	Damping	Ref. Branch	For Output	Name
		•	1	1	15	2	1	Rigid 🗸	0	0.0	0.0	1		
							Ok		Cance	1	Help		~	Check for System Errors
C	Connec	tion F	From S	Station										

Selectable Output Units.

Selectable Frequency Units between CPM or Hz, in accordance with the user's preference, or the industry standard format can be set simply by checking a box in the options form.

•	Options 🗖
Description Natural Frequencies / Mode Shapes	Steady State Response Time Transient Response Output Options
Natural Frequencies and Mode Shape Opt Preferred Units © Cycles/Minute O Hertz Damping Options	Selections Compute all natural frequencies and the first 6 mode shapes Compute natural frequencies and mode shapes below 0.0 cycles/min. Ignore all damping (i.e. undamped analysis.)
	k Cancel Help
Natural Frequencies / Mode Shapes	

Import of Models. Import a complete TORSION multi-shaft system or only a single shaft from another TORSION input file. Imported shafts can be included on new system models either by inserting into a shaft, or appending to a shaft model. A powerful modeling tool to efficiently model like or similar systems in rapid fashion.



Import of Models (continued).

Shaft models can be **flipped from left to right** with a single button click.

•					5	System	1	- • ×		
В	rancł	nes	Materi	als Elements	Conne	ections	Discs Springs			
				Total Element	s	Speed	Branch Name			
			1		14	1800.0	SYNCH. MOTOR			Move Branch Up (Ctrl Up)
	F		2		11	10800.0	COMPRESSOR 2STG			Move Branch Up (Ctrl Up)
	1	۲	3		14	1800.0	SYNCH. MOTOR			Reverse Elements
									ш	Neverse Lieffielits
	Rev	erse	Eleme	ents						
	1			Ok			Cancel Help			
Bra	nch	Tota	al Elem	ents (use branc	h elen	ment tab	os to change)			

- Shaft models can be moved up or down in the system model with a single button click.
- Shaft elements can be moved along the shaft in either direction with a single click.
- Shaft elements can be **divided** into a user specified number of smaller elements, while retaining the overall geometry (length, OD, ID, etc.) in the process.



Import of Models (continued).

Shaft element **data entry grids can be detached** from the System Form to allow multiple shaft element grids to be modified concurrently.

æ											Syste	m											
Brand	hes	Materi	als Eleme	ents	Connecti	ons D	iscs	Springs															
AILE	lemen	ts Br	anch 1 Eler	ments	s Branch	1 2 Elen	nents																
			Branch Number	Mat Nur	terial I mber Ger	Jse ometry	Таре	r Leng	gth OD	1 ID1	OD2 II	l D2 Stif	Jse fness jiam	Stiffness Diameter	. s	tiffness	Damping	, Inertia	Use Dyn Mag	Dynamic Magnifier		N	ame
l l		1	1		1	✓		1	1.0 7	5 2.36	7.5 2	.36		0.0		0.0	0.0	0.0		0.0	мотон	R NDE	
*	(2	1						Bi	anch 3	Elemen	ts, clo	ose to	re-at	tach t	to the S	Shaft Sys	tem Fo	rm				
ź		3	1				!	Material Number	Use Geomet	y Tape	· Length	OD1	ID1	OD2	ID2	Use Stiffness Diam	Stiffness Diameter	Stiffness	Damping	Inertia	Use Dyn Mag	Dynamic Magnifier	^
		5	1			•	1	1	~		23.0	16.0	0.0	16.0	0.0		0.0	0.0	0.0	0.0		0.0	LS GEAR
		7	1				2	1	-		21.0	7.5	0.0	7.5	0.0		0.0	0.0	0.0	0.0		0.0	LS GEAR SH
		, 8	1		÷2		3	3	✓		27.0	7.0	0.0	7.0	0.0		0.0	0.0	0.0	0.0		0.0	LS COUPLIN
		9	1		÷N		4	1	✓		10.0	8.0	0.0	8.0	0.0		0.0	0.0	0.0	0.0		0.0	MOTOR DE
		10	1		•		5	1	~		14.0	8.0	0.0	8.0	0.0		0.0	0.0	0.0	0.0		0.0	
		11	1		i 🔽		6	1	~		10.0	9.0	0.0	9.0	0.0		0.0	0.0	0.0	0.0		0.0	
		12	1				7	1	-		20.0	9.0	0.0	11.0	0.0		0.0	0.0	0.0	0.0		0.0	
		13	1	-			8	2	~		15.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0		0.0	MOTOR COI
	<			- i	»=		9	2	✓		20.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0		0.0	MOTOR COI
							10	2	✓		15.0	14.0	0.0	14.0	0.0		0.0	0.0	0.0	0.0		0.0	MOTOR COL
[h]								1			20.0	11.0	2.36	9.0	2.36		0.0	0.0	0.0	0.0		0.0	
[-1249]					1		12	1	✓		14.0	9.0	2.36	9.0	2.36		0.0	0.0	0.0	0.0		0.0	
Liemer	it Brar	ich N	Imper			<					141		2.86	8.0	Zish								>
																							(

- Create Templates . Templates can be created for shaft component assemblies for TORSION model input files, allowing for quick access to, and rapid construction of, new multi-shaft systems.
- Text Output Viewer. User selectable text output viewer that can be Word, Open Office Writer, Notepad, WordPad, or any other program which accepts text file input. Setting are specified in the ARMD Settings form from the help menu.

vi	ARMD Settings – 🗆 🗙
General	2 DOF Layout Recent Lists Grid & Material Colors Model Colors and Fonts Advanced
	Application maximized at startup Always save data on solver run Do not always display solver output Sort grids during data entry
	Text Viewer WordPad NotePad Other Text Viewer Path: Image: Star 4/200 Text Pad (Star 200 Percent) Percent
	Preferred units US Customary/English OSI/Metric
	Preferred frequency units
	Preferred damping output units (Rotordynamics graphics only)
	Restore Defaults Restore all settings to default. Restore Defaults
	OK Cancel Help

> 2-D GRAPHICS MODEL.

Real-time graphics update of the 2-D image corresponding to numeric data input in data grids provides visual confirmation of model correctness while building system models.

🚭 System Model		
ID1: 0.0 OD2: 9.0ID2: 0.0	C:\UsersPublicIDocuments\ARMD60\TORSION\Samples\SYNC-MOT.TOI SAMPLE PROBLEM NUMBER 3. TWO BRANCH SYSTEM; MOTOR-GEAR-COMPRESSOR DRIVE TRAIN. 0 TO 12 SEC. TORSIONAL RESPONSE TO SYNCHRONOUS MOTOR START-UP OF DRIVE SYSTEM.	
Shaft Inertia (WR²) = 5667.938 1bf-in² E Shaft Stiffness = 5.459190e+08 in- 1bf/nadlan		
Uniform Display Scale		6 8 10 1 2
Display Station Number	2. COMPRESSOR 2310	5 7 9 11
Display Filled Symbols		
Display Scaled Discs		
Display Branch All •		
Connection View: Stub •		
Mode Shape: #1: 1.495E+3 cpm -	Ť –	
Scale Mode By Branch		
Animate Mode Shape		
	1. SYNCH. MOTOR 6 7 8 9 11 11 11	
Animation Speed		
Y		
Zoom		
Key Commands		

2-D Model auto resizing gives user the option to "fit-to-page" complete models or single branches. User can automatically view the model with the correct aspect ratio, thereby permitting rapid, visual model review.

2-D model viewer mode options now include:

Single Branch View.

Auto Scale to Width for the complete model or a single shaft.

Stub Shaft View to represent large, multi-shaft models in a simplified fashion.

Auto Aspect Ratio presentation.



Interrogate an element using the 2-D Model Viewer to see all defining element data in a side-bar data window.

Element selection with control keys within the 2-D model viewer permits easy identification of particular cells within large models. This is useful for closely spaced, thin elements.

Rotated view option for copying the 2-D model graphic to the clipboard.

Metafile enabled copy and paste of system models and graphics for better report graphics.

Tool panel has been added on the 2-D display window for enhanced graphics control and better visibility of display options.



RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA ● Tel:610-415-0412 ● www.rbts.com ● Fax:610-415-0413

Page 12 of 19

Steady State Interharmonic Excitation & Response. Electric motor controllers used in variablespeed drive (VSD) applications generate integer and non-integer harmonic torsional excitations. Intersections between these harmonic excitations with relevant torsional natural frequencies can create "troublesome" levels of resonant response and, therefore, must be considered. ARMD's TORSION software module provides a complete evaluation of VSD-related harmonic excitations.



Page 13 of 19

Generator/Motor Electrical Excitations. Among the features incorporated in TORSION package are electrically-induced, time-varying exciting torques associated with generator and induction

motor operation that include: Generator

- 1: 3-phase short circuit
- 2: Line-to-line short circuit
- 3: False coupling short circuit
- Induction Motor
- 4: Start from standstill
- 5: 3-phase short circuit at terminals
- 6: 2-phase short circuit at terminals
- 7: High-speed automatic reclosing



Startup characteristics of synchronous motor, user-specified time-transient external-torques, & calculated system response torques are available in the graphics output file.



RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • www.rbts.com • Fax:610-415-0413 Page 14 of 19



3-D Shaft Viewer Utility (ARMDShaftViewer)

ARMD Shaft Viewer is a 3-D rotor system graphics utility integrated in the ARMD suite. It uses modern 3-D graphic rendering technology to provide a highly realistic view of rotating assembly models and drive train system models. In addition, dynamic performance results generated by the rotor dynamics module ROTLAT and torsional vibration analysis module TORSION can be presented. Displayed models and their dynamic performance results can be rotated, zoomed, moved and animated to provide the user with an efficient and enhanced view of the system dynamic characteristics. The ARMD Shaft Viewer **workspace** is shown below.



Automatic[•]Scaling

The Shaft Viewer can be run as a stand-alone display utility either from the ARMD main menu or from the computer's Start menu. It is also fully integrated into the ROTLAT Rotor Dynamics and TORSION Torsional Vibration modules, where it is automatically loaded/accessed via the View menu.



The default opening view is isometric (ISO). Viewpoint is modified using the buttons for zooming and rotation on the left side of the display. By pressing the + and – buttons, the display can be zoomed or rotated about any of the three axes. The arrow buttons in the middle of the Viewpoint group move the display left, right, up, and down. Continuous motion can be achieved by holding any of the arrow buttons down. The display can be reset at any time to one of 4 standard viewpoints, the default ISO view, or projections on the YZ, XZ, or XY planes. The Enclose button re-centers the model without changing its orientation.



Various elements of the model can be selected for display using the check boxes in the Visibility control group. When Solid and Mesh items are selected, the viewer performs an automatic level-of-detail (LOD) calculation to determine when the mesh is too dense. If required, the software then suppresses the mesh display automatically.



The screens shown above and to the right, first show the mesh suppressed on part of the model followed by full mesh as we zoom in.

If the solid display is not selected, but the mesh is, then the LOD calculation is not performed and the mesh is shown for all elements.

Shaft element information can be found in the shaft element display when an element is selected.

🖶 📼 Branch 3 Element 9				
🚊 📼 Branch 3 Element 10				
OD 1: 39				
ID 1: 0				
OD 2: 39				
ID 2: 0				
Len: 27.56				
🕀 📼 Branch 3 Element 11				
🖶 📼 Branch 3 Element 12				



Among the main features of the Shaft Viewer is its ability to display and animate the motions calculated by the various ARMD solvers. When the Shaft Viewer loads a ROTLAT or TORSION shaft system model, it automatically looks for supported solver output files. No user interaction is needed. These output sets are then presented to the user for display in the *Output Set Property* drop-down box on the viewer's main toolbar.

Once an output set and property has been selected (i.e. mode shape 1) it is displayed as shown below, with and without the shaft solid model.

For enhanced visualization of torsional vibration analysis results, such as mode shapes, presentation is an angular twist about the rotational Z axis. The angular twist displayed has a maximum range of +/- 45 degrees and the twist lines extend out beyond the model surface by a factor of 1.25 times the shaft's maximum OD.

For long drive trains, visualization and animation of torsional behavior, the angular twists displayed have a maximum range of +/- 90 degrees and the twist lines extend out beyond the model surface by a factor of 2 times the shaft's maximum OD as shown here.

HIP

<u>3-Dimensional Presentations</u> Torsional Twist Mode

Generator

Ouput Set: TORNAT Mode Shapes

Mode 2

[None]

2.66E+4 cpm

Mode 1: 2.09E+3 cpm

Mode 2: 2.66E+4 cpm Mode 3: 3.08E+4 cpm

Mode 4: 3.14E+4 cpm

Mode 5: 4.16E+4 cpm

Output Set Property: 🔺



2-D Graphics Utility (ARMDGraph)

ARMDGraph is a graphics utility that employs a Workspace concept to manage multiple graphs with associations to single or multiple graphics output files. The workspace environment contains all user defined plot and chart configuration settings for graphics output files generated by

ARMD solvers.	Workspace Configuration: Chat(1)		
The workspace	🖂 Graphs	Set Lines Details Line Defaults Annotations Line Marker	
The workspace configuration form consists of two panels. The left panel contains a tree view of the graphs, charts, and graphic output files. The right panel contains all chart and graph	Graphs Graphs Graphs → Default Charts Const - 1 ⊖ Output Files L (1) SYNC-MOT.tnc US	Set Lines Details Line Defaults Annotations Line Marker File Contents Units Frequency (Cycles/Min) Image: Sequency (Cycles/Min) Image: Sequency (Cycles/Min) Image: Sequency (Cycles/Min) Image: Sequency (Cycles/Min) Image: Sequency (Cycles/Min) Image: Sequency (Cycles/Min) Image: Sequence (RPM) Image: Sequence (Cycles/Min) Image: Sequence (Sequence) Image: Sequence (Sequence) Image: Sequence (Sequence) Image: Sequence (Sequence) Image: Sequence (Sequence) Image: Sequence (Sequence) Image:	Chart Type Line X Axis Unit Rotational Speed (RPM) Rotational Speed (RPM) V Lines Units Frequency (Cycles/Min) Y Lines Units Frequency (Cycles/Min) Ine File 1st Order (1) SYNC-MOT Inc Mode 1, Cpm = 1495.2 0.0 (1) SYNC-MOT Inc Mode 2, Cpm = 4209.5 0.2 (1) SYNC-MOT Inc Mode 3, Cpm = 15237.9 0 (1) SYNC-MOT Inc Mode 3, Cpm = 15237.9 0 (1) SYNC-MOT Inc Mode 3, Cpm = 15237.9 0 (1) SYNC-MOT Inc Inc
settings.	Save Workspace Use Current Files	Replace File	

ARMDGraph features include:

- Workspace concept that contains all graph settings and linked graphics output files in one form customized by the user.
- > Existing workspace can be easily applied to newly generated graphics output files.
- > New graphical user interface to access and customize graphs.
- > New file format (*.usrx) allows more customization of graphics data than previous (*.usr) format.
- > Ability to create multiple graphs each of which may contain multiple charts.
- > Ability to plot from two or more graphics output files.
- > Backwards compatible with files generated by RBTSGRAF (*.usr) graphing utility.
- Customizable annotations and line markers.
- > Automatic detection of graphics data file changes and updates.
- > Plots can be rotated and copied to the clip board as bitmaps or enhanced metafiles.
- Utilizes GUI help system.
- > Accelerator keys for accessing menu items and switching between charts.
- > Multiple plots per window (1, 2, 3 or 4) including line, polar, and FFT plots.
- Templates for automatic configuration of graphs.
- Save/restore user options (*.USRX), for custom graphs, including:
 - Log, semi-log or linear axis scaling.

• Draw curves with lines, symbols or both.

Automatic or manual axis scaling.

• Grid lines (ON or OFF).

- Legend position (hidden, inside or outside right).Macro strings for flexible title assignment.
- RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA Tel:610-415-0412 www.rbts.com Fax:610-415-0413 Page 18 of 19

Graphics Utility (ARMDGraph)

With ARMDGraph, in few simple steps a workspace can be set up, saved and a graphical representation of simulation results from ARMD solvers can be generated as illustrated below.



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/modules 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:

Personal computer with Microsoft Windows 8, 10, 11 or higher (32 or 64 bit).

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

For further information, please contact us.



Rotor Bearing Technology & Software 1041 West Bridge Street Phoenixville, PA 19460 USA

> Telephone: Facsimile: Web: Email:

610-415-0412 610-415-0413 www.rbts.com info@rbts.com

ARMD^I- The Worldwide Leading Software For Rotating Machinery Analysis

Advanced Rotating Machinery Dynamics

ARMD is a well established software package used worldwide to perform complete rotating machinery dynamic analysis. ARMD employs a user-friendly interface and window environment with pulldown menus and context-sensitive help. ARMD integrates the most advanced and complete rotor dynamics, torsional vibration, and bearing analysis programs under one environment in a seamless fashion to give you the power to model your rotating machinery with ease, efficiency, and above all accuracy. Some applications in which ARMD has been utilized include rotating machinery such as a miniature air turbine for a dental drill, a large turbine generator set for a power plant, a small compressor for an air conditioner, a pump for an artificial heart, a fuel pump for a jet engine, an electric motor and spindle for a miniature computer hard disk, a canned pump for petrochemical processing plant, synchronous motor driven drivetrains, and a gear box for an Uranium enrichment plant.



Rotor Bearing Technology & Software 1041 West Bridge Street Phoenixville, PA 19460, USA

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

Dr.-Ing. Andreas Laschet · Apolloniaweg 6 · 51515 Kuerten · GERMANY Phone: +49 2268 901650 · E-mail: info@laschet.com · Web: www.laschet.com



RBTS' software has gained international reputation for its:

- Technical Capabilities
- Completeness
- User Friendliness
- 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





Dr.-Ing. Andreas Laschet

Engineering Service & Technical Consulting

Apolloniaweg 6 · 51515 Kuerten · GERMANY

Ph: +49 2268 901650 · E-mail: info@laschet.com · www.laschet.com

ARMD[™]– Advanced Rotating Machinery Dynamics – Software BEARINGS Package

The **ARMD** software package is capable of facilitating comprehensive evaluations of fluid-film bearings. **Practically any bearing or bearing system available in the industry can be analyzed with one of the bearing solution modules**. The FLUID-FILM bearing modules (JURNBR, HYBCBR, THRSBR and TILTBR) solve the lubrication problem in two dimensions eliminating any approximation typically associated with one dimensional analysis or with look-up table methods.



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 effects such as cavitation, misalignment, pressurized boundaries, pressurized grooved feeding system, pressurized nozzle feeding system, surface/structural deviation, and lubricant feed circuitry (JURNBR, HYBCBR) with specified pressures or restrictors (capillary, orifice, or flow control valve), groove geometry and chamfers.



- Load capacity / journal or runner position
- Attitude angle
- Viscous power loss
- Righting moments
- Flow requirements
- Stability (bearing whirl)
- Spring and damping coefficients
- Clearance and pressure distribution
- Recess pressures and flows
- Heat balance and temperature rises for bearing system and individual pads



ARMD[™] Software – BEARINGS Package



The release of RBTS' ARMD Version 6 fluid-film bearing modules is a major milestone in the product's development history, rolling out a **completely new and improved** graphical user interface for the package with enhanced numerical capabilities and new technical features. The software's front end was redesigned with our customers' and industry's input to incorporate the most logical, efficient, and productive techniques to model and analyze common as well as complex configuration, fluid-film lubricated journal and thrust bearings, of all sizes with ease.

ARMD users will immediately see the improvements as bearing design data are presented in a flatter, more accessible format, with key fields and analysis options readily visible from the main data entry screens. Fluid-film bearing design and performance evaluation productivity is vastly improved as a wide selection of templates accompanied by a "wizard" style sequence of dialogs allows the user to setup and evaluate most of the commonly used bearings in industry with few key strokes. Tab selected grids and input forms allow the user to see all of the data on screen at the same time. Furthermore, the ability to simultaneously run multiple instances of the program permits rapid side-by-side comparison of results.

Bearing configurations and special features that can be evaluated with the various solution modules include but not limited to:

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

- Plain surface
- o Multi-groove
- Pressure dam
- Elliptical or lemon
- Rayleigh step or pocket
- Tapered land
- Lobe or canted lobe
- Any configurable pad surfaces
- Multi-recess

Tilting-Pad Journal Bearings (TILTBR)

- o Central pivot
- o Offset pivot
- Evenly spaced pads
- Grouped pads
- Load between pads
- Load on pad
- Any load direction
- o Any preload
- o Leading/trailing edges taper
- Fluid-inertia force effects
- Support pivot stiffness

Fixed and Tilting-Pad Geometry Thrust Bearings (THRSBR)

- Plain surface
- Multi-aroove
- Step land
- Step pocket
- Tapered land
- Taper pocket
- Tilting pad
- Compound taper
- Any configurable pad surfaces





ARMD[™] Software – BEARINGS Package

Illustrated below, complete bearing performance results are generated when the Run button is pressed. The solution is performed for user specified operating conditions taking into consideration the pressurized feeding system. Heat balance is performed for the overall bearing system as well as individual pads in the bearing.

[O Post-Processor	
Modeled	Description Sample Problem 6 - 5 Pad Tilting Pad Journal Bearing. High Speed Test Rig Support Bearings. Pad Pivot Stiffness NOT Included.	Pressure/ Clearance Distributions <u>3D View Button</u>
Bearing Details —	Diameter 3.5 Pad Angle 60.0 # of Pivot Clearances Axial Length 2.5 Orientation Angle 0.0 Viscosity Radial Clearance 0.004 Rotational Speed 20000.0 Full Matrix	50 1.000000e-06
Scroll	Single Case Multiple Cases Lubricant Properties Analysis	
through -) cases.	Operating Conditions	3D
	Clearance 0.004 Load 5000.0 Load Angle 270.0 Ort. Angle Preload 0.4 Speed 20000.0 Grv. Angle 0.0 No. of Pads	90.0 5.0
Complete	Min.Film Thick> 9.8316E-04 (Inch) ECC = 0.6344 @ Angle = 270.00 (Deg) Power-Loss > 2.5591E+01 (HP) Side-Leakage QF -> 1.7102E+00 (Gpm) Load Capacity > 4.9955E+03 (Lbf) Inlet-Flow QI -> -1.5409E+01 (Gpm)	
Bearing Performance Results including	Supply-Oil Temp.> 119.997 (Deg.F) >>> STIFFNESS (Lbf/Inch) Supply Flow Rate> 6.1604 (Gpm) KXX ; KXY> 3.883E+06 1.229E+00 Film-Temp (avg.)> 176.056 (Deg.F) KXX ; KYY> 1.690E+00 6.829E+06 Viscosity> 1.017E-06 (Rens) Heat Content> 3.622 (BTU/G/F) >>> DAMPING (Lbf-Sec/Inch) Groove Temp> 1.65.765 (Deg.F) DXX ; DXY> 1.637E+03 3.463E-04	
system and individual pac heat balance.	Max. Temp. (avg.) > 186.347 (Deg.F) DYX ; DYY> 1.420E-04 2.551E+03 Individual Pad Results Below	Generated text output after Run
	Supply Flow Rate to Bearing = 6.1604E+00 (gpm) @ Ts = 1.2000E+02 (deg.F) Resulting in a Computed Mixed-Oil Exit Temperature -> 1.7064E+02 (deg.F)	pressed
	Sump/Groove Avg-Film Max-Film Min-Film Power Side Pad Temperature Temperature Temperature Thickness Loss Leakage No. (degree F.) (degree F.) (inch) (hp) (gpm)	
	1 1.7247E+02 1.7550E+02 1.7853E+02 3.8107E-03 2.4191E+00 1.1370E-01 2 1.6620E+02 1.7180E+02 1.7740E+02 2.5828E-03 3.3132E+00 3.9459E-01 3 1.6167E+02 1.9445E+02 2.2723E+02 9.8316E-04 8.2725E+00 4.0366E-01	
	5 1.8108E+02 1.8668E+02 1.9228E+02 2.5828E-03 3.3132E+00 3.9459E-01	~
	Ok Cancel Help	2
_	Sergis Protein 5 - 5 Part Titrig Pal Journal Bearry, Hay Speed Testing Support Bearry, Hay Speed Testing Support Bearry, Hay Speed Testing Support Bearry, Hay Speed Testing Support Bearry,	4.06286-00
	15216-0 15226-0 13796-0 12756-0 12756-0 12756-0 12756-0 12756-0 12756-0 12756-0 12756-0 12756-0 12756-0 12756-0 12756-0 12756-0	34796-01 39796-01 34895-01 33895-01 33895-01
	1.0014-03 1.0014-03 1.0014-02	2 0000-03 2 2008-03 2 2508-03 2 2508-03 2 5508-03
	6.3095-42 5.0775-42 4.34675-42 3.1965-42 3.1965-42 3.1965-42 1.1965-42 3.196	2:386-0 14456-0 1.7596-0 1.2586-0 1.2586-0
	2 Contract Encode Contead Enco	3D View 1.1798-03 Clearance Distribution 20118-04

Purchasing Options

ARMD is constructed from various solution modules for rotating machinery/systems:

Fluid-Film Bearings

- Rotor Dynamics
- Torsional Vibration
 - I Vibration Rolling-Element Bearings
- Lubricant Analysis

Tailored to suit your needs and budget. You may purchase any combination of programs/modules or all if you wish. Licensing is available as a single seat or multi-seat network configuration. With your purchase, the package includes software (CD or download), quick start manual, electronic user's manual, technology transfer and training session (optional), updates, maintenance, and support.

System Requirements

Computer with Microsoft Windows 8, 10, 11 or higher (32 or 64 bit).

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

For further information, please contact us.



Rotor Bearing Technology & Software 1041 West Bridge Street Phoenixville, PA 19460 USA

Telephone:	610-415-0412 610-415-0413
Web:	www.rbts.com
Email:	info@rbts.com

ARMDTM - The Worldwide Leading Software For Rotating Machinery Analysis

Advanced Rotating Machinery Dynamics

ARMD is a well established software package used worldwide to perform complete rotating machinery dynamic analysis. ARMD employs a user-friendly interface and window environment and context-sensitive help. ARMD integrates the most advanced and complete rotor dynamics, torsional vibration, and bearing analysis programs under one environment in a seamless fashion to give you the power to model your rotating machinery with ease, efficiency, and above all accuracy. Some applications in which ARMD has been utilized include rotating machinery such as a miniature air turbine for a dental drill, a large turbine generator set for a power plant, a small compressor for an air conditioner, a pump for an artificial heart, a fuel pump for a jet engine, an electric motor and spindle for a miniature computer hard disk, a canned pump for petrochemical processing plant, synchronous motor driven drive-trains, and gear boxes for a uranium enrichment plant and ship propulsion drives to name a few.



RBTS' software has gained international reputation for its:

- Technical Capabilities
- Completeness
- User Friendliness
- Support & Service



Rotor Bearing Technology & Software, Inc. 1041 W. Bridge Street, Phoenixville, PA 19460, USA

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

Dr.-Ing. Andreas Laschet · Apolloniaweg 6 · 51515 Kuerten · GERMANY Phone: +49 2268 901650 · E-mail: <u>info@laschet.com</u> · Web: <u>www.laschet.com</u>



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 Engineering Service & Technical Consulting

Apolloniaweg 6 · 51515 Kuerten · GERMANY

Ph: +49 2268 901650 · E-mail: info@laschet.com · www.laschet.com