APM Bear

User's Guide

APM Bear

The system for non-ideal bearings calculation

Version 9.1

User's Guide

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Moscow Region, Russia, 141070

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C O N T E N T S

F I G U R E S

I N D E X

Introduction

APM Bear—what is it?

APM Bear is a non-ideal bearing parameters calculation system developed by the Research and Software Development Center APM Ltd.

The following parameters could be calculated in the APM Bear
- Displacements in the rolling contact bearings
- Maximum contact stress
- Longevity
- Forces acting on the rolling bodies
- Moment of friction
- Loss of power
- Heat release

The calculations could be made for eight most widely used types of bearings:
- radial ball bearing
- selfaligning ball bearing
- radial-thrust ball bearing
- thrust ball bearing
- radial roller bearing
- selfaligning roller bearing
- radial-thrust roller bearing
- thrust roller bearing

Hardware and software requirements

Required Software: MS Windows 2000, XP.

What's in this manual

Introduction (this section) tells you what APM Bear is in general, what parameters and what types of bearings could be calculated. You will requirements to hardware and system software.

Chapter 1, Problems, initial data and results contains description of the problems solved with APM Bear. The strict definitions of all calculated parameters and initial data are given. Presentation of the results is described.

Chapter 2, A quick example, answers to common questions leads you through a sample session in order to demonstrate main operations—how to start program, enter initial data, perform calculations, browse the results. The second part of this chapter contains answers to common questions that may arise when you work with APM Bear.

Chapter 3, Data base and archive files summarizes the local data base features—structure, using, updating. Format of archive files used to store initial data and results is described.

Chapter 4, APM Bear environment describes the main elements of APM Bear environment—menus, dialog boxes and controls, information windows.

Chapter 5, Command reference contains complete description of all commands of the main menu and popup menus.

Typefaces used in this book

To facilitate reading and avoid misunderstanding we use a set of typefaces. Their uses are as follows.

`a:\setup`	This typeface represents text as it appears or anything you must type (for example, `a:\setup` to start installation program).
SETUP.EXE	We use all capital letters for the names of files and keys.
Help	APM Bear command names are shown in boldface.
Results	Italics is used for the names of dialog boxes and controls

How to contact APM

To contact APM you can use one of the following ways:

Send fax. Our Moscow fax number is +7 (495) 585-06-11.

Call by phone +7(495) 585-06-11 (Moscow), +7(495) 514-84-19

Write a letter and send it to
Research and Software Development Center APM LTD
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Moscow Region
141070 Russia
web: http://www.apm.ru, http://www.apmwm.com
e-mail: com@apm.ru, com@apmwm.com

Chapter 1

Problems, initial data and results

This chapter consists of three parts and preface. In the preface the general features of the APM Bear are outlined. In the first part bearing parameters that you can calculate in the APM Bear are described. A strict definition is given for each parameter in order to avoid misunderstanding. The forms in which parameters calculated and forms they can be looked through by the user are described. Second part contains the description of bearing types you can calculate in the APM Bear. In the third part a full definition of initial data is given.

APM Bear—new approach to the bearing calculation

Rolling contact bearings are among the most frequently used machine elements in the mechanical engineering. Reliable bearing parameters determination and optimum mode of operation selection are of great importance for mechanical equipment performances, particularly for its accuracy and longevity.

It is not exaggeration to say that the stiffness (displacements) determination is the keystone and at the same time the stumbling block in the bearing calculation. The stiffness is important itself and besides that it is used in calculation of many other parameters.

The classic method of stiffness determination is based on the solution of so-called contact problem. To solve this problem the methods of the theory of elasticity are used. The solution of the contact problem is based on some assumptions, known as the Hertzian assumptions. Among them one of the most important is the requirement of the ideal smoothness of contacting surfaces.

However, the real contacting surfaces always have the irregularities. The amplitude of these irregularities is comparable with the amplitude of contact displacements. It makes the classic methods of contact problem solving unsuitable, the errors can reach as much as 100% and more.

The general theory of non-ideal contact was developed in the Research and Software Development Center APM Ltd. It takes in consideration the essentially statistical nature of processes, that takes place when non-ideal surfaces are contacting. The effective methods of contact stiffness and displacement determination were developed. The reliability of these methods was proved by the experimental investigations.

The important thing you have to mind is that the real contact between rolling bodies and raceway has the statistical nature. Therefore, its characteristics, such as stiffness and displacements you can determine in statistical sense only—as the sample realization, average values, variance, etc.

In the APM Bear the sample realization of bearing displacements is computed. It consists of 100 members. Using it you can determine the average displacements and stiffness, its variance, minimum, maximum and the most frequent values, the shape of field of dispersion, etc. Accordingly, all parameters that are calculated using the displacements (moment of friction, loss of power, forces acting on the rolling bodies) are represented as arrays of 100 members, supplemented with statistical parameters. You can look through these data in a variety of ways—as a simple table, as histogram, as graph, as epure and even as animation. It gives you the real picture of behavior of your bearing in all its complexity and completeness. And at this moment our job is finished. Next is your move—to use these data.

Results

In the APM Bear the following parameters are calculated:

- Displacements in the rolling contact bearings
- Maximum contact stress
- Longevity
- Forces acting on the rolling bodies
- Moment of friction
- Loss of power

- Heat release

In this section we give description of each parameter. Description includes three topics. In the first topic (**Definition**) a strict definition of parameter is given. Second topic (**What's calculated**) tells you in what form parameter is calculated—an array, a single value, etc. The last topic (**Presentation**) describes the forms in which parameter is displayed.

Displacements and stiffness

Definitions

Stiffness is the ability of a body to resist deformation, caused by an external load. Numerically **stiffness** is the load that causes deformation equal to 1 (in the selected system of the measurement units).

Compliance is ability of a body to be deformed by an external load. Numerically **compliance** is the deformation caused by an external load that is equal to 1 (in the selected system of the measurement units).

Displacement is an absolute displacement of the bearing center caused by an external load.

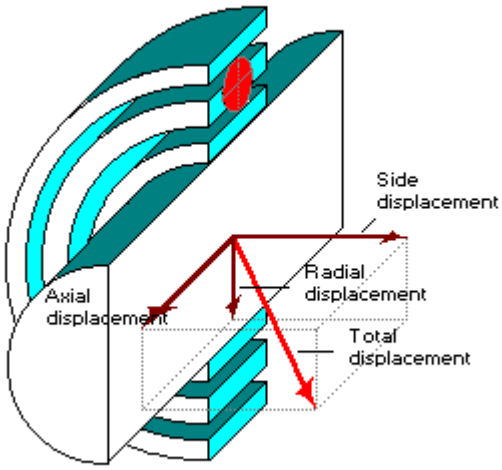


Figure 1.1 Bearing displacement components. In the most common case the total displacement of the bearing can have up to three components—axial, radial and side. Axial displacement is directed along the shaft axis; radial displacement is perpendicular to the rotation axis and parallel to the radial load; side displacement is perpendicular both to axial and radial displacement.

Components of the displacement Depending on the type and the external load applied bearing displacement can be one-, two- and three-dimensional. The following names are used for the displacement components (see Fig. 1.1)

axial—the component of the total displacement directed along the axis of the shaft the bearing is mounted on;

radial—the component which is parallel to the radial force direction and perpendicular to the shaft axis;

side (or lateral)—the component perpendicular both to the shaft axis and to the radial load.

Beatings (**runout**) Relative displacement of the bearing center caused by its rotation and depended on the bearing geometry, accuracy and external load.

In the APM Bear absolute and relative displacements coincide, so the terms '*displacement*', '*beatings*' and '*runout*' are used interchangeably.

What's calculated

The calculation of the displacements is the backbone of the system. The user of the APM Bear has the unique opportunity to determine (and even to observe directly, as you will see below) the real manner of the bearing's movement in detail.

To characterize displacements the array of 100 positions of the bearing center is computed. For each position up to three components could be determined (axial, radial and side, see Fig. 1.1). With radial-thrust bearings that are arranged in pairs, the displacements are calculated for each bearing separately.

Using this array you can estimate maximum and average displacements, look through the field of dispersion of the displacements, to determine which displacement components prevail and so on. Using the displacements one can easily calculate the stiffness and vice versa the compliance of the bearing. It is not an exaggeration to say that you are given exhaustive characteristics of the bearing movement.

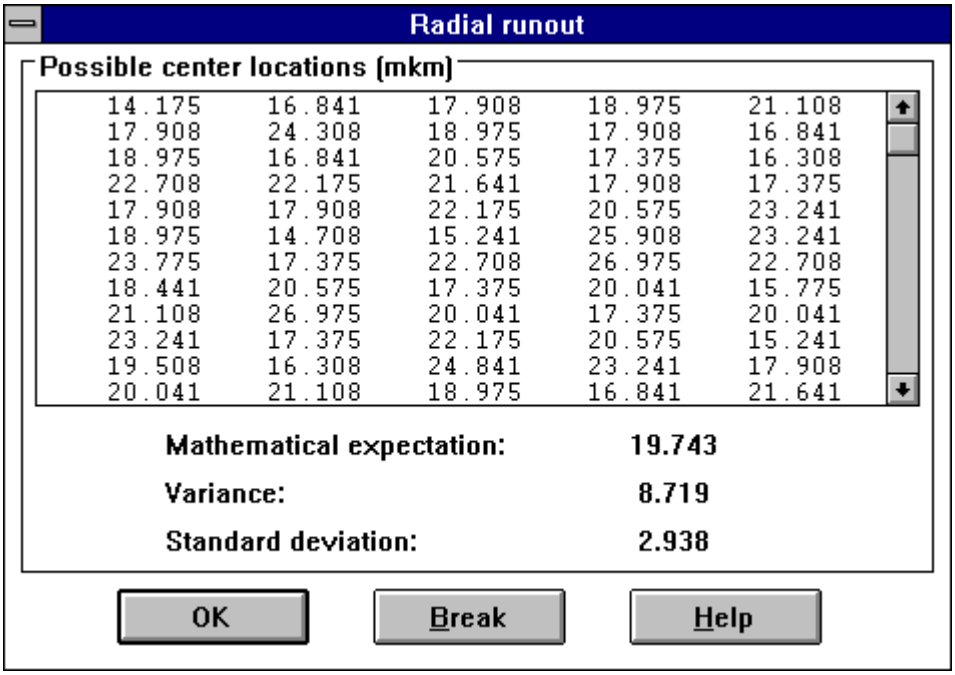


Figure 1.2 An array of radial displacements. In the upper part of the window the listbox filled with radial displacement values is shown. Below the statistical parameters of the radial displacement distribution are listed.

Presentation

The displacements are presented in APM Bear in the following way:

1) **As a table.** The window with a listbox filled with displacement values is displayed. In this window the statistical characteristics of displacements are shown as well—the average value, variance and standard deviation. Each component of the displacement (axial, radial, side) is displayed in a separate window. In Fig.1.2 you can see a table with radial displacements for a radial ball bearing.

2) **As a histogram**. The histogram is used to demonstrate the features of the distribution of the displacement values. The total range of displacement amplitude is divided into twenty equal intervals and for each interval the percentage of displacements fell within it is computed. See Fig. 1.3 where the histogram of the side displacements for the radial ball bearing is shown.

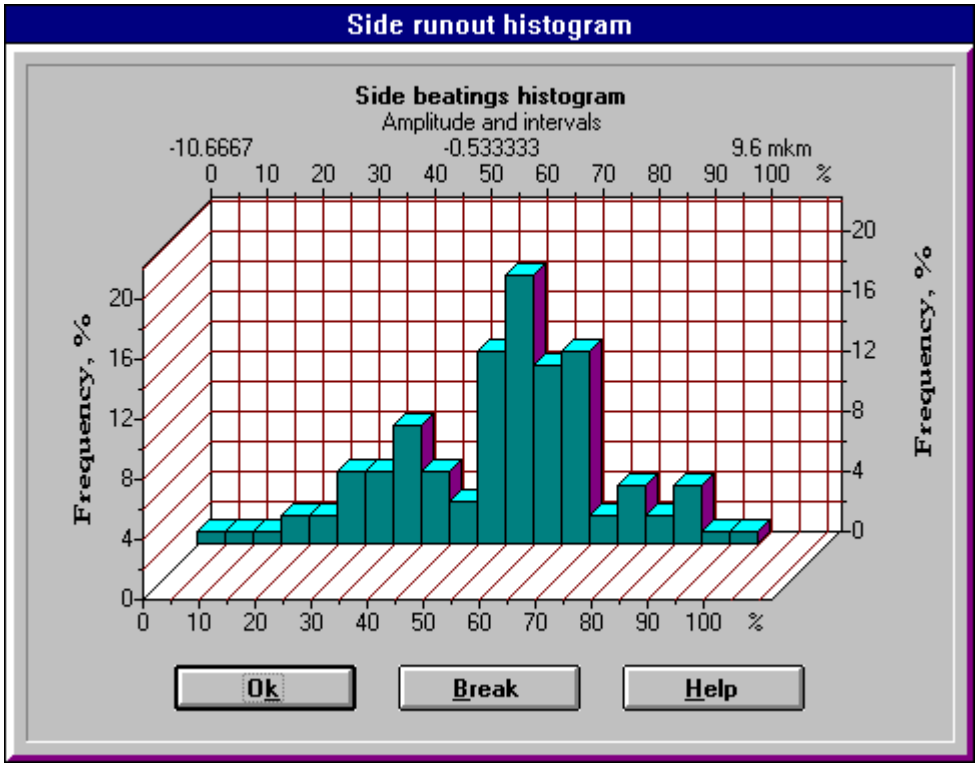


Figure 1.3 The histogram of side beatings of a radial ball bearing

3) **As a spatial field of bearing center positions**. In the tables and histograms the components of the total bearing displacement are shown separately. To see a combined distribution of the displacements 2D and 3D fields of dispersion are used. In Fig. 1.5 the 2D field of bearing center positions of a radial ball bearing is shown, in Fig. 1.4—the 3D field of the radial-thrust ball bearing displacements.

4) **As animation**. To give you a general idea about real manner of bearing motion animation is used. To make animation the same array of 100 bearing center positions is used. In Fig.1.6 a fragment of animation for radial-thrust ball bearing is shown.

Maximum contact stress

Definition

Maximum contact stress is the stress in the contact of the most loaded rolling body or its part.

What's calculated

In the APM Bear the maximum contact stress value is calculated. It is shown in the *Summary* groupbox of the *Results* dialog box.

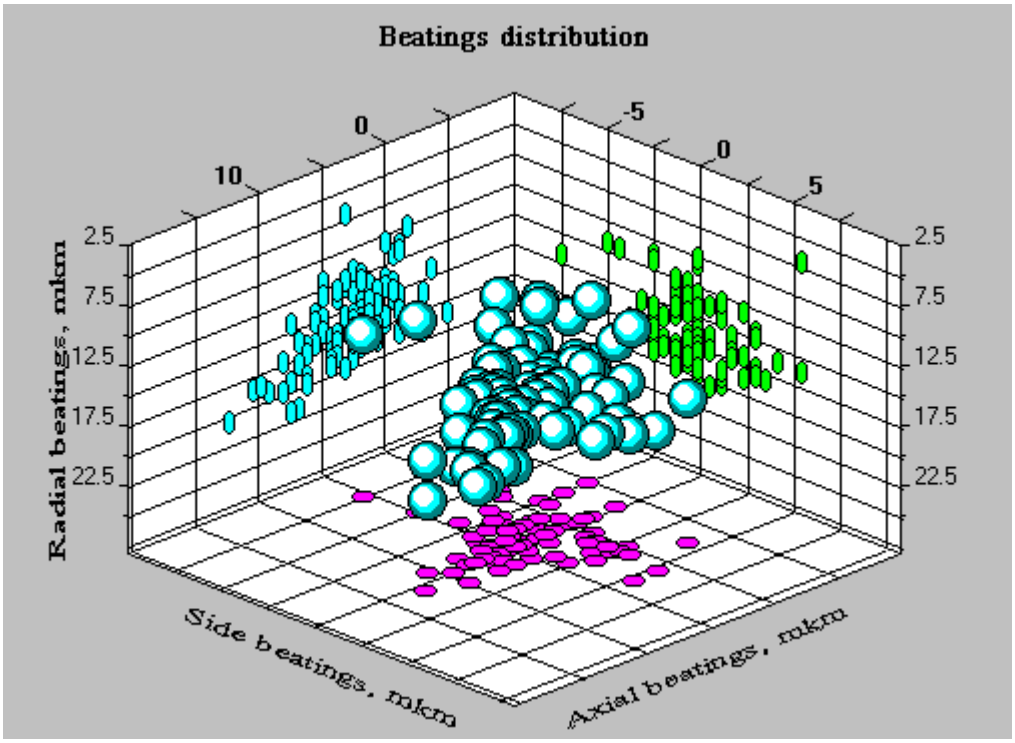


Figure 1.4 3D spatial distribution bearing center positions of the radial-thrust ball bearing. These graphs are used for radial-thrust bearings. Displacement of bearing of this type in the common case has three components—axial, radial and side. These components are laid off along X-axis, Z-axis and Y-axis respectively. Pseudospherical points correspond to the total bearing center displacement. Elliptical points drawn at the coordinate planes display pair distributions of the components - axial—radial, axial—side and radial—side. Either the total displacement distribution or pair distributions can be hidden to facilitate picture perception.

Longevity

Definition

Longevity is the period of time during which 90 bearings from every 100 will not have fatigue failure.

What's calculated

In the APM Bear the longevity value is calculated. It is shown in the *Summary* groupbox of the *Results* dialog box.

Forces acting on the rolling bodies

Definition

Forces acting on the rolling bodies or the normal forces are the forces applied to the individual rolling bodies from the raceway they are in contact with. These forces depend on the bearing geometry, accuracy, external load and relative position of the rolling bodies and rings.

What's calculated

In the APM Bear the forces acting on the rolling bodies are calculated for each of 100 bearing center positions.

Presentation

The forces acting on the rolling bodies are shown

1) As an epure drawn in the sketch of bearing

2) As a graph

At Fig.1.7 you can see a dialog window with epure and graph of the forces acting on the rolling bodies.

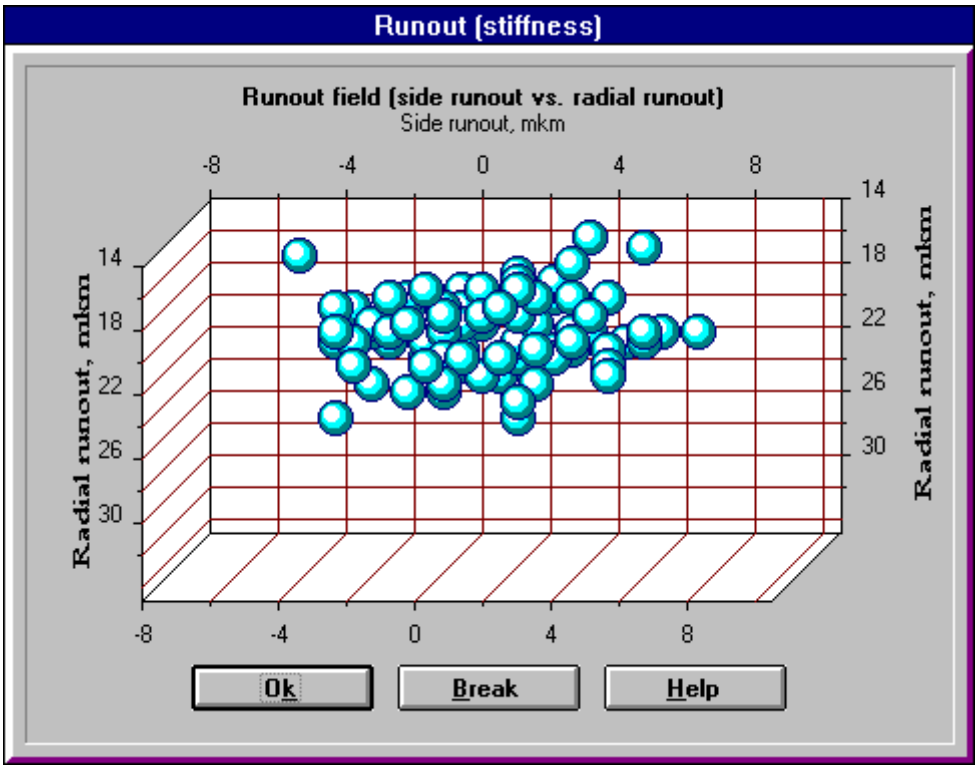


Figure 1.5 2D spatial distribution bearing center positions of the radial ball bearing. Graphs of this type are drawn in the APM Bear for bearings whose displacement has two components—radial and side. These are radial and selfaligning bearings. Radial displacement is laid off along the Y-axis, side displacement—along the X-axis. Points on the graph correspond to the bearing center positions.

Moment of friction

Definition

Moment of friction is the torque to be applied to the bearing to compensate the action of frictional forces.

What's calculated

In the APM Bear an array of 100 values of moment of friction is computed.

Presentation

Moment of friction values can be presented

1) As a table supplemented with statistical parameters (average value, variance, standard deviation).

2) As a histogram.

3) As a graph.

Besides that the average value is displayed in the *Summary* groupbox of the *Results* dialog box.

Loss of power

Definition

Loss of power is the power dissipated in the bearing due to the friction in the contact of rolling bodies with raceways.

What's calculated
In the APM Bear an array of 100 values of loss of power is computed.

Presentation
Loss of power values can be presented
1) As a table supplemented with statistical parameters (average value, variance, standard deviation).
2) As a histogram.
3) As a graph.
Besides that the average value is displayed in the *Summary* groupbox of the *Results* dialog box.

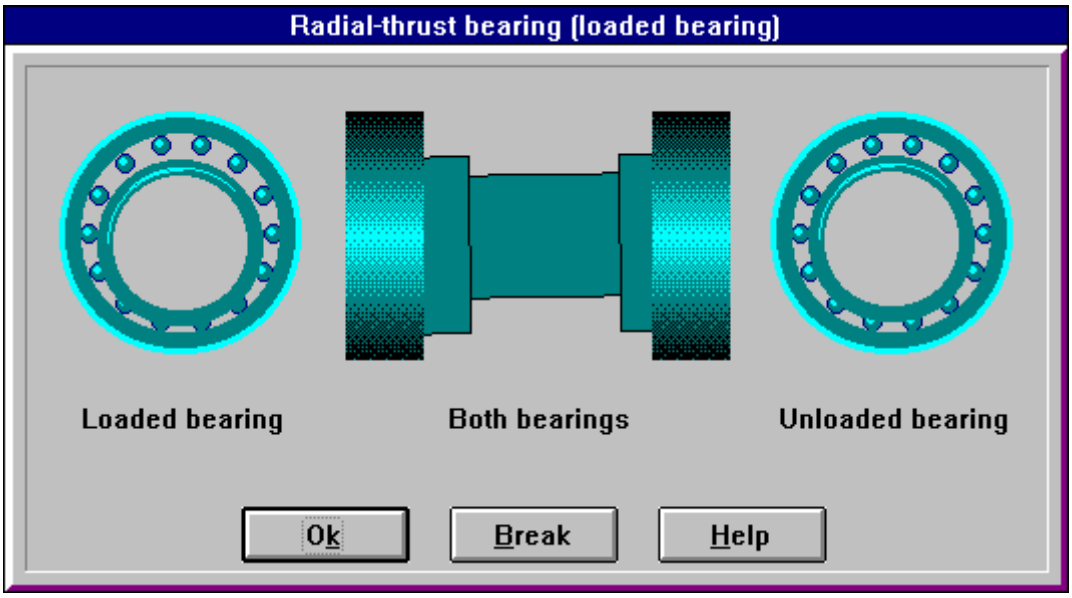


Figure 1.6 Fragment of the bearing movement animation for the radial-thrust bearing. At the left and right parts of the window user can look through the radial and side displacements of the bearings making up a pair unit. In the central part of the window the whole assembly is shown including both bearings and part of the shaft they are mounted on. This allows a user to observe axial and radial displacements of the bearings and to trace how the skewing of the shaft is changing during bearing rotation.

Heat release

Definition
Heat release is the amount of heat released in the bearing due to friction.

What's calculated
In the APM Bear the amount of heat released in the bearing due to the friction during a time period of one hour is calculated. It is shown in the *Summary* groupbox of the *Results* dialog box.

Types of bearings

This section contains a short description bearing types that you can calculate in the APM Bear.
We begin this sections with several general definitions.

Bearing —a part of a shaft's support structure that takes up a load and provides shaft's rotation.

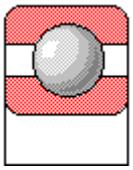
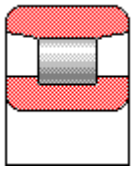
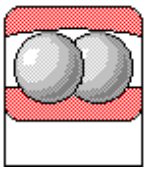
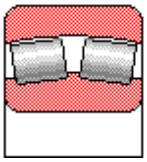
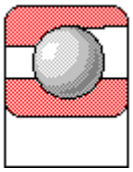
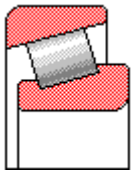
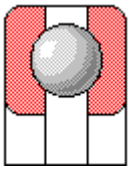
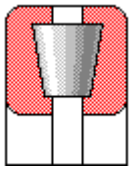
Rolling contact bearing —a bearing with rolling solids (spherical or roller) between the surfaces of supporting and rotating components. There are outer and inner rings in the bearing in addition to the rolling solids.

Ball bearing —rolling contact bearing with spherical rolling bodies.

Roller bearing —rolling contact bearing with rolling bodies having the form of cylindrical or conical rollers.

Non-ideal bearing —rolling contact bearing with geometrical dimensions deviated from the nominal values.

In the APM Bear you can calculate bearings of eight most widely used types.

Type	Scheme	Definition	Type	Scheme	Definition
Radial ball bearing		Ball bearing designed to run under radial load.	Radial roller bearing		Roller bearing designed to run under radial load.
Selfaligning ball bearing		Ball bearing with two rows of rolling bodies designed to run under radial load.	Selfaligning roller bearing		Roller bearing with two rows of rolling bodies designed to run under radial load.
Radial-thrust ball bearing		Ball bearing designed to run under combined load included both radial and axial forces.	Radial-thrust roller bearing		Roller bearing designed to run under combined load included both radial and axial forces.
Thrust ball bearing		Ball bearing designed to run under pure axial load.	Thrust roller bearing		Roller bearing designed to run under pure axial load.

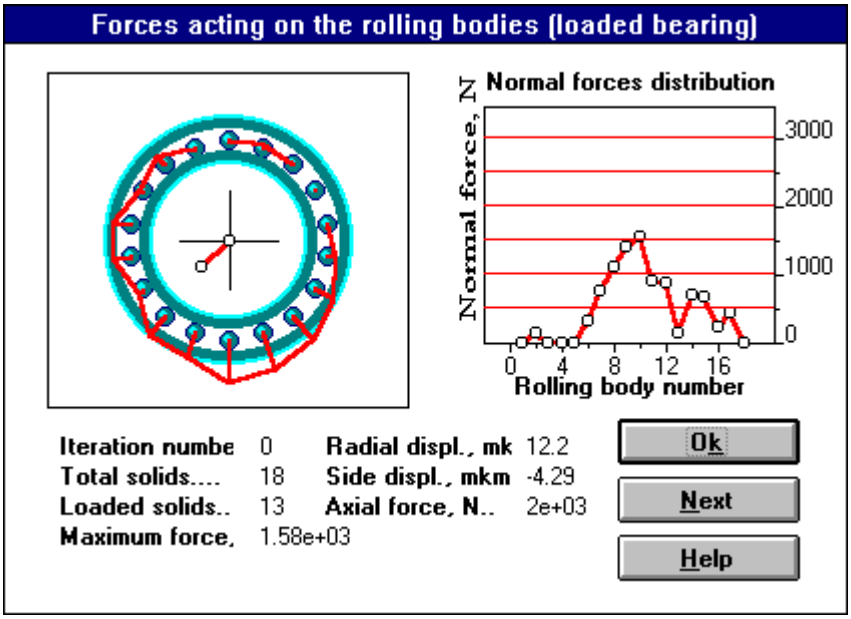


Figure 1.7 A dialog box with epure and graph of the forces acting on the rolling bodies (radial-thrust ball bearing) . Using 'Next' button you can get to the next bearing center position and in this a way to trace how the forces are changing. It could be seen that in the given example rolling bodies are not loaded uniformly. To improve the situation one may, for example, use a bearing with a higher accuracy or change preload.

Initial data

This section contains description of all parameters used in APM Bear as initial data for calculations.

Geometry

The following parameters are used to characterize bearing geometry.

Outer diameter Initial data	The bearing outer ring diameter with the nominal value coinciding with that of the bore's. Measurement units - millimeters (mm).
Inner diameter	The bearing inner ring diameter with the nominal value coinciding with mating shaft diameter value. Measurement units - millimeters (mm).
Rolling body diameter	Nominal value of the rolling body diameter. Measurement units millimeters (mm).
Roller length	Theoretical value of the roller-raceway contact zone length. Measurement units - millimeters (mm).
Contact angle	Angle measured between the load direction and the plane that is normal to the bearing axis. Measurement units - degrees.
Rolling bodies number	For a single-row bearing - the total number of the rolling bodies, otherwise number of the rolling bodies in one row.
Rolling bodies rows number	Number of rolling bodies rows in the bearing.

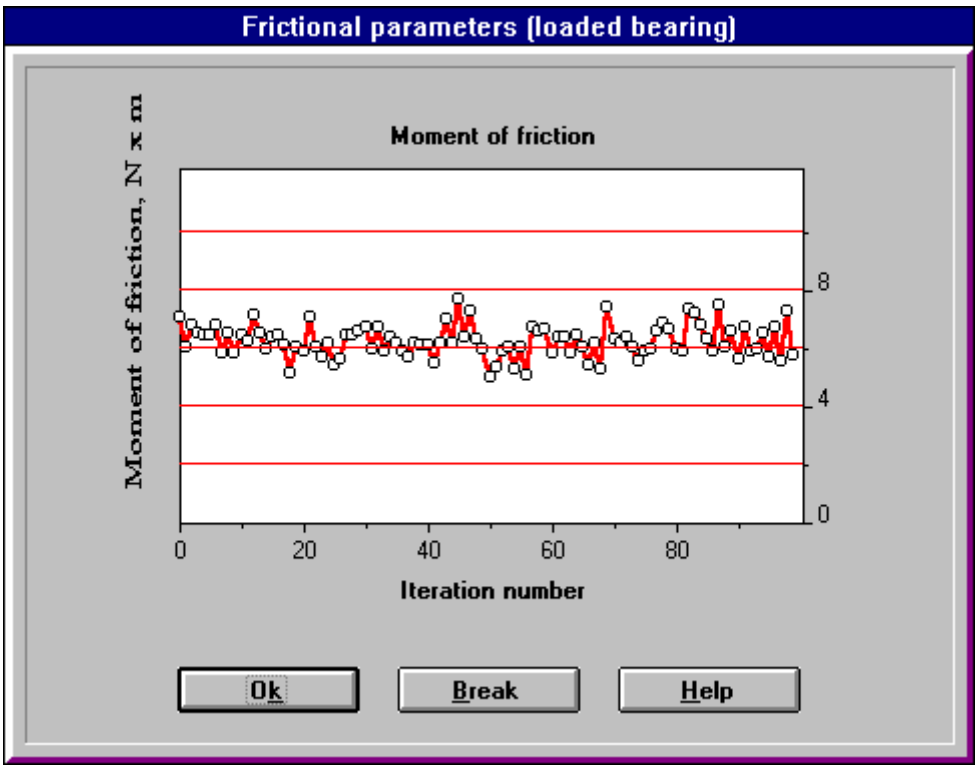


Figure 1.8 Graph of the friction moment values (radial-thrust ball bearing). On the Y-axis moment of friction values are laid off, on the X-axis—number of the bearing center position the moment of friction value is correspond to.

Accuracy

To characterize bearing accuracy two parameters are used

Outer ring raceway radial runout	The difference between the maximum and minimum thickness of the outer ring of the bearing.
Inner ring raceway radial runout	The difference between the maximum and minimum thickness of the inner ring of the bearing.

Working conditions

The following parameters are used in APM Bear to describe conditions the bearing is worked at.

Radial force	A component of the summary force that is directed along the radius to rotation center. Measurement units - newtons (N).
Axial force	A component of the summary force that is parallel to the axis of rotation. Measurement units - newtons (N).
Radial force of loaded support	Radial load acting on the loaded bearing (see Fig. 29 for definition of loaded and unloaded bearings). This parameter is used for radial-thrust bearings only.

Radial force of unloaded support	Radial load acting on the unloaded bearing (see Fig. 29 for definition of loaded and unloaded bearings). This parameter is used for radial-thrust bearings only.
Axial preload force	Axial force providing the preloading; it is obtained by means of relative axial displacement of the inner and outer rings of the bearing. Measurement units - newtons (N).
Dynamics factor	The coefficient considering a level of vibrationess (impact) of a load applied; it depends on the state of external action (load). This parameter is dimensionless.
Radial preload displacement	Value of radial displacement of the bearing's ring that is made in process of assembling of bearing unit. Measurement units - millimeters (mm).
Rotational speed	Number of full rotations during the time period of one minute. Measurement units - routes per minute (rpm).

Loaded and unloaded bearings

In the APM Bear radial-thrust bearings are considered mounted in a pair. Bearing which load is increased under the influence of external axial force is called loaded. Bearing which load is decreased under the influence of external axial force is called unloaded (see Fig. 1.9).

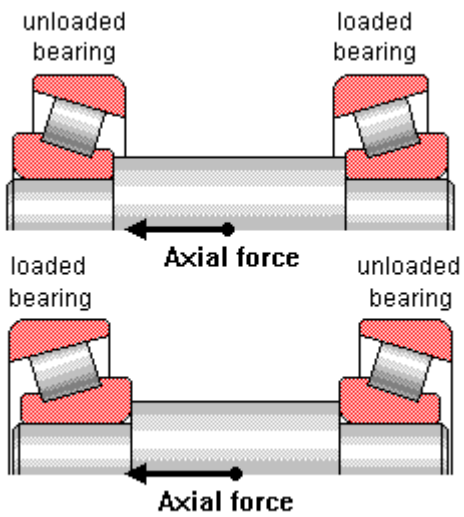


Fig. 1.9 Loaded and unloaded radial-thrust bearings

Chapter 2

A quick example, answers to common questions

This chapter is addressed to those of our readers who have idiosyncrasy to weighty manuals studying and prefer to learn new programs just at the PC board. In the first section of this chapter we lead you through a sample session in order to demonstrate main operations required to calculate bearing parameters. In the second section the answers to common questions that may arise when user works with APM Bear will be given.

APM Bear—A sample session

To calculate a bearing with APM Bear you have to carry out the following steps:

- start APM Bear
- select the type of bearing
- enter initial data
- perform calculations
- look through the results

How to start APM Bear

To start APM Bear open a group window entitled APM WinMachine (it is created by the installation program) and select APM BEAR icon. Then double-click it or press ENTER key.

How to select type of bearing

First thing you are to do is to point out type of bearing you want to calculate. Select **Data | Bearings Types** command. The dialog box with list of bearing types will be displayed (see Fig. 5.9). Select the desired item and press *Ok* button to confirm your choice.

How to enter initial data

Next step is the initial data input. All the initial data in the APM Bear are divided into three groups. These are data characterizing:

- geometry of the bearing
- its manufacturing errors (accuracy)
- conditions the bearing should works at

To begin data input select the **Data** command in the main menu. This command invokes a popup menu that consists of three items—**Geometry, Accuracy** and **Working Conditions** (Fig. 5.8). When you select one of them, a dialog box for an input of the parameters, belonging to the respective group is displayed. These dialog boxes are shown in figures 5.10, 5.13 and 5.15 respectively. You have to enter all the data you will be asked for in these dialog boxes.

How to perform calculations

After you finish data input, select the **Calculate** command in the main menu. The *Calculations* window will be displayed. It shows a current percentage of calculation execution, so you can evaluate a time required to complete it.

How to look through the results

Select the **Results | Results** command in the main menu. The *Results* dialog box will be displayed (see Fig. 5.16). It includes buttons for each result item. Select button correspond

to result item you want to look through. Or select *Show All* button that initiates the successive demonstration of all the results. For details see section *Results command* in Chapter 5.

APM Bear in questions and answers

Question: APM Bear—what is it?

Answer: APM Bear is a new state-of-the-art program for non-ideal bearing parameters calculation developed in the Research and Software Development Center APM LTD, Moscow .

Q: What parameters could be calculated in the APM Bear?

A: In the APM Bear you can calculate

- displacements in the rolling contact bearings
- maximum contact stress
- longevity
- forces acting on the rolling bodies
- moment of friction
- loss of power
- heat release

For details see section *Results* in Chapter 1.

Q: What types of bearings could be calculated in the APM Bear?

A: In the APM Bear bearings of eight types can be calculated:

- radial ball bearing
- selfaligning ball bearing
- radial-thrust ball bearing
- thrust ball bearing
- radial roller bearing
- selfaligning roller bearing
- radial-thrust roller bearing
- thrust roller bearing

See section in *Types of Bearings* in Chapter 1.

Q: What is non-ideal bearing?

A: The bearing is considered non-ideal if its manufacturing errors cannot be ignored in the context of the problem to be solved. Many important problems of contact stiffness and strength require the bearing to be considered non-ideal. The universal method of non-ideal contact problems solving was developed. Reliability and effectiveness of this method were proved by experimental investigations.

Q: Why an array of displacements?

A: The displacements are calculated as a result of contact problem solving. In the case of rolling bodies and raceways contact, the contacting surfaces have the randomly distributed irregularities, caused by the manufacturing errors. The amplitude of these irregularities is comparable with that of contact displacements, so if you don't take them in consideration the errors can reach 100% and more. These irregularities can be described only statistically, and only statistical solutions can be obtained. To determine bearing displacements the statistical simulation is used. The array of 100 possible bearing center positions is computed. Using this array you can determine the average, minimum, maximum and the most frequent displacements, to look the shape of field of dispersion, etc. This gives you much more real and complete picture of bearing behavior than traditional methods does. Accordingly, the parameters calculated on the base of displacements (moment of friction, loss of power, forces acting on the rolling bodies) are presented as arrays.

Q: What is the recommended strategy of working with APM Bear?

A: The APM Bear allows to calculate bearing parameters in the statistical formulation, i.e., to determine average values of parameters and its dispersion. The existing analytical

dependencies, used to calculate stiffness, provides large errors, both qualitative and quantitative.

Using APM Bear you can reliably estimate the working accuracy of the mechanical equipment you are designing. You can find manufacturing accuracy, geometry parameters, preload value that guarantee required working accuracy. The optimization can be made if you select the appropriate efficiency function that is corresponded to required performances.

With APM Bear you can determine true longevity of preloaded bearing. This parameter depends on the forces, acting on the rolling bodies. You can get the reliable values of the latter only if you take in consideration the manufacturing accuracy of the rolling bodies and raceways.

The forces acting on the rolling bodies determine the moment of friction and heat release in the bearing.

The APM Bear can be used to control the preload value.

The APM Bear can be applied to the various problems of

- statics
- dynamics
- kinematics
- endurance analysis
- determination of accuracy, loading and frictional parameters

of the machine elements.

The APM Bear provides you with new approach to the problems of designing.

Q: How to select type of bearing to be calculated?

A: To select type of bearing use **Data | Bearing Type** command or press CTRL + B. In the dialog box displayed select type of bearing you want to calculate. Then select *Ok* button or press ENTER key. A pictogram of bearing type you have selected will be displayed in the left part of the screen. See section *Bearing Type command* in Chapter 5.

Q: How to enter initial data?

A: To enable data input you have to select type of bearing (see above question).

To enter data on bearing geometry use **Data | Geometry** command or press CTRL+G. In the *Geometry* dialog box enter parameters values or select *Data base* button to use Bear data base.

To enter data on bearing accuracy select **Data | Geometry** command or press CTRL+A. The *Accuracy* dialog box will be displayed. Enter parameter values or select *Db* button to use Bear data base.

To enter data characterizing the conditions bearing work under use **Data | Working conditions** command or press CTRL+W. In the displayed dialog box enter parameters values.

Q: Where to get geometry data?

A: The bearings are highly standardized parts of machines. There are a number of standards (national and international) and a lot of catalogues of bearing producing companies. Most likely you will use one of them. You can put these standards and catalogues in the APM Bear data base to facilitate data input. Data base provides you with a fast, convenient and correct access to bearing dimensions data.

Q: Where to get accuracy data?

A: In the modern mechanical engineering, tolerances and fits are standardized. You can put standard you work with in the data base and use the advantage of automatic data input.

Q: Where to get data on working conditions?

A: These data describe real conditions your bearing is work under.

The total external load applied to bearing should be decomposed to axial force, directed along shaft axis, and radial force that is perpendicular to shaft axis.

In the case of radial-thrust bearings (ball and roller) which a mounted in pair units, you have to input radial force for each bearing separately.

Q: How to perform calculations?

A: Select **Calculate** command in the main menu or press ALT + C. Remember that this command is disabled until you finish initial data input.

Q: How to look through the results?

A: To look through the results select **Results** command from the main menu or press ALT + R. The *Results* dialog box will be displayed. Use appropriate buttons of this dialog box to display result items or select *Show All* button to initiate successive results demonstration. See section *Results command* in Chapter 5.

Q: How to look through displacements (stiffness)?

A: Use **Results** command to open *Results* dialog box.

If you are interested in the average values only you can see them in the *Summary* group box of the *Results* dialog box.

To look through any displacement component as a table select *Array* button of the respective group box (*Axial Displacements, Radial Displacements* or *Side Displacements*).

To look through any displacement component as a histogram select *Histo* button of the respective group box (*Axial Displacements, Radial Displacements* or *Side Displacements*).

To look through combined distribution of two or three displacement components select *Graph* button of the *Center Locations* group box.

Q: How to look through maximum contact stress?

A: Use **Results** command to open *Results* dialog box. Maximum contact stress value is shown in the *Summary* group box.

Q: How to look through longevity?

A: Use **Results** command to open *Results* dialog box. Longevity value is shown in the *Summary* group box.

Q: How to look through forces acting on the rolling bodies?

A: Use **Results** command to open *Results* dialog box, then select *Normal Forces* button. The dialog box will be displayed with the epure and the graph corresponds to the first bearing center position. To go over to the next position use *Next* button.

Q: How to look through bearing movement animation?

A: Use **Results** command to open *Results* dialog box, then select *Bearing Movement* button.

Q: How to look through moment of friction?

A: Use **Results** command to open *Results* dialog box. In the *Moment of Friction* group box use

- *Array* button to display moment of friction as a table (supplemented with average value, variance and standard deviation)
- *Histo* button to display moment of friction histogram
- *Graph* button to display moment of friction graph

Average value of the moment of friction is also shown in the *Summary* group box.

Q: How to look through loss of power?

A: Use **Results** command to open *Results* dialog box. In the *Loss of Power* group box use

- *Array* button to display loss of power as a table (supplemented with average value, variance and standard deviation)
- *Histo* button to display loss of power histogram
- *Graph* button to display loss of power graph

Average value of the loss of power is also shown in the *Summary* group box.

Q: How to look through heat release value?

A: Use **Results** command to open *Results* dialog box. Heat release value is shown in the *Summary* group box.

Q: How to print out data and results?

A: Use **File | Print** command or press CTRL + P to print out initial data and results. In the dialog box displayed select items you want to be printed (see Chapter 5, Fig. 5.5). If the bearing you work with is of radial-thrust type, you are to select one of two bearings (loaded or unloaded) making up a pair unit (see Chapter 1). Until you select result items and bearing, *Print* button is disabled. Use **File | Printer setup** command to specify printer type and connection and printing options as well (see section *Printer Setup command* in Chapter 5).

Q: How to use data base for initial data input?

A: Data base implemented in the APM Bear is intended to store data on bearing dimensions and accuracy.

To get geometry data from data base select **Data | Geometry** command. Dialog box for geometry data input will be opened (see Fig 5.10). Select *Data base* button. Dialog box providing access to data base will be displayed (Fig 5.11). Select bearing you want to calculate and click *Ok.* Bearing parameters will be copied to the respective edit controls of first dialog box. See Chapter 3 and Chapter 5 for details.

To get accuracy data from data base select **Data | Accuracy** command. In the dialog box for accuracy parameter input there are two buttons marked with text *Db* (Fig. 5.13). One of them corresponds to the outer ring diameter deviation, another—to that of inner ring. Select appropriate button. Dialog box providing access to accuracy data base will be opened (Fig. 5.14). Select deviation corresponding to required accuracy class and bearing dimensions. Then select *Ok*—accuracy value will be retrieved from the data base and copied to the respective edit control of the first dialog box. See Chapter 3 and Chapter 5 for details.

Q: How can I change data base contents?

A: Use commands of **Data base** popup menu. Each of its commands let you edit one of data base objects. You can update, delete or insert any object except bearing types. For details see Chapter 3 and Chapter 5.

Q: What structure has data base? How to find bearing or accuracy I need?

A: Virtually there are two data bases in APM Bear—one on bearing dimensions and another on accuracy.

Data base on bearing dimensions has three levels. In the most down level there are bearing records. Each record includes a number of parameters and is corresponding to an individual bearing. Bearing records are grouped in subtypes. Subtypes are united in standards. Standard is equivalent to the standard on bearings (such as ISO) or to catalogue of bearing producing company. That is, to find required bearing you are to point out standard and subtype this bearing belongs to. When searching for bearing, remember that they are sorted by numbers (identificators) in the alphabetical order. To facilitate searching the filtration operation is implemented. You give a set of conditions and a group of bearings that meet these conditions is displayed. See Chapter 3 for details.

As for accuracy data base, it consists of two levels. The lower level is represented by accuracy record. It includes the diameter range and the deviation value corresponding to it. Accuracy records are grouped in the accuracy classes. So, to find required accuracy value you are first to select accuracy class. In this class you search for diameters range the bearing fall within and take accuracy value corresponding to it. See Chapter 3 for details.

Q: How to contact APM?

A: Our Moscow fax number is +7-(095) 585-06-11.
Our Moscow phone number is +7-(095) 585-06-11, +7(095) 514-84-19

Our address is:

Research and Software Development Center APM LTD
Korolev-Center, box 58,
Moscow Region
141070 Russia

Chapter 3

Data base and archive files

Archive files

When you work with Bear you can save initial data and calculation results as files on the hard disk or on the diskettes. File contents depends on the current position in problem solving. If you have already defined initial data, but perform not calculations, you can save only initial data. When calculations are finished you can save calculation results as well. When you load previously saved file, you will be just in the same position you were when the file was created. You can review data and results, modify data and repeat calculations, etc.

How to create and load archive files see sections **Load Data command** and **Save Data command** in the Chapter 5.

Data base

The bearings are highly standardized parts of machines. When you calculate a bearing, most likely you take initial data from the international or national standard (for example from the ISO standard) or use catalogues of companies producing the bearings.

To facilitate this job the local data base containing the data on bearing dimensions and accuracy is implemented in the APM Bear.

Data base structure

From the user's perspective

APM Bear data base structure was selected to imitate the operations succession and objects' hierarchy habitual for user.

When working 'manually' usually you take either the reference book with the required standard or a catalogue of bearing-producing company. Then you find in it the section containing data on bearing of the interesting you types—say, radial ball bearing. In this section you find a table with required subtype (for example bearings with sealing washer). In the table you choose a row (record) corresponding to the required bearing. And finally you find in this row the parameters (fields) you are need in.

The data base for bearing geometry includes the following logical levels

Geometry data base logical levels	Objects
Standard	Standard or catalogue of bearing-producing company (for example, ISO standard)
Type	Type of bearing (for example, radial ball bearing)
Subtype	Subtype of bearing (for example, radial ball bearing with sealing washer or radial ball bearings of light series, etc.)
Bearing	Specific bearing of given standard or catalogue
Parameter	Specific parameter of the bearing (for example, outer diameter)

These levels form the 'coordinate system' of geometry data base.

The following parameters are stored in the geometry data base
- Bearing number (identificator)
- Outer diameter
- Inner diameter
- Rolling body diameter
- Rolling bodies number
- Rolling bodies rows number
- Contact angle
- Roller length
- Dynamic load rating
- Static load rating
- Mass

The last three parameters are given for reference only. They are not used as initial data for calculation, but you can use them for searching and selection (filtering, see below).

When you want to determine accuracy value you do this in the following steps. First, basing on technological considerations you determine accuracy class. Then you find the interval of the outer (inner) diameter you bearing fall in. And finally you take a deviation value corresponding to this interval.

Accordingly, accuracy data base implemented in the APM Bear includes two structural levels—accuracy classes and deviations.

Three parameters are stored in the accuracy data base. These are minimum and maximum diameters, that makes up interval and deviation corresponding to this interval.

From the programmer's point of view

The data base structure from the programmer's perspective is somewhat different.

APM Bear data base is implemented as data base of relational type. The main structural element of bearing geometry data base is the type of bearing. There are eight tables—one for each type of bearing. The structural levels 'standard' and 'subtype' are realized through the index files. As for accuracy data base, its main table is formed by deviation values. The 'accuracy class' level is implemented through indexes.

Operations

All the operations allowed in the APM Bear data base can be divided into two classes:
- operations for retrieving data for calculation
- operations for editing and expanding data base contents

Using data base for initial data input

The main purpose of the APM Bear data base is to facilitate initial data input and save you from tiresome searching for required parameters in the thick reference books and catalogues. Once you filling in the data base, you can retrieve the data required by means of a few mouse clickings or key pressures.

Inquiries to the data base for initial data are made from the same dialog boxes where respective parameters are entered. You open the *Geometry Data* dialog box (see Fig. 5.10) or *Accuracy Data* dialog box (Fig. 5.13) and select button marked with text *Data base* or *Db.*

Geometry parameters input

Open the *Geometry Data* window (Fig. 5.10). Select *Data Base* button. In response to this action the dialog box shown in Fig. 5.11 will be displayed. Use *Standard* listbox to select standard or catalogue and *Subtype* listbox—to select bearing subtype. Use *Select* button if you need to choose a group of bearings that satisfy to a set of given conditions. After finishing these operations, select a bearing you need in the *Data* window that occupies the central part

of dialog box. Then select *Ok* button—geometry parameters will be copied from the data base to the edit controls of the *Geometry Data* dialog box. Select *Ok* button of this dialog box to confirm data and close this dialog box.

Accuracy parameters input

Open the *Accuracy Data* window (Fig 5.13). It contains two edit controls for input of radial runout of the inner and outer ring's raceways. Just to the right of these edit controls there are two buttons marked with letters 'Db.' Select these buttons to get respective parameter value from the data base. The dialog box shown in Fig. 5.14 will be displayed. Use *Accuracy Class* listbox to select accuracy class you need. *Data* window in the middle of the dialog box contains a table where for any given diameter range the correspondent diameter deviation is shown. Point out with selection bar the deviation value you want to use and select *Ok* button. The deviation value will be copied to the respective edit control of the *Accuracy Data* dialog box.

Data base editing

There is sufficiently large number of bearing standards and bearing-producing companies. In APM Bear data base the user is provided with a set of operations for changing and expanding data base content.

Data base on bearing geometry

As mentioned above, the following objects hierarchy is implemented in the geometry data base

- standard
- type of bearing
- subtype
- bearing (record or a set of parameters of specific bearing)
- parameter (the concrete parameter of the specific bearing)

The user can update, insert and delete standards, subtypes and bearings. The user cannot use these operations for the types of bearings (the set of bearing types is fixed). The user cannot add new or delete existing parameters (the set of parameters is fixed for each type of bearing).

Operations with record (bearings)

To perform operations with records, open the **Data base** popup menu (see Fig 5.17). In its upper part eight commands are listed which names coincide with types of bearing calculated in the APM Bear. Each of these commands invokes on the screen dialog box for editing bearings of respective type (Fig. 5.18). In each dialog box there are *Standard* and *Subtype* listboxes. Use these controls to identify uniquely bearing you need. Use buttons *Update, Insert, Delete* to execute operations of the same name.

Updating of record

In the dialog box described above (Fig. 5.18) select *Update* button. The dialog box for record edition will be called on the screen (see Fig. 5.19). It contains edit controls for every parameter stored in data base. Current parameter values are displayed in these edit controls. Type new values and select *Ok* to confirm them.

Insertion of a new record

Use the succession of actions described in the above section, but instead of *Update* select *Insert* button. The same dialog box for record edition will be displayed, but with empty edit controls. Enter parameter values and select *Ok* button for confirmation.

Deleting existing record

Using selection bar (a row of inverted text) point out the record you want to delete and press *Delete* button. Dialog box will be displayed with the warning message asking if you really want to delete record selected. Press *Ok* to confirm deletion.

Search (filtering)

This operation allows you to select a group of bearings that satisfies a set of given conditions. Click with mouse or press with a key the *Select* button of dialog box described above (Fig. 5.18). The dialog box shown in Fig. 5.20 will be called on the screen. It contains a set of controls that allows you to determine condition for each parameter used for bearing of considered type. The conditions are of following type

Minimum value {Relation1} Parameter {Relation2} Maximum value

Here {Relation1} is one of the following operations—'>', '≥', '='. {Relation2} includes the operations '>' and '≥'. In other words the required interval for parameter values is determined. For example, the condition can be as follows:

40 ≤ Outer diameter < 80

According to this condition all bearing with outer diameter greater or equal than 40 mm and lesser than 80 mm will be selected.

If you want the exact matching use the '=' operation.

To assign minimum and maximum values use the edit controls that are in the leftmost and rightmost positions in each row. To assign {relation} type use listboxes placed between edit controls and parameter name.

IMPORTANT NOTE: When you have selected the set of conditions, it will be stored and used each time you make inquiry to the data base until you select new conditions or clear the conditions.

Operations with subtypes

To do any operation with subtype select **Data base | Subtype** command. The dialog box shown in Fig. 5.23 will be displayed. It includes *Update, Insert* and *Delete* buttons. By means of these buttons you can update existing subtype, insert new and delete existing ones respectively. *NOTE: Every type of bearing must include at least on subtype. If you need not in the dividing of the given type into subtypes, you should define one subtype with an arbitrary name and place in it all the bearings of this type.*

Starting new subtype

To add new subtype use *Insert* button. The dialog box shown in Fig 5.24 will be displayed. Enter the name of subtype in the *Name* edit control. The code of new subtype is shown in the *Code* control. It is for internal use and is inaccessible for user. It should be noted that in the dialog box shown in Fig. 5.24 you determine only the name of new subtype. To fill it with bearings use dialog box for bearing records editing (see above).

Editing existing subtype

The only editing operation allowed for subtype is changing of its name. With selection bar mark subtype you want to change and select *Update* button. The dialog box described in the previous paragraph will be called. In the *Name* edit control it contains the current name of subtype. Enter new name and select *Ok* button for confirmation.

Deletion of existing subtype

With selection bar choose subtype you want to delete and select *Delete* button. The warning message will be displayed. Select *Ok* to confirm deletion. *NOTE: You should remember that when you delete a subtype all bearings of this subtype will be deleted from data base.*

Operations with standards

Use **Data Base | Standard** command. It displays dialog box for standard editing (Fig 5.21). In its central part there is the table where standards currently in data base are listed. In the lower part there are some pushbuttons including *Update, Insert* and *Delete* buttons. By means of these buttons the editing operations of the same name are performed. *The data base must contain at least one standard.*

Starting new standard

If you want to introduce a new standard select *Insert* button of the dialog box described above. The dialog box shown in Fig. 5.22 will be invoked at the screen. Type the name of standard in the *Name* edit control. The code of new standard is shown in the *Code* edit control. It is for internal use in data base and is inaccessible for user. It should be noted that in dialog box described above you determine only the name of new standard. To fill it with bearings data use dialog box for bearing records and subtypes editing (see above).

Editing existing standard

The only editing operation for standard is the changing of its name. With selection bar mark standard you want to change and select *Update* button. The dialog box described in the previous paragraph will be called. In the *Name* edit control it contains the current name of standard. Type new name and select *Ok* button for confirmation.

Deletion of existing standard

With selection bar mark the standard you want to delete and select *Delete* button. Warning message will be displayed. Select *Ok* to confirm deletion. *NOTE: You should remember that if you delete a subtype all bearings that belong to it will be deleted too.*

Data base on accuracy

Data base on accuracy contains objects of two levels:
- accuracy classes
- deviations.

The user is allowed to update, insert and delete both accuracy classes and deviations.

Operations with record (deviations)

To edit deviations use **Data Base | Outer ring** command if you want to edit data for outer ring of bearing and **Data Base | Inner ring** command if you need to edit data for inner ring. In both cases the same dialog box will be displayed (Fig 5.27). In its upper part there are two listboxes—*Type* and *Accuracy Class* that are used for operation object identification.

Updating of record

When you select *Update* button the dialog box shown at Fig. 5.28 is displayed. It contains three edit controls where current parameters values are shown. Use these edit controls to enter new values of maximum diameter, minimum diameter and deviation.

Insertion of a new record

Insert button selection invokes the same dialog box, which was mentioned in the above paragraph. The only difference is that it's edit controls are empty. Enter the values and select *Ok* button.

Deletion existing record

With selection bar choose record to be deleted and select *Delete* button. Warning message will be displayed. Select *Ok* to confirm deletion.

Operations with accuracy class

Select **Data base | Accuracy classes** command. The dialog box, shown in Fig 5.25 will be called at the screen. Use *Type* list box to point out type of bearing. Use *Update, Insert* and *Delete* buttons to edit accuracy classes. *At least one accuracy class must be defined for each type of bearing.*

Starting new accuracy classes

Use *Insert* button of the dialog box described above. The dialog box shown at Fig 5.26 will be displayed. In the *Name* edit control enter the name of the accuracy class you want to add to the data base. The code of accuracy class is shown in the *Code* edit control. It is for internal use in data base and is inaccessible for user. It should be noted that in the dialog box described you determine only the name of new accuracy class. To fill it with diameters and deviations use dialog box for accuracy records editing (see above).

Editing existing accuracy classes

The only editing operation for accuracy class is the changing of its name. With selection bar mark accuracy class you want to change and select *Update* button. The dialog box described in the previous paragraph will be called. In the *Name* edit control it contains the current name of accuracy class. Type the new name and select *Ok* button for confirmation.

Deletion existing accuracy classes

With selection bar choose accuracy class you want to delete and press *Delete* button. Warning message will be displayed. Press *Ok* for deletion confirmation. *NOTE: You should remember that if you delete the accuracy class, all the records related with it will be deleted from the data base.*

The recommended way of data base filling

The best way of data base filling is from up to down, when you start from defining the highest level elements and gradually go down in the hierarchy of objects.

When you work with bearing dimensions we recommend you to begin with the defining of all the standards that you suppose to use. After that you may define subtypes for all types of bearing. You must define at least one subtype for any type you plan to use, even if you do not use subdivision on subtypes. Having finished with definition of subtypes you may begin the main work—the filling of bearing tables.

When you fill the accuracy data base you should begin with defining of all the accuracy classes. After that you may begin the filling of accuracy tables with deviation values.

DBIMPORT utility program

Using DBIMPORT utility program you can import the tables of the APM Bear data base from the ASCII text files. DBIMPORT is DOS program. You can start it either from DOS command line or from Windows.

Input files for DBIMPORT consist of rows of text. Each row is corresponded to one row of the data base (i.e., record). It includes fields values separated by commas. The fields

represented by symbol strings can be placed in the double quotations. Here is an example of input file contents for the data base on bearing geometry (radial ball bearing)

```
406,  90, 30, 19.05, 6, 1, 47000, 26700, 0.72
407, 120, 35, 20.64, 6, 1, 55300, 31000, 0.93
408, 110, 40, 22.23, 6, 1, 63700, 36500, 1.20
```

The values in this example are (from left to right) bearing number, outer diameter, inner diameter, rolling body diameter, rolling bodies number, rolling bodies rows number, dynamic load rating, static load rating, mass of bearing.

The input file content for the accuracy data base looks like that

```
 80, 120, -20
120, 180, -25
180, 250, -30
```

The values in the rows are minimum and maximum bearing diameters and deviation corresponding to this diameter's range.

Input files for DBIMPORT utility must have .ASC extensions (for example, MYBEAR.ASC).

With DBIMPORT you can import the following types of data:

- standards
- subtypes
- bearings dimensions
- accuracy classes
- outer diameter deviations
- inner diameter deviations.

When you fill the data base with DBIMPORT utility we recommend to use the same sequence of actions that was described in the end of previous section, i.e., from up to down.

When you start DBIMPORT the following menu will be displayed on the screen

```
APM Ltd (R) Bear Data Import Utility  Version 1.00
Copyright (C) APM Ltd. 1993-1994. All rights reserved

        1. Subtypes
        2. Standards
        3. Bearings
        4. Accuracy classes
        5. Inner deviation
        6. Outer deviation
        0. Quit

        Enter your choice :
```

With this menu you must select data base object for which you want to import data. Type the number that corresponds to your choice and press ENTER key.

Bearing subtypes import

When you select the subtypes import operation the menu for choosing bearing type will be displayed. Select type you want to work with. After that you will be offered to input the name of ASCII file with data on subtypes The name must not include the extension (.ASC extension is assumed). Following that data are loaded from the text file specified to the data base and program stopped. ASCII file for bearing subtypes must contain the only field—for subtypes names. Code for a subtype is assigned automatically.

Standards import

If you select standards import, you have to enter ASCII file name (without extension). Input files must contain the names of standards only.

Bearing records import

When you are importing data on bearing dimensions, first you are to point out type of bearing. Then you need to input the code of subtype and the code of standard. Finally you must type a name of ASCII file (without extension).

Below we give the list of fields for each type of bearing.

Radial ball bearing
- bearing number (string of symbols)
- outer diameter, mm
- inner diameter, mm
- rolling body diameter, mm
- rolling bodies number
- rows number
- dynamic load rating, N
- static load rating, N
- mass, kg

Selfaligning ball bearing and radial-thrust ball bearing
- bearing number (string of symbols)
- outer diameter, mm
- inner diameter, mm
- rolling body diameter, mm
- rolling bodies number
- contact angle, deg
- dynamic load rating, N
- static load rating, N
- mass, kg

Ball thrust bearing
- bearing number (string of symbols)
- outer diameter, mm
- inner diameter, mm
- rolling body diameter, mm
- rolling bodies number
- rows number
- dynamic load rating, N
- static load rating, N
- mass, kg

Radial roller bearing
- bearing number (string of symbols)
- outer diameter, mm
- inner diameter, mm
- rolling body diameter, mm
- rolling bodies number
- roller length, mm
- rows number
- dynamic load rating, N
- static load rating, N
- mass, kg

Selfaligning roller bearing and radial-thrust roller bearing
- bearing number (string of symbols)
- outer diameter, mm
- inner diameter, mm
- rolling body diameter, mm

- rolling bodies number
- roller length, mm
- contact angle, deg
- dynamic load rating, N
- static load rating, N
- mass, kg

Thrust roller bearing
- bearing number (string of symbols)
- outer diameter, mm
- inner diameter, mm
- rolling body diameter, mm
- rolling bodies number
- roller length, mm
- contact angle, deg
- rows number
- dynamic load rating, N
- static load rating, N
- mass, kg

Accuracy classes import

When you import accuracy classes you have to select bearing type and to type the name of the ASCII file (without extension). Input files must contain the accuracy class names only.

Diameter deviations import

When you are importing deviations you must input the code of accuracy class and the name of ASCII file (without extension). This file must include the following fields

- the upper limit of diameter range, mm
- the lower limit of diameter range, mm
- deviation, mkm.

CHAPTER 4

The APM Bear environment

APM Bear is intended to run under Microsoft Windows version 3.1 and a later. Standard dialog tools of Windows were used in the program. It follows standard conventions, recommended for a user interface of application programs, running under Microsoft Windows. So, those, who have any experience in Windows, will not encounter any problem with learning APM Bear. But if you haven't such experience, don't worry. To work with APM Bear, you are supposed to be specialist in mechanical engineering, not in computers. User interface of APM Bear is fairly straightforward and intuitively clear. To learn how to perform calculations with APM Bear you will need no more than 1—2 sessions.

In this chapter we give you a brief description of the most frequently used APM Bear environment components.

Systematic description of all menu commands and dialog box options is given in Chapter 5.

The environment components

Menus

Menu is a displayed list of commands (actions) available when you are working with a program. We shall speak about four kinds of menu—system, program, main and popup.

System menu (see Fig. 5.31, Chapter 5) is your "window to Windows." It allows you to interact with Windows. Using the system menu you can exit the program, interrupt the program execution for a some time and switch to another program, resize and move your program window and so on. For the list of System menu commands see section *System Menu* in Chapter 5.

The program menu contains commands of the application program. The program menu usually has hierarchical structure with the main menu at the top. The main menu is always on the screen. Each item of the main menu is either a command (which performs an immediate action), or a name of the next level menu—so called popup menu. (The word "popup" reflects a style of menu—it is used for menus, primarily invisible and called to screen ("popup") only when necessary.) Items of popup menu are, in their turn, either commands, or popup menus of the next level in menu hierarchy. Fig. 5.1 (Chapter 5) demonstrates the main menu of the APM Bear together with all its popup menus.

Choosing menu commands with a keyboard

To execute a menu command with the keyboard use the following sequence of actions:

1) Open the main menu. To do this press ALT or F10 key; the first element of the main menu becomes selected (inverted).

2) Use arrow keys to move inverted bar to the desired command or popup menu name (using this way you can select the system menu as well). Press ENTER key—if you have selected a command it will be executed, if you have selected a popup menu—it will be activated. If there is an underlined letter in the command name, press it instead of using arrow keys. In this case steps 1 and 2 can be combined—press and hold ALT key and then press the key that corresponds to the underlined letter.

3) If the desired command is in the popup menu use an arrow key or an underlined letter to move the selection bar around the popup menu and then press ENTER key.

Choosing menu commands with a mouse

To execute a menu command with a mouse just click (press and release the left button of the mouse) at the desired command.

Shortcuts

There are two ways to speed up command selection. With the keyboard you can use so called accelerators—the combinations of keys initiating execution of some specific command. Usually accelerators are used for frequently called commands, located in the popup menus. For example, in the APM Bear to invoke a dialog box for the bearing type selection simply press CTRL and B keys instead of selecting popup menu **Data** in the main menu and then **Bearing type** command. For the list of accelerators implemented in the APM Bear refer to chapter 5, section *Accelerators.*

Another way to speed up selection is the use of speedbar buttons. Speedbar is a group of pictographic buttons located below the main menu (see Fig. 32). Each button corresponds to frequently used command. To execute a command click appropriate button with the mouse. Speedbar buttons commands are described in chapter 5, section *Speedbar.*

Dialog boxes

Dialog boxes are windows that are used for data input, options selection, for displaying additional and explanatory information, warning messages—in other words, these are windows used to keep up the dialog with a user. You can easily see where you will meet a dialog box—command (in the menu and on the buttons) invoking a dialog box is followed by ellipsis.

Dialog box elements

Dialog box consists of elements of different kinds that have common name 'controls.' By means of controls you can interact with a dialog box—set parameter values, select options and actions, turn switches on and off and so on. Below we give brief description of controls used in dialog boxes, implemented in the APM Bear.

Buttons

Buttons are controls initiating immediate execution of some kind of action. For example, *Ok* button in the dialog box shown in Fig. 5.10 closes the dialog box and informs the program that you confirm parameter values you've entered in the edit controls. *Help* button in the same dialog box invokes *Help* window with some explanatory information. Buttons could be of two types—text and pictographic. For text buttons the action, initiated by a button, is designated by the string of the text (usually in a single word). In the case of pictographic buttons a conventional sign (pictogram) is used for the purpose. You can see example of the pictographic buttons in Fig. 5.32 in Chapter 5, where APM Bear speedbar is shown.

Radio buttons

Radio buttons are used when you need to select one and the only item (option, mode, element, type, etc.) from a set of possible mutually exclusive variants. As an example in Fig. 5.9 is shown the dialog box for choosing the type of bearing to be calculated. Radio button is drawn as a circle. If the alternative associated with the given radio button is selected, this circle has a bullet in its interior, otherwise it is empty. To select radio button click it with mouse. When using keyboard, move input focus (dashed frame) to desired radio button by means of TAB and arrow keys and press SPACE key.

Check boxes

By means of check boxes, parameters (options) which can have only one from two possible states ("turned on" and "turned off") are represented. In Fig. 5.5 you can see a dialog box for selection of the results that should be printed. There is a list of items you can print out in this dialog box. A check box is placed near each item. You can "strike through" (check) the check box (say, by the mouse clicking) and the respective item will be printed, or you can clear the check box and the item will not be printed. The check box is drawn as a rectangle with an option (parameter) name near it. If an option, associated with the check box is "turned on," a rectangle has a cross-hair in it's interior, otherwise it is empty. To change a check box

state click it with the mouse. When using keyboard, select desired check box with TAB and arrow keys and press SPACE key.

Edit controls

Edit control or text box is intended for information input. It has form of a rectangle where you are to type a numeric value or a string of text. Near the rectangle there is a text prompting what kind of information should be entered. You can see examples of edit controls in Fig. 5.10 where the dialog box for geometry parameters input is shown. Just after the edit control becomes active, its behavior slightly differs depending on whether it is empty or not. If the edit control is empty, a special cursor—so called "input cursor" appears in it. It has the form of flashing vertical line. This cursor shows where the current character will appear when you type it—just to the right of the vertical line. If the edit box already contains a text (default or earlier typed), this text automatically becomes selected (inverted). Any new character being typed at the moment replaces the existing text. You can delete the selected text by pressing DEL of BACKSPACE keys as well. To avoid replacing or deleting press any of the arrow keys to deselect the existing text.

List boxes

List box is a set of variants, one of which you can (or should) choose. (Sometimes you are allowed to choose more than one variant simultaneously.) If there is not enough room for all variants in the list box area, it is provided with scroll bars (see below). You can find the examples of the list boxes in Fig. 5.3 where the dialog box for archive file loading is shown. The dialog box includes list boxes for a file name and directory choosing. To select a desired element with the mouse you should click this element and then to click an appropriate command button. To speed up the operation you can simply double-click the desired item. When using a keyboard, you have to move a selection bar (inverted row with dashed frame) to the desired item first. Or press the first letter of this item. Windows highlighted the first element that begins with a corresponded letter. Then press ENTER key to select the desired item and execute associated command.

Dropdown list boxes

Dropdown list box is a variety of the list box that initially is displayed in a reduced state and can be opened when necessary. When in reduced form, a dropdown list box is drawn as a rectangle with highlighted current choice (or default choice). To the right of the rectangle there is an arrow. When you select it a drop down list box is opened. In Fig. 5.3 you can see two dropdown list boxes—*List Files of Type* and *Drives*.

Scroll bars

Scroll bar is a special kind of control used to look through a text or pictures the size of which exceeds the size of the window or the dialog box they are displayed on. Scroll bars could be positioned either vertically (for up and down movement) or horizontally (for left and right movement). The major elements of scroll bars are arrows (located at each of its ends) and a scroll box (or a thumb). The arrows allow you to scroll the content of the window by the fixed increment (in the case of the text—usually by one row). The thumb indicates what part of the document or picture is currently displayed in the window. Say, if the thumb is located in the middle of the scroll bar, the middle part of the document is displayed.

When using a mouse the following actions are available

- to scroll by one row click appropriate arrow;
- to scroll by one window click above or below the thumb on the vertical scroll bar (to the left or to the right of the thumb on the horizontal scroll bar);
- to scroll continuously place cursor on the appropriate arrow then press the left button and hold it until the desired information appears in the window;
- to scroll to an arbitrary position catch the thumb (place cursor on thumb, press left button and hold it) and move it to desired position.

If you work with a keyboard use arrow keys to move to the desired part of the document (picture). Besides that you can use the following keys and combinations:

- PAGE UP or PAGE DOWN—to scroll by one window up or down
- CTRL + PAGE UP or CTRL + PAGE DOWN—to scroll by one window to the left or to the right
- HOME—to move to the beginning of the current window
- END—to move to the end of the current window
- CTRL + HOME—to move to the beginning of the document
- CTRL + END—to move to the end of the document

An example of scroll bar you can see in Fig. 1.2 where it is used with list box.

Groupboxes

Groupbox is a group of controls in the dialog box that can be logically joined based on one or another principle. Visually a groupbox has the form of a rectangle, surrounding the controls it consists of. When navigating around the dialog box, TAB key is used to move from one groupbox to another; to move inside the groupbox arrow keys are used. Groupboxes in the *Results* dialog box (*Moment of Friction, Loss of Power,* etc.) in Fig. 5.16 may serve as an example.

Caption

Caption is a bar in the uppermost part of the dialog box. Usually the name of the dialog box is displayed in it. If a dialog box has a caption you can move it around the screen. To do this, place mouse cursor at the caption, press and hold the left button and move the mouse. When the window reaches the desired position release the button.

Enabled and disabled controls and menu items

To avoid obvious errors sometimes it is necessary to make some functions temporarily inaccessible to the user. For example, it is a good reason to forbid calculations until the user finishes the data input. To do this, controls and menu items initiating forbidden functions are disabled (they don't respond to the user action). Visually disabled elements are "grayed"—the text is drawn with the gray color; pictographic elements are "washed out."

How to move around the dialog box

With a mouse you simply click (or in some cases double click) on the desired control.

With a keyboard use TAB key to move from one group of controls to another (SHIFT + TAB—in reverse direction) and arrow keys to move inside the group. If the name of the control contains an underlined letter press the corresponded key to reach this control.

How to work with the dialog box

The common way you work with the dialog box includes two steps:

1) Set necessary controls in the desired state.
2) Select confirmation button (in APM Bear dialog boxes this is *Ok* button).

Information windows

The last elements of the APM Bear environment are the information windows. They are used to display a reference information and does not require the user's actions. Four information windows implemented in the APM Bear are always on the screen. These are *Bearing Type* window, *Geometry Data* window, *Accuracy Data* window and *Working Conditions Data* window. They are used to display initial data. The *Calculations* window is displayed when calculations are performed.

Bearing Type window

Bearing Type window is located in the left upper part of the APM Bear screen (see Fig. 4.1). In this window the pictogram and the name of the currently selected type of bearing are displayed.

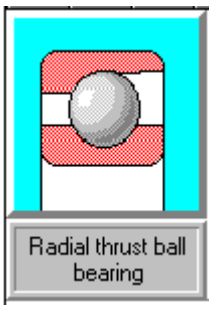


Figure 4.1 Bearing Type information window. In the upper part of window the pictogram of currently selected type of bearing is shown, in the lower —its name.

Geometry Data window

This window is used to display initial data describing the bearing geometry (see Fig. 4.2). If a parameter is not yet defined, "n/defined" is displayed opposite its name, if it is not used for a bearing of given type—"n/used" is displayed.

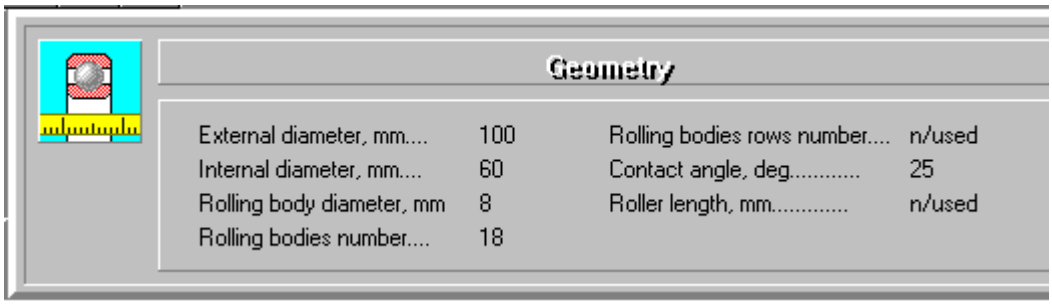


Figure 4.2 Fragment of the Geometry Data window.

Accuracy Data window

This window is used to display initial data, describing bearing accuracy (see Fig. 4.3).

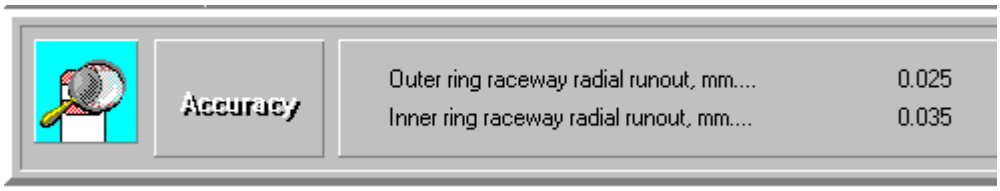


Figure 4.3 Fragment of the Accuracy Data window

Working Conditions Data window

This window is used to display initial data, describing conditions the bearing is works under (see Fig. 4.4).

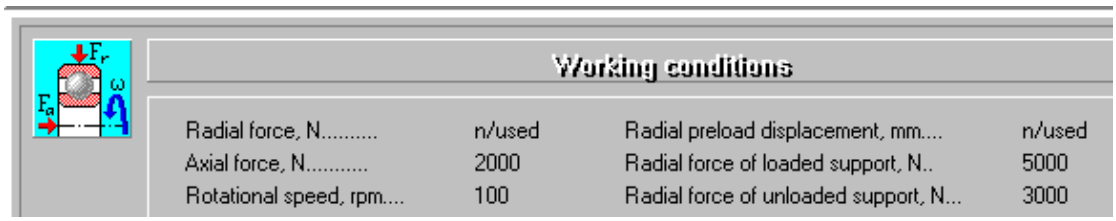


Figure 4.4 Fragment of the Working Conditions Data window

Calculations window

This window displayed on the screen when you select Calculate command to begin calculations. It is used to show you the current percentage of calculation fulfillment.

To finish this chapter we note once more that most of the APM Bear environment components are standard elements of the Microsoft Windows user interface. If you want to get a more detailed description of these elements, please refer to your Microsoft Windows User's Guide.

Chapter 5

Command reference

In this section we give you a complete description of each menu command and dialog box option in the APM Bear environment. Fig. 5.1 shows the main menu of the APM Bear and all the pulldown menus called from the main menu.

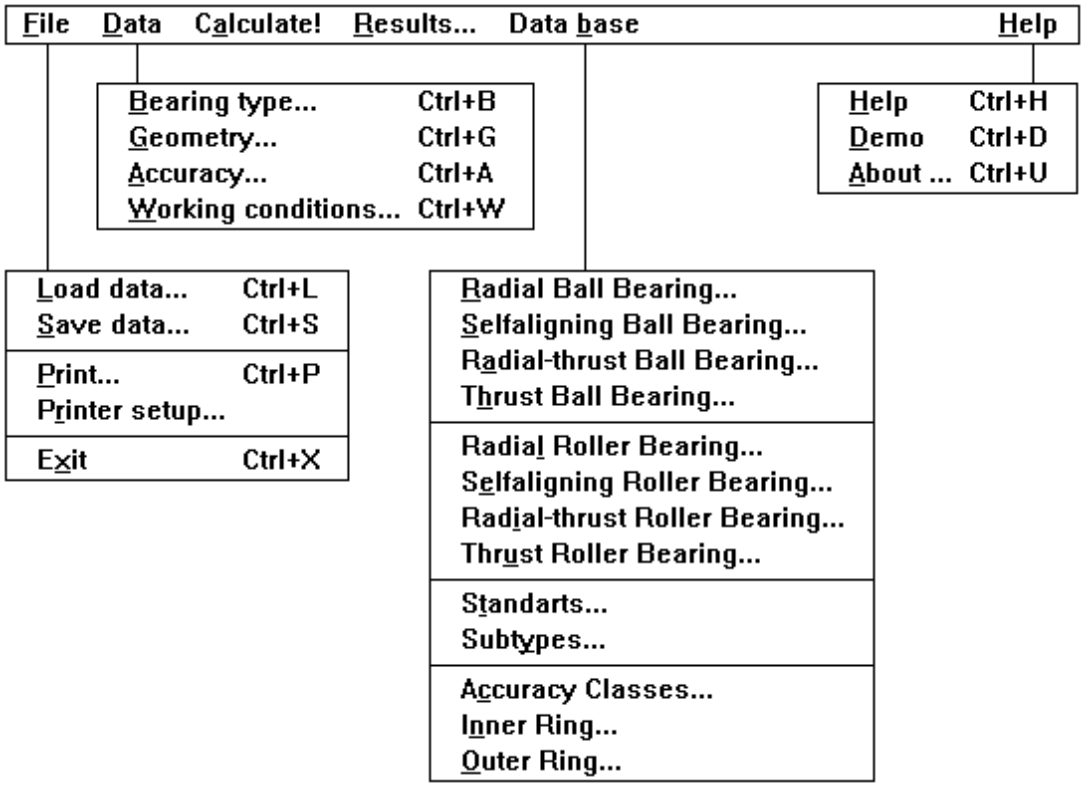


Figure 5.1 APM Bear menu structure

File menu

The **File** menu includes commands for

- loading information from archive files
- saving information to archive files
- printing initial data and calculation results
- choosing printer and printing options
- quitting the program

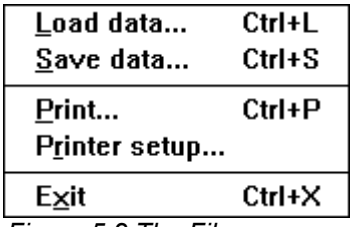


Figure 5.2 The File menu

Load Data command

The **File | Load Data** command opens the *Load Archive File* dialog box. By means of this dialog box you can select the archive file to be loaded (for description of archive files see Chapter 3).

Shortcuts

Speedbar 
Keys CTRL + L

Save Data command

The **File | Save Data** command opens the *Save Archive File* dialog box. Using this dialog box you can specify the archive file in which initial data and calculation results will be saved.

Shortcuts

Speedbar 
Keys CTRL + S

Print command

The **File | Print** command allows you to print out calculation results. When you select this command the dialog box shown in Fig. 5.3 is called on the screen.

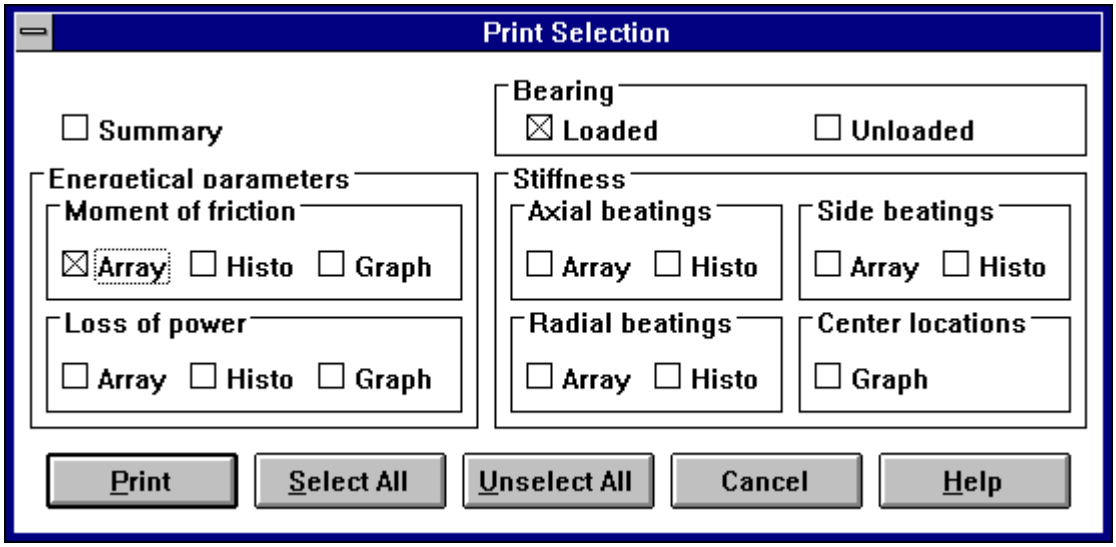


Figure 5.3 The dialog box for selection results items to be printed

For each parameter you can print out there is separate check box in this dialog box. Mark items you want to be printed and select *Print* button. Use *Select All* button if you want to print out all the results. Use *Unselect All* button if you want to clear all check boxes. Check boxes entitled *Array* to print out respective parameters as a table, *Histo*—as a histogram and *Graph*—as a graph. If you mark the check box entitled *Summary,* the average values of parameters calculated in the APM Bear—longevity, maximum contact stress, displacements, moment of friction, loss of power and heat release will be printed. Groupbox *Bearing* includes two check boxes—*Loaded* and *Unloaded.* By means of these controls you may select for which of radial-thrust bearings (loaded, unloaded of both) you want to print out the calculation results. Definition of loaded and unloaded radial-thrust bearings see in Chapter 1.

After you choose items to be printed and have selected *Print* button, another dialog box will be displayed (see Fig. 5.4).

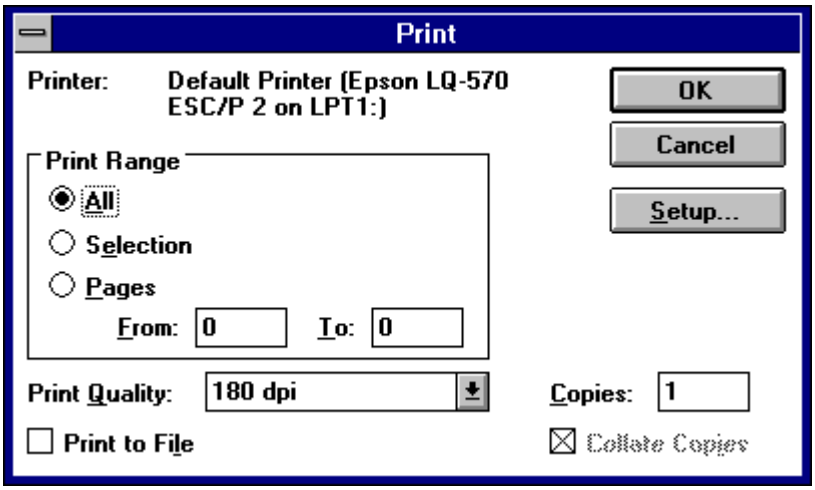


Figure 5.4 The Print dialog box.

Using this dialog box you can specify some options of printing. In the left upper part of dialog box currently selected type of printer is indicated. To change it use Control Panel application of Microsoft Windows. For details see you Microsoft Windows User's Guide. *Print Range* group box let you choose what part of results will be printed. We do not recommend you use controls of this group box. The matter of fact is that described dialog box is part of Microsoft Windows not APM Bear. In APM Bear items to be printed are determined in another way (see above). *Print Quality* list box let you select printing resolution (in dots per inch) from a number of allowed ones (for printer of currently selected type). *Setup* button invokes dialog box for detailed specification of printing option. This dialog box is different for each type of printer. In *Copies* edit control you can indicate number of copies you want to get. If you mark *Print to File* check box, printing will be directed in the file instead of printer. You can print out this file later.

Shortcuts

Speedbar 
Keys CTRL + P

Printer setup command

The **File | Printer setup** command invokes the Print Setup dialog box shown at Fig. 5.5.

With this dialog box you can specify printer settings. Using controls of *Printer* group box you can select type of printer (from a number of already installed in Microsoft Windows. To install new printer use *Printers* utility of *Control Panel* application, described in your Microsoft Windows User's Guide). With *Orientation* group box controls you can select how the printing will be oriented relatively to paper sheet—parallel to short side *(Portrait)* or to long side *(Landscape).* Controls of *Paper* group box let you choose paper sheet size (*Size* list box) and the type of paper advance (*Source* group box). And finally, *Options* button invokes printer-specific dialog box for more detailed tuning of printing.

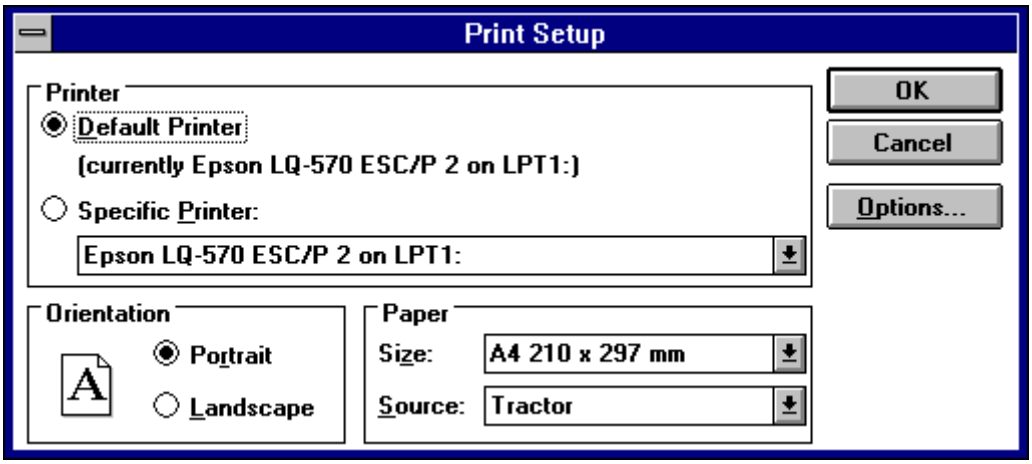


Figure 5.5 The Print Setup dialog box

Exit command

Use **File | Exit** command to exit APM Bear.

Shortcuts
Keys CTRL + X

Data menu

The **Data** command of the main menu invokes **Data** popup menu shown at Fig. 5.6.

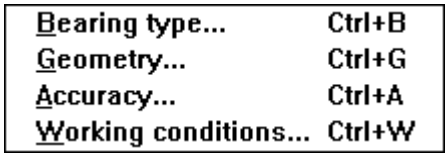


Figure 5.6 Data popup menu

Here we give the description of the Data menu commands.

Bearing Type command

The **Data | Bearings type** command displays the dialog box for choosing the type of bearing. This dialog box is shown in Fig. 5.7.

The dialog box described includes 8 radio buttons. Every button designates one of the types of bearing you can calculate in the APM Bear. The buttons are divided into two groupboxes—*Ball Bearings* and *Roller bearings*. All you have to do with this dialog box is to select a desired type of bearing, either with a mouse or arrow keys or underlined letters in bearing type names and then "press" Ok button. In the case of radial ball bearing you have additionally select assembling type (by means of the group box of the same name). Assembling type can be either *single* or *double*. As a result of your action in the *Bearing Type* window (see Chapter 4) a pictogram of bearing you've selected will be displayed. Simultaneously all the parameter values in the *Geometry Data* window, *Accuracy Data* window and *Working Conditions Data* window will be set to "not defined." The **Geometry, Accuracy** and **Working Conditions** commands in the **Data** popup menu become enabled, so you can define your initial data. The **Calculate** and **Results** commands become (or remain) disabled (grayed).

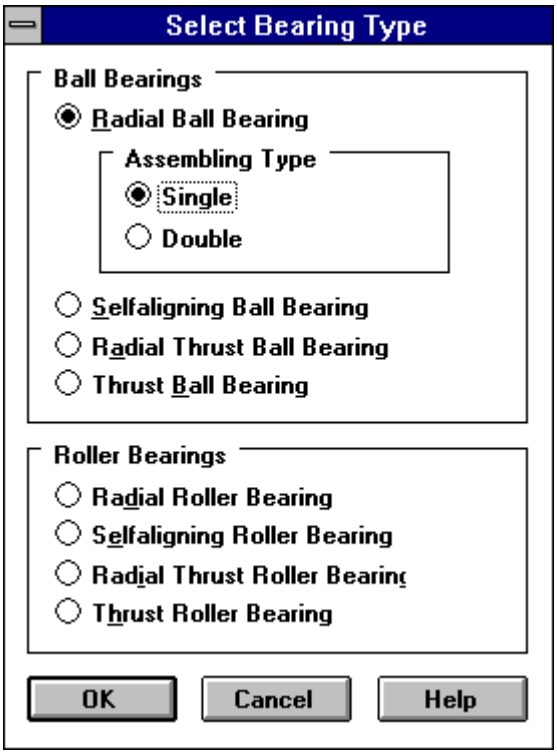


Fig. 5.7 Dialog box for bearing type selection.

Shortcuts
Keys CTRL + B

Geometry command

The **Data | Geometry** command displays the dialog box for geometry parameters input. This dialog box includes edit controls for parameters, defining bearing geometry. The number of parameters to be entered depend on the type of bearing to be calculated. As an example in Fig. 5.8 the dialog box for geometrical parameters of the radial ball bearing is shown.

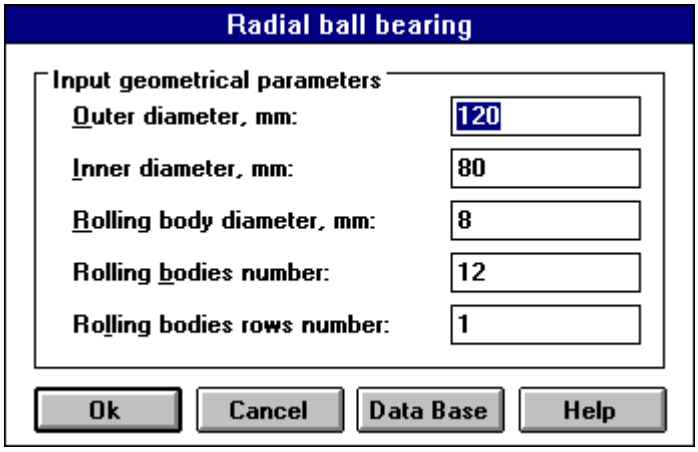


Fig. 5.8 The dialog box for the radial ball bearing geometrical parameters input

When you finish input of all the parameters, presented in the dialog box, select *Ok* button to inform a program that you confirm values you have entered. Immediately after this, the values you have entered will be displayed in the *Geometry Data* window. Of course, at any moment you can select a *Cancel* button to cancel a dialog box. You must remember, however, that you cannot perform calculation until you define all the parameters.

If you select *Data Base* button, the dialog box shown in Fig. 5.9 will be displayed. It gives you an access to the data base. In the upper part of this dialog box there are *Standard* and *Subtype* dropdown list boxes. Using these controls you can select standard (catalogue) and bearing subtype respectively (see Chapter 3 for data base structure definition). (Type of bearing you define when execute **Bearing Type** command described above.) Central part of the dialog box is occupied by the *Data* window. In this window the bearings related to selected subtype are displayed. Data are presented in the table form. There is a header in the upper part of table, where parameters name and measurement units are given. Use a selection bar (a row of inverted text) to pick out a bearing you will work with. The data from selected row of a table will be copied to the respective edit controls of the *Geometry Data* dialog box. The *Select* button is used to select a subset of bearings, that meet to the given conditions. When you click this button the dialog box is displayed. For details see section **Radial ball bearing command** in this chapter.

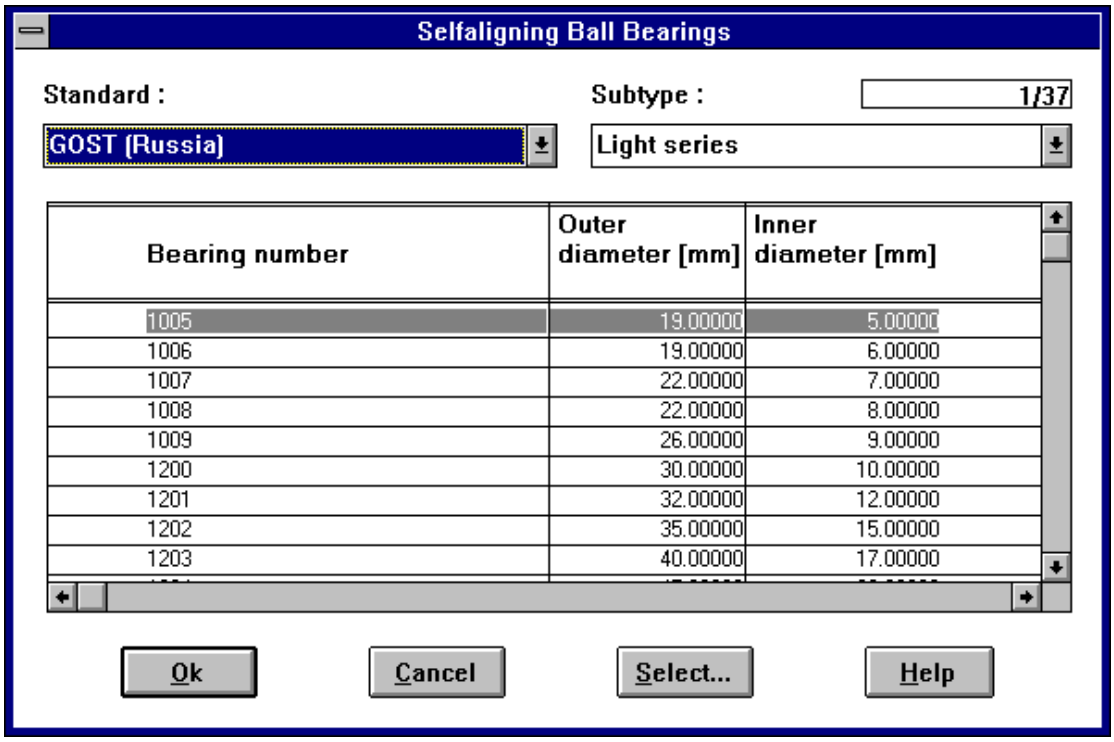


Figure 5.9 The dialog box for retrieving geometry parameters from data base

To avoid errors during the data input, checking for allowable values is implemented. The width of allowable intervals is sufficiently big to include all cases of practical interest. These intervals for geometrical parameters are as follows:

Table 1

Allowable limits for geometry data

Parameter	Minimum allowable value	Maximum allowable value
Outer diameter, mm	> 0	2000
Inner diameter, mm	> 0	2000
Rolling body diameter, mm	> 0	300
Rolling bodies number	> 0	200
Rolling bodies rows number	> 0	10
Contact angle, deg	0	90
Roller length, mm	> 0	700

If you have entered the value that is out of allowable interval for respective parameter, the warning message will be displayed after you select *Ok* button.

Fig. 5.10 An example of warning message displayed when data are out of allowable limits.

After you select *Ok* button you will be brought back just to that item of *Geometry Data* dialog where you entered erroneous value. Besides checking for allowable values there are some other kinds of initial data control.

Below we give lists of geometrical parameters for each type of bearing calculated in the APM Bear. Description of the parameters is given in the Chapter 1.

Radial ball bearing 1. Outer diameter of the bearing, mm 2. Inner diameter of the bearing, mm 3. Rolling body diameter, mm 4. Rolling bodies number 5. Rolling bodies rows number	**Selfaligning ball bearing** 1. Outer diameter of the bearing, mm 2. Inner diameter of the bearing, mm 3. Rolling body diameter, mm 4. Rolling bodies number 5. Contact angle, degrees
Radial-thrust ball bearing 1. Outer diameter of the bearing, mm 2. Inner diameter of the bearing, mm 3. Rolling body diameter, mm 4. Rolling bodies number 5. Contact angle, degrees	**Thrust ball bearing** 1. Outer diameter of the bearing, mm 2. Inner diameter of the bearing, mm 3. Rolling body diameter, mm 4. Rolling bodies number 5. Rolling bodies rows number
Radial roller bearing 1. Outer diameter of the bearing, mm 2. Inner diameter of the bearing, mm 3. Rolling body diameter, mm 4. Rolling bodies number 5. Rolling bodies rows number 6. Roller length, mm	**Selfaligning roller bearing** 1. Outer diameter of the bearing, mm 2. Inner diameter of the bearing, mm 3. Rolling body diameter, mm 4. Rolling bodies number 5. Contact angle, degrees 6. Roller length, mm
Radial-thrust roller bearing 1. Outer diameter of the bearing, mm 2. Inner diameter of the bearing, mm 3. Rolling body diameter, mm 4. Rolling bodies number 5. Contact angle, degrees 6. Roller length, mm	**Thrust roller bearing** 1. Outer diameter of the bearing, mm 2. Inner diameter of the bearing, mm 3. Rolling body diameter, mm 4. Rolling bodies number 5. Rolling bodies rows number 6. Roller length, mm

Shortcuts
Keys CTRL + G

Accuracy command

The **Data | Accuracy** command displays dialog box for accuracy parameters input. In contrast to geometry and working conditions, the same dialog box is used for all types of bearings calculated in the APM Bear (see Fig 5.11).

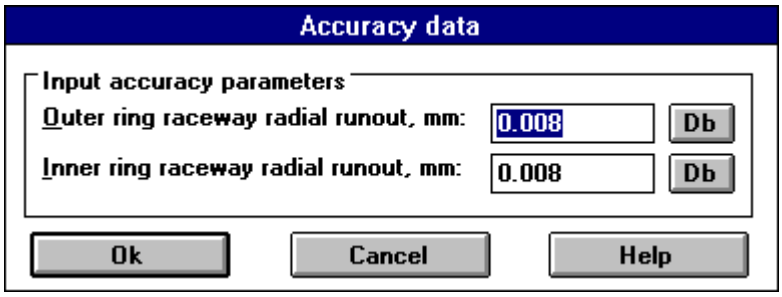
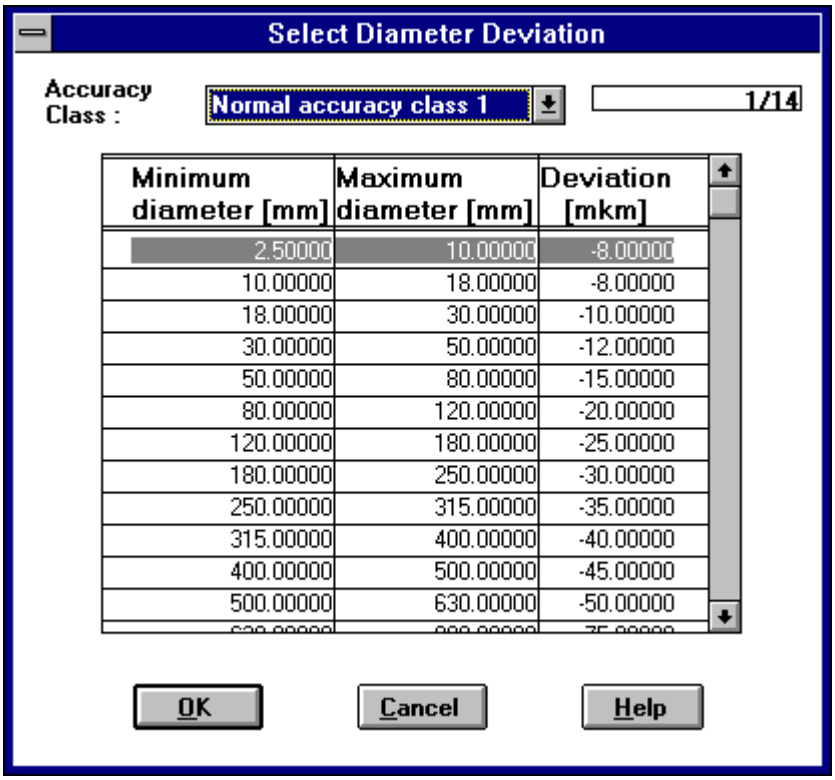


Fig 5.11 Dialog box for accuracy parameters input

This dialog box includes two edit controls in which you have to input two parameters characterizing calculated bearings manufacturing errors. These are radial runout of the outer and inner rings of the bearing. The measurement units for these parameters are millimeters. To the right of each edit control there is *Db* button. Using it you call data base containing accuracy data. In Fig. 5.12 the dialog box providing access to accuracy data base is shown.



Minimum diameter [mm]	Maximum diameter [mm]	Deviation [mkm]
2.50000	10.00000	-8.00000
10.00000	18.00000	-8.00000
18.00000	30.00000	-10.00000
30.00000	50.00000	-12.00000
50.00000	80.00000	-15.00000
80.00000	120.00000	-20.00000
120.00000	180.00000	-25.00000
180.00000	250.00000	-30.00000
250.00000	315.00000	-35.00000
315.00000	400.00000	-40.00000
400.00000	500.00000	-45.00000
500.00000	630.00000	-50.00000

Fig. 5.12 The dialog box for selection accuracy values from the data base

Just below the caption, *Accuracy Class* drop-down list box is located. Use it to select accuracy class you will work with. Contents of selected accuracy class is displayed in the *Data* window. It is presented as a table. First column of this table contains minimum diameter value, second—maximum diameter, and third—diameter deviation. Place the selection bar on the row with the diameter deviation value you want to use and select *Ok* button. Selected value will be copied to the respective edit control of the *Accuracy Data* dialog box.

Allowable intervals for accuracy parameters are listed in Table 2

Allowable limits of the accuracy parameters. Table 2

Parameter	Minimum allowable value	Maximum allowable value
Outer ring radial runout, mm	> 0	10.0
Inner ring radial runout, mm	> 0	10.0

Shortcuts
Keys CTRL + A

Working Conditions command

The **Data | Working conditions** command invokes a dialog box for the input of the parameters characterizing conditions under which the calculated bearing works. You have to enter the values of the parameters in the respective edit controls and after that select *Ok* button to confirm these values. As in the case of geometry, a set of parameters depends on the type of a bearing. As an example in Fig 5.13 a dialog box for input of working conditions parameters for radial-thrust ball bearing is shown.

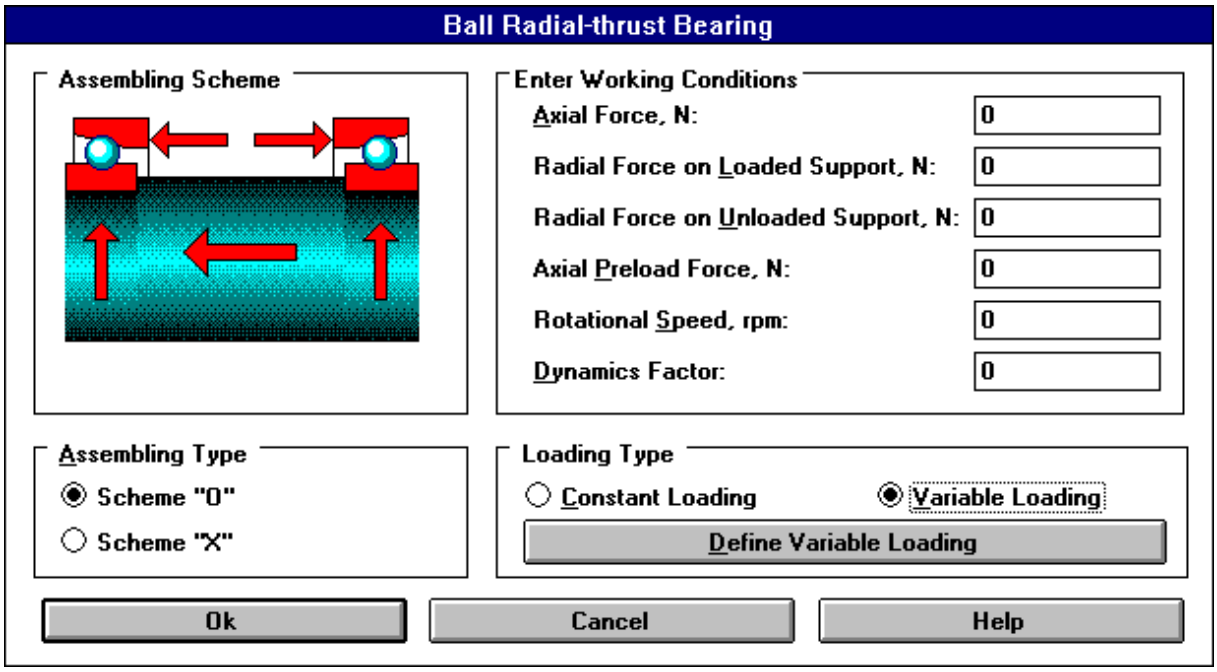


Fig. 5.13 The dialog box for the radial ball bearing working conditions parameters input

Below we give a list of parameters for each type of bearings.

Radial ball bearing	**Selfaligning ball bearing**
1. Radial force, N 2. Rotational speed, rpm 3. Dynamics factor	1. Radial force, N 2. Axial force, N 3. Radial preload displacement, mm 4. Rotational speed, rpm 5. Dynamics factor

Radial-thrust ball bearing 1. Axial force, N 2. Radial force on loaded support, N 3. Radial force on unloaded support, N 4. Axial preload force, N 5. Rotational speed, rpm 6. Dynamics factor	**Thrust ball bearing** 1. Axial force, N 2. Rotational speed, rpm 3. Dynamics factor
Radial roller bearing 1. Radial force, N 2. Radial preload displacement, mm 3. Rotational speed, rpm 4. Dynamics factor	**Selfaligning roller bearing** 1. Radial force, N 2. Axial force, N 2. Radial preload displacement, mm 3. Rotational speed, rpm 4. Dynamics factor
Radial-thrust roller bearing 1. Axial force, N 2. Radial force on loaded support, N 3. Radial force on unloaded support, N 4. Axial preload force, N 5. Rotational speed, rpm 6. Dynamics factor	**Thrust roller bearing** 1. Axial force, N 2. Rotational speed, rpm 3. Dynamics factor

Allowable intervals for parameters characterizing working conditions are listed in table 3

Table 3

Allowable limits of the parameters characterizing conditions the bearing worked under

Parameter	Minimum allowable value	Maximum allowable value
Radial force, N	0	10000000
Axial force, N	0	10000000
Rotational speed, rpm	0	100000
Dynamics factor	1	5.0
Radial preload displacement, mm	0	10.0
Radial force for loaded support, N	0	10000000
Radial force for unloaded support, N	0	10000000
Axial preload force, N	0	100000

When you finish all the initial data input, the **Calculate** command in the main menu become enabled.

Shortcuts
Keys CTRL + W

Calculate command

The **Calculate** command of the main menu starts calculation. The information window is displayed on the screen that shows you the current percentage of the calculation fulfillment, so you can estimate the time required to finish calculations.

Shortcuts

Speedbar 

Results command

The **Results** command of the main menu invokes the *Results* dialog box shown at Fig. 5.14 on the screen. Using this dialog box user can select and look through any of the calculation results.

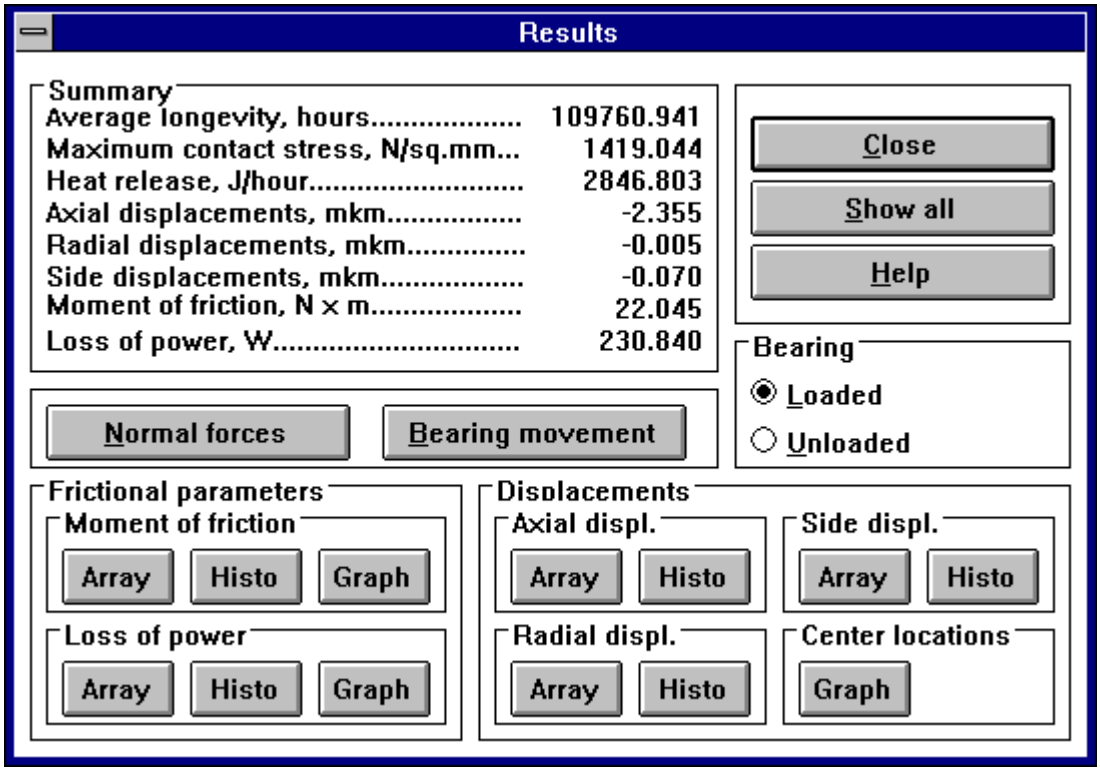


Fig. 5.14 The Results dialog box

Below we give a brief description of all controls of the *Results* dialog box.

Summary group box

In this group box main parameters values are listed.

"More..." button

When you select this button, the dialog box for detailed longevity results demonstration is displayed (see Fig. 5.14a). It shows two values of longevity—calculated on the basis of non-ideal contact theory and that calculated with conventional methods. Besides that, dialog box includes edit box where calculated value of dinamic load rating is displayed. You can enter new value for this parameter and determine new longevity value using *Recalculate Longevity* button.

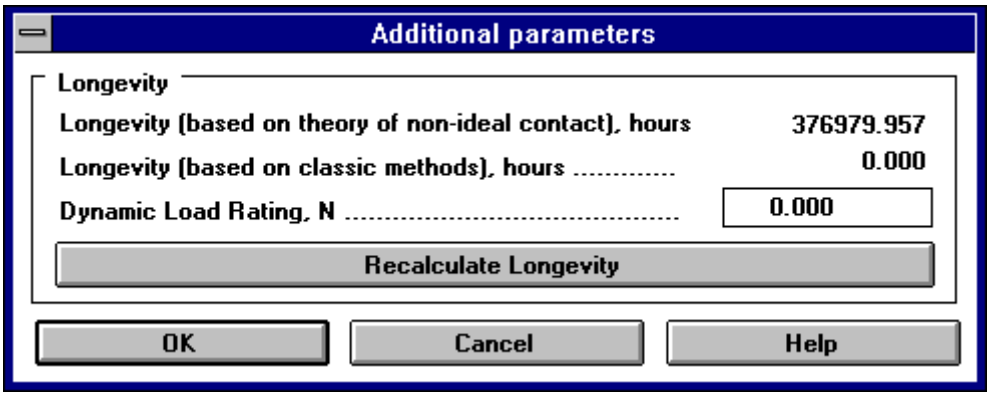


Figure 5.14a Dialog box for detailed longevity parameters demonstration

Normal Forces button

If you select *Normal Forces* button, the window shown in Fig. 1.7 will be invoked. In this window the distribution of the forces acting on the rolling bodies is shown.

To characterize forces acting on the rolling bodies window three objects are displayed. These are epure of forces, a graph of forces and a table with reference information.

Epure of the forces is drawn in the left hand upper part of the window. It includes a simplified scheme of the bearing. In the center of the bearing the displacement vector is shown (for all types except thrust bearings). From the center of each rolling body the force acting on this body is laid off in the radial direction. If the number of rolling bodies is too large, it may not be shown. Here is a little note about the direction the forces are laid off. For all types of bearings the same direction is used—along the radius. In fact, this is true only for radial and selfaligning bearings, but for the simplicity we use radial direction for other types of bearings as well.

In the right hand upper part of the window, forces acting on the rolling bodies are shown as a graph. The amplitude of the force is laid off along the axis of ordinates, the rolling body ordinal number—along the axis of abscissas. The uppermost body has zero number, numbers are increasing clockwise. If the number of rolling bodies is relatively small, data points are shown together with line of the graph, otherwise there are only lines.

The reference parameters are listed in the lower part of the window. These are:

Iteration number	sequential number of bearing center position the forces are displayed for
Total solids	total number of rolling bodies
Loaded solids	number of rolling bodies with nonzero force acting on it
Maximum force	maximum force for current iteration
Axial displacement	axial component of current bearing displacement
Radial displacement	radial component of current bearing displacement
Side displacement	side component of current bearing displacement
Axial force	axial force acting on the bearing
Radial force	radial force acting on the bearing

Next button is used to get over to the next bearing center position.

Bearing Movement button

In APM Bear large series of positions of the bearing center is computed. If you select *Bearing movement* button you can look through these displacements in the form of animation. To make the displacements, which are some micrometers in the order of magnitude, more obvious, considerable scale increase is necessary, so a certain extent of distortions inevitable. Nevertheless, animation gives you a good general idea about real manner of a bearing motion—which displacements dominate, how they are changing, whether there is a skewing of the shaft (in the case of radial-thrust bearings), etc. An example of bearing movement animation is shown in Fig. 1.6.

Note that for the radial-thrust bearings the movement of both loaded and unloaded bearings are shown simultaneously, together with shaft's movement.

Frictional Parameters group box

Frictional parameters computed in the APM Bear are the moment of friction and the loss of power. User can look through these parameter values using the buttons of the *Moment of Friction* and *Loss of Power* group boxes.

Moment of Friction group box

Groupbox *Moment of Friction* includes *Array, Histo* and *Graph* buttons. Using these buttons one can look over the values of the moment of frictional forces as a table, histogram and graph respectively.

Loss of Power group box

This group box joins three buttons intended to demonstrate the loss of power arising due to the work of the frictional forces. *Array* button shows a table of 100 values of the loss of power together with average value, variance and standard deviation. *Histo* button demonstrates the histogram, allowing you to estimate the density of probability distribution. *Graph* buttons displays the graph of the loss of power, so you can see how this parameter changes during rotation of the bearing.

Displacements group box

The characteristics of the rolling contact bearing stiffness calculated in the APM Bear are displacements (beatings) of the bearing center. Depending on the type of the bearing, displacements may have up to three components—axial, radial and side (see Chapter 1 for details). Stiffness group box includes buttons for demonstration of beating components both separately and in a combination.

Axial Displacements group box

This group box includes *Array* and *Histo* buttons intended to display axial beating values as a table and as a histogram respectively.

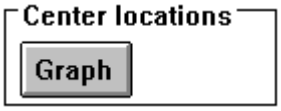
Radial Displacements group box

Array and *Histo* buttons of this group box allow user to look through radial beatings either in the form of a table or as a histogram.

Side Displacements group box

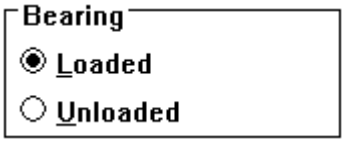
The same as above, but demonstrates side beatings.

Center Locations group box



The only button of this group box—*Graph* demonstrates the spatial distribution of the bearing center locations. For radial and selfaligning bearings this is 2D scheme with radial beatings laid off along the X-axis and side beatings—along the Y-axis (see Fig 1.5, Chapter 1). In the case of radial-thrust bearings the scheme becomes three-dimensional because of axial beatings are added (Fig 1.4, Chapter 1). In the dialog window for radial-thrust bearings the buttons *Points* and *Projections* are presented. They used to show and hide spatial positions of bearing center and projections of these positions on the coordinate planes respectively.

Bearing group box



In the APM Bear radial-thrust bearings are considered mounted in a pair (see Chapter 1, Fig. 1.9). All the parameters are calculated for each of the bearings (making up a pair). To indicate which bearing you want to look through, select one of the radio buttons—*Loaded* or *Unloaded.* (Definition of loaded and unloaded bearings see in Chapter 1.) For all other types of bearings this option is disabled.

Show All button

Buttons of the *Results* dialog box allow you to look through each calculated parameter separately. But you can also initiate sequential demonstration of all the result items by choosing *Show All* button. At any moment you can interrupt demonstration with *Break* button implemented at each result window, or by pressing Esc key. To continue demonstration the user is to select *Ok* button, or to press ENTER key.

Help button

Invokes the help on the *Results* dialog box.

Close button

Closes the *Results* dialog box.

Shortcuts

Speedbar 

Data Base menu

Data base popup menu commands let you edit APM Bear data base. The purposes, structure and functions of the latter are described in Chapter 3.

Figure 5.15 The Data Base popup menu

Radial Ball Bearing command

Data base | Radial Ball Bearing command let you edit data for radial ball bearings. It invokes at the screen *Radial Ball Bearing Edit* dialog box, shown in Fig. 5.18.

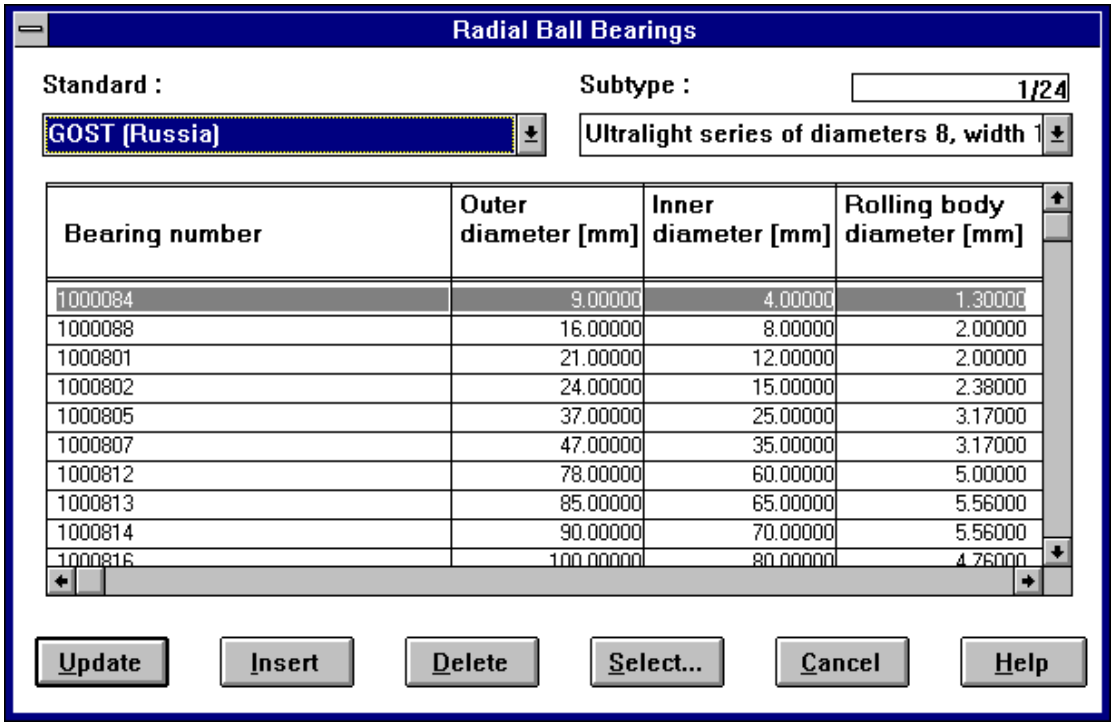


Figure 5.16 The dialog box for bearing data base records editing

Standard drop-down list box

Use this list box to select standard you want to work with.

Subtype drop-down list box

Use this list box to select subtype you want to work with.

Data window

Data window is used to display data base content for bearings of selected type, subtype and standard. It looks like a table. Its header contains parameter names together with measurement units. The rest of the table is occupied by the records. Each record corresponds to a bearing and contains parameters characterizing the latter. To choose a bearing use selection bar—a row of inverted text. *Data* window is provided with horizontal and vertical scroll bars.

Update button

Use this button to update record already in data base. With selection bar choose a record you want to update and select *Update* button. The dialog box shown in Fig 5.17 will be displayed. It's edit controls contain current parameter values for bearing selected. Enter new values and select *Ok* button for confirmation.

Insert button

Use this button to add new record in the data base. The dialog box shown in Fig. 5.17 will be displayed. Use the respective edit controls to define all the parameters and select *Ok* to confirm data. When using this operation you should remember that records in APM Bear data base are sorted by the bearing number (identificator) in the alphabetical order.

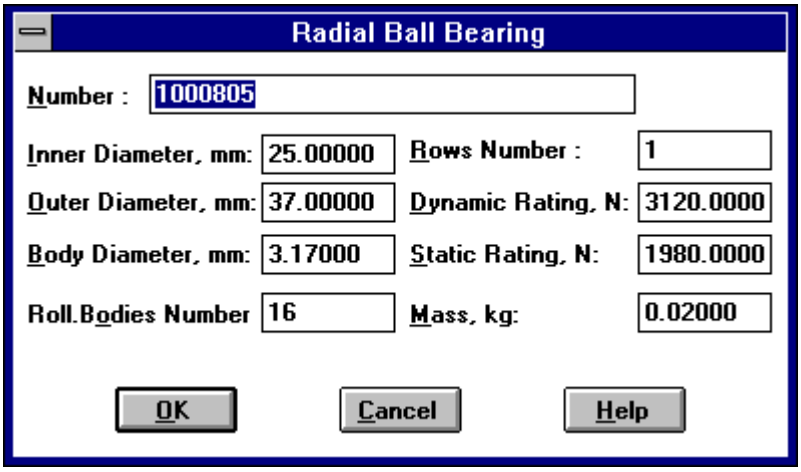


Figure 5.17 The dialog box used for updating of existing records and inserting new ones

Delete button

Use this button to delete record from the data base. Place selection bar on the record (i.e., bearing) you want to delete and select *Delete* button. The following warning message will be displayed

Select *Ok* button to confirm deletion.

Select button

Use this button to select a subset of bearings of given subtype that satisfies to a given set of conditions. The dialog box shown in Fig. 5.18 will be displayed. It looks like a table of controls—one row for each field of bearing data base record (i.e., for each bearing parameter). Each row of controls defines a condition of the following type

Minimum value { Relation} Parameter {Relation} Maximum value

Here {Relation} is one of operations '<', '≤', or '='. In other word these conditions determine allowable intervals for bearing parameters. For example the following condition

50 < Inner diameter ≤ 100

selects all bearings with inner diameter greater than 50 mm and lesser or equal to 100 mm.

The controls destination is as follows. In the leftmost edit control enter the lower limit value. In the dropdown list box next to the right select relation type (<, ≤ , =) for the lower limit. In the list box next to the parameter name select type of relation for the upper limit, and finally, in the rightmost edit control type upper limit value.

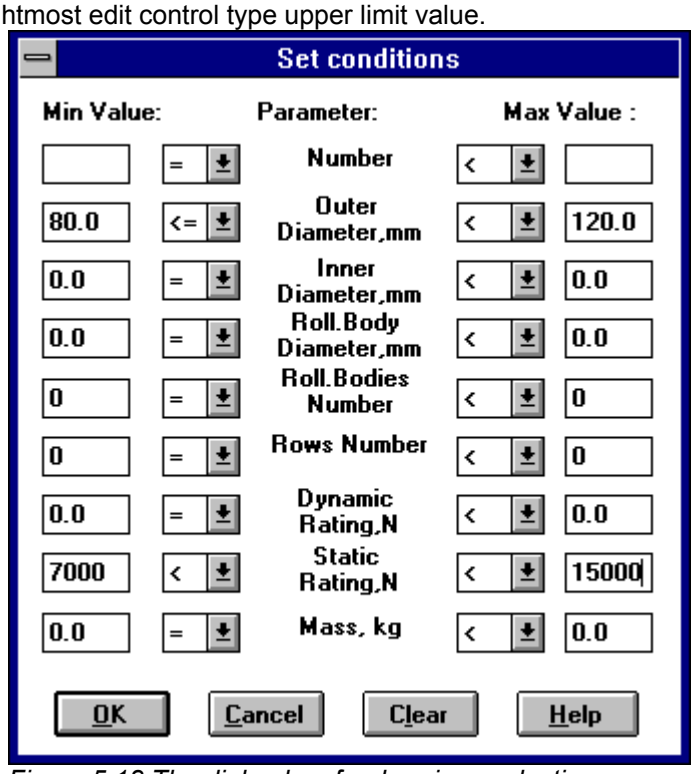


Figure 5.18 The dialog box for bearings selection

Selfaligning Ball Bearing command

Use **Data base | Selfaligning Ball Bearing** command to edit data base for selfaligning ball bearings. The dialog box absolutely identical by its content and functions to that shown in Fig. 5.16 will be displayed. See **Radial Ball Bearing** command description for details.

Radial-thrust Ball Bearing command

Use **Data base | Radial-thrust Ball Bearing** command to edit data base for radial-thrust ball bearings. The dialog box absolutely identical by its content and functions to that

shown in Fig. 5.16 will be displayed. See **Radial Ball Bearing** command description for details.

Thrust Ball Bearing command

Use **Data base | Thrust Ball Bearing** command to edit data base for thrust ball bearings. The dialog box absolutely identical by its content and functions to that shown in Fig. 5.16 will be displayed. See **Radial Ball Bearing** command description for details.

Radial Roller Bearing command

Use **Data base | Radial Roller Bearing** command to edit data base for radial roller bearings. The dialog box absolutely identical by its content and functions to that shown in Fig. 5.16 will be displayed. See **Radial Ball Bearing** command description for details.

Selfaligning Roller Bearing command

Use **Data base | Selfaligning Roller Bearing** command to edit data base for selfaligning roller bearings. The dialog box absolutely identical by its content and functions to that shown in Fig. 5.18 will be displayed. See **Radial Ball Bearing** command description for details.

Radial-thrust Roller Bearing command

Use **Data base | Radial-thrust Roller Bearing** command to edit data base for radial-thrust roller bearings. The dialog box absolutely identical by its content and functions to that shown in Fig. 5.16 will be displayed. See **Radial Ball Bearing** command description for details.

Thrust Roller Bearing command

Use **Data base | Thrust Roller Bearing** command to edit data base for thrust roller bearings. The dialog box absolutely identical by its content and functions to that shown in Fig. 5.16 will be displayed. See **Radial Ball Bearing** command description for details.

Standards command

Use **Data base | Standards** command to edit bearing standards (see Chapter 3 for standard definition). The *Edit Standard* dialog box is displayed in response to this command (Fig. 5.19).

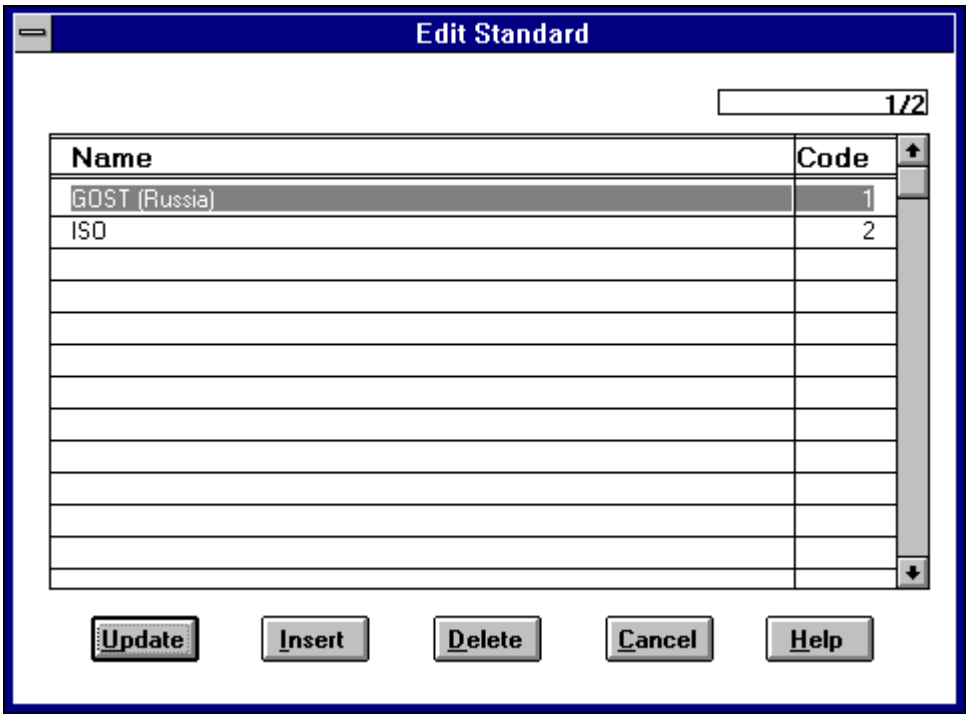


Figure 5.19 The Edit Standard Dialog Box

Update button

This button is used for standard name changing. When you select this button the dialog box shown in Fig. 5.20 is displayed. In the *Name* edit control type new name of standard and select *Ok.* Parameter *Code* is for internal use in data base. It is shown for reference only.

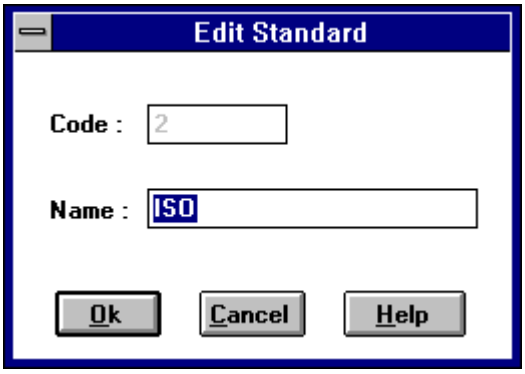


Figure 5.20 The dialog box for Standard editing

Insert button

Use this button when you want to add new standard. The dialog box shown at Fig. 5.20 will be displayed. In the case of insertion of new standard, *Name* edit control will be empty. Enter the name of new standard and select *Ok* for confirmation. To fill in new standard with bearings and subtypes use respective dialog boxes.

Delete button

By means of this button you can delete existing standard. Place selection bar on the standard to be deleted and click *Delete* button. Warning message will be displayed. Select *Ok* for confirmation. *Remember, however, that when you delete the standard, all the bearings and subtypes belonging to it will be deleted as well.*

Subtypes command

The **Data base | Subtype** command is used for subtypes editing (definition of subtypes see in Chapter 3). When you select this command the *Edit Subtype* dialog box is displayed on the screen (Fig 5.21).

The *Edit Subtype* dialog box controls are described below.

Type dropdown list box

Use this list box to specify type of bearing you will work with.

Update button

Use this button to change the name of subtype. When you select *Update* button, the *Edit Subtype* dialog box is invoked on the screen (see Fig 5.22). In the *Name* edit control of this dialog box enter new name and select *Ok* for confirmation. *Code* parameter is of internal use and is inaccessible for user.

Insert button

Use this button to start new subtype. The dialog box shown in Fig. 5.22 will be displayed. In the *Name* edit control type the name of new subtype and select *Ok* for confirmation. To fill in subtype with bearings use dialog boxes for bearing data editing (see above).

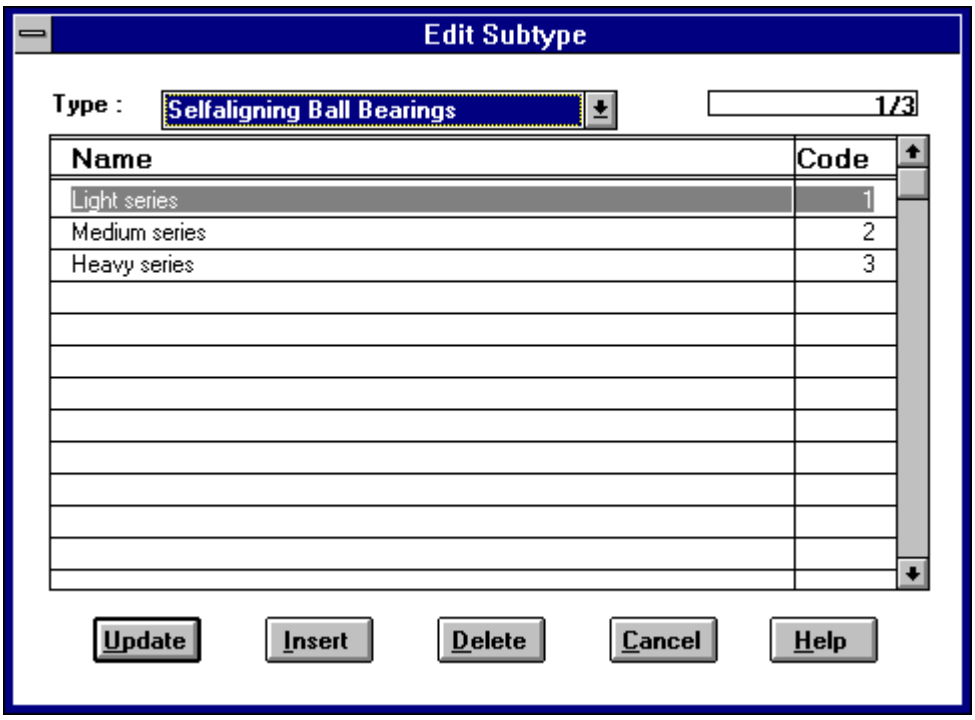


Figure 5.21 The Edit Subtype dialog box

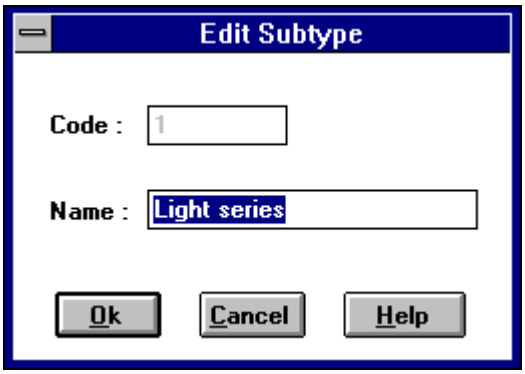


Figure 5.22 The dialog box for Subtype editing

Delete button

To delete subtype mark it with selection bar and then select *Delete* button. The warning message will be displayed. Press *Ok* to confirm the deletion. *You should remember that if you delete subtype, all the bearings belonging to it will be deleted as well.*

Accuracy Classes command

The **Data base | Accuracy Classes** command is intended for accuracy classes editing. In response to this command the *Edit Accuracy Class* dialog box shown in Fig 5.23 is displayed. The controls and functions of this dialog box are described below.

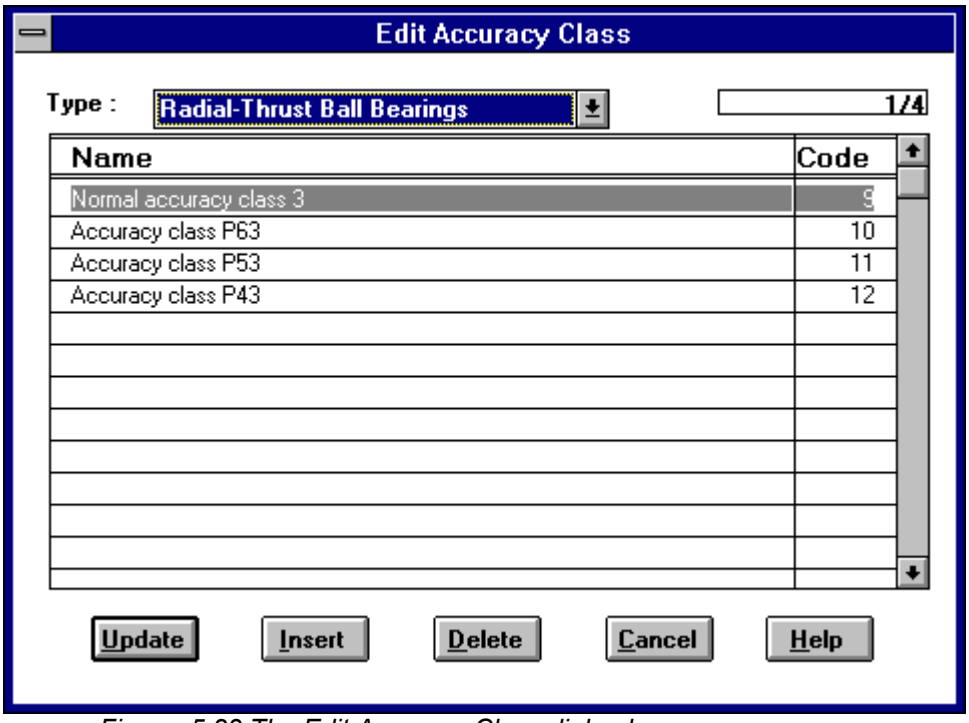


Figure 5.23 The Edit Accuracy Class dialog box

Type dropdown list box

Use this list box to select type of bearing you want to work with.

Update button

Use this button to change the name of accuracy class. When you select this button the dialog box shown in Fig. 5.24 is displayed. In the *Name* edit control enter new name for accuracy class and select *Ok* button for confirmation.

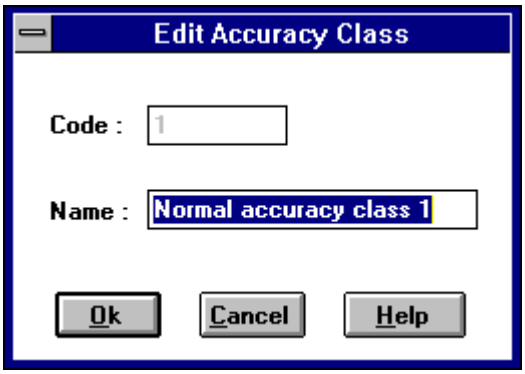


Figure 5.24 The Edit Accuracy dialog box

Insert button

Use Insert button to add new accuracy class. When you select this button the dialog shown in Fig. 5.24 will be displayed. In the *Name* edit control enter the name of the new class and click *Ok* for confirmation.

Delete button

This button is intended for deletion of existing accuracy classes. With selection bar choose accuracy class you want to delete and select *Delete* button. When warning message will be displayed, select *Ok* to confirm deletion.

Outer Ring command

The **Data base | Outer Ring** command is used for editing accuracy data for bearing outer ring. When you select this command the dialog box shown in Fig. 5.25 is called on the screen. Below we give the descriptions of controls of this dialog box and its functions.

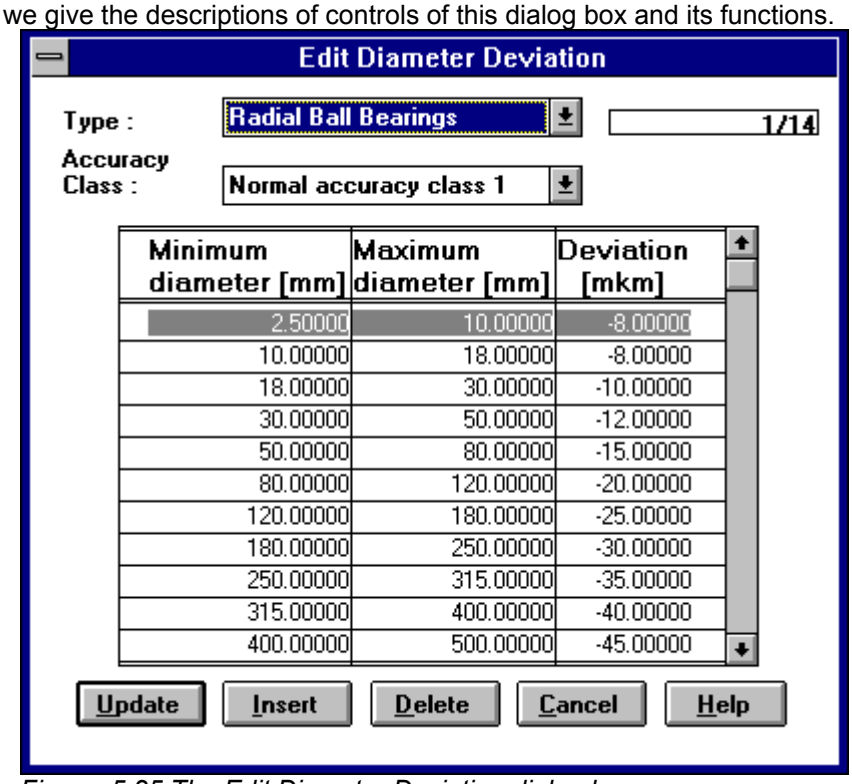


Figure 5.25 The Edit Diameter Deviation dialog box

Type list box

Use this list box to select type of bearing you want to work with.

Accuracy Class list box

Use this list box to select accuracy class you want to work with.

Update button

Use this button to change values of the existing record. The dialog box shown in Fig. 5.26 will be displayed. It contains edit controls for every accuracy parameter. When the dialog box is opened these edit controls contain current values of parameters. Enter new values and select *Ok* button for confirmation.

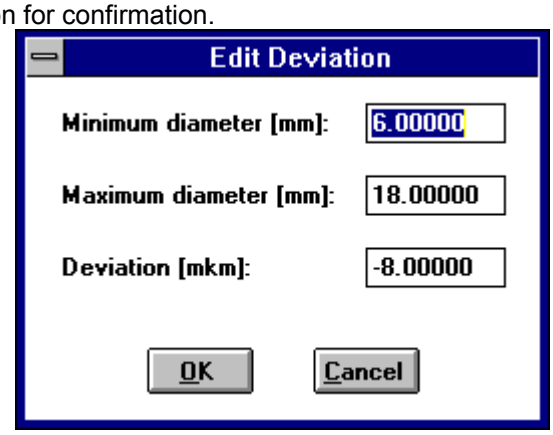


Figure 5.26 The Edit Deviation dialog box

Insert button

With this button you can insert new accuracy record. The dialog box shown in Fig. 5.28 will be displayed. In the edit controls type accuracy parameters values and select *Ok* for confirmation.

Delete button

Use this button to delete accuracy record choosed with selection bar. When warning message will be displayed select *Ok* button to confirm deletion.

Inner Ring command

The **Data base | Inner Ring** command is used for editing accuracy data for bearing inner ring. This command absolutely identical by its functions to the **Data base | Outer Ring** command described above.

Help menu

Help popup menu (Fig. 5.27) contains commands that

- call APM Bear help system
- switch program to the demonstration mode
- display *About* dialog box

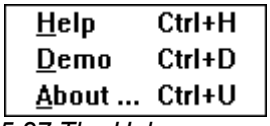


Figure 5.27 The Help popup menu

Help command

Help | Help command invokes window with APM Bear help contents. Select topic of your interest and click it with mouse or press ENTER key. In fact, when you call help in

application program that runs under Microsoft Windows, the special program in Windows starts (WINHELP.EXE). This is a sophisticated hypertext system, that provides you with versatile tool for reference information retrieving. For detailed information about Windows help system please refer to your Microsoft Windows User's Guide. To get online information use **Help | How to Use Help** command in the menu of help system.

Shortcuts

Speedbar 
Keys CTRL + H

Demo command

Help | Demo command switches Bear to the demonstration mode. In the right hand lower part of the screen the dialog box shown in Fig. 5.28 is displayed.

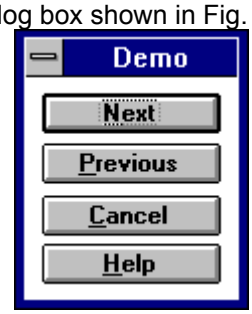


Figure 5.28 The dialog box managing APM Bear demonstration

Using this dialog box you can execute APM Bear in the step-by-step mode. At each step either a window with explanatory information is displayed or some of Bear commands are executed. *Next* button initiates the next step execution, *Previous* button returns you to previous step. In the demo mode Bear commands are executed in the automatic manner, the user's interference is impossible. In this moment demo managing dialog box and all its buttons are disabled. You have to wait until command execution will be finished. In the demo mode you are shown the radial ball bearing calculation.

Shortcuts
Keys CTRL + D

About command

Help | About command calls *About* dialog box on the screen. It displays the program name and the version together with the license information.

Shortcuts
Keys CTRL + U

System menu

The system menu let you interact with Windows. The commands of this menu are as follows:

Restore	Restores the previous size of application program window
Move	Let you move application program window with keyboard
Size	Let you change the size of application program window with keyboard
Minimize	Reduce application program window to iconized state
Maximize	Restores application program window to its maximum size
Close	Terminates the program
Switch To	Let you switch to another program

Figure 5.29 The System Menu of the APM Bear

To open the System menu use ALT+MINUS (-) keys or click the button in the left upper corner of the application program window.

Speedbar

The speedbar is the group of pictographic buttons located below the main menu (Fig. 5.30). The speedbar is intended to speed up selection of some frequently used commands.

Figure 5.30 The speedbar of the APM Bear

The buttons of the speedbar initiate the following commands (from left to right):

- **File | Load Data**
- **File | Save Data**
- **File | Print**
- **Calculate!**
- **Results**
- **Help | Help**

To execute command with speedbar simply click the appropriate button with mouse.

Accelerators

Accelerator is the combination of the keys used to speed up command selection. In the APM Bear the following accelerators are used.

Command	Accelerator
File | Load Data	CTRL+A
File | Save Data	CTRL+S
File | Print	CTRL+P
File | Exit	CTRL+X
Data | Bearing Type	CTRL+B
Data | Geometry	CTRL+G

Data | Accuracy	CTRL+A
Data | Working conditions	CTRL+W
Help | Help	CTRL+H
Help | Demo	CTRL+D
Help | About	CTRL+U

Warnings and error messages

In this section we describe the warnings and error messages that can be displayed when you work with APM Bear.

Initial data entering messages

To avoid rough errors during initial data input, checking for allowable values is implemented in APM Bear. If you have entered the value that is out of allowable interval the warning message will of the following kind will be displayed

```
CONTACT ANGLE value must be between 0 and 90 degrees
```

You have to correct the value.
Besides checking for allowable values there are some other kinds of initial data control.

Archive file creation and loading messages

The messages, listed below can appear when you create or load archive files where initial data and calculation results are stored. For definition of archive files see Chapter 3.

```
"C:\BEAR\TEST.WBR"
Cannot find this file
Please verify that the correct path and filename are given
```

You have entered non-existing path or filename.

```
C:\BEAR\TEST.DAT
is not a valid Bear archive file
```

The file you have attempted to load is not a valid APM Bear archive file.

```
"To create an archive file you must previously define initial
 data."
```

You had attempted to create an archive file before you defined initial data. To be allowed to create the archive file you have at least to finish input of one of initial data groups (geometry, accuracy or working conditions).

```
"C:\WIN_BEAR\TEST.WBR"
This file already exists
Replace existing file?
```

You attempt to save data in one of the existing files. The dialog box with this message contains two buttons—*"Yes"* and *"No."* Select *"Yes"* if you really want to write data in this file, otherwise select *"No."*

```
"Not enough free space for archive file on disk X:"
```

It is impossible to create an archive file on the specified drive because of insufficient free space. Change disk or delete some files to provide more free space.

Data base messages

The messages, described in this section can be displayed when you work with APM Bear data base. These messages have the text '`APM Bear Data Base Message`' in the caption of message window. The structure and functions of the data base are explained in

Chapter 3. The menu commands that implement these functions are summarized in Chapter 5.

`Accuracy class not defined`

At least one accuracy class should be defined in the APM Bear data base for selected type of bearing. For definition of accuracy class see Chapter 3.

`Bearing standard not defined`

At least one standard should be defined in the APM Bear data base. For definition of standards see Chapter 3.

`Bearing subtype not defined`

At least one subtype should be defined for any type of bearing. For definition of subtypes see Chapter 3.

`Can't share PARADOX.NET - is SHARE.EXE loaded?`

Before to start APM Bear you should run the DOS program SHARE.EXE to provide correct access to the data base files.

`Could not find file`

Data base cannot find the required table in the working directory (the directory where BEAR.EXE is located). All the tables must be in the working directory.

`Disk is write-protected`

If you want to edit or expand the data base, the disk should be open for writing.

`File is busy`

Data base table is locked by another task. Terminate this task and try again.

`File is locked`

Data base table is locked by another task. Terminate this task and try again.

`Key violation`

You have attempted to insert the record whose key coincides with that of record always in data base.

`Multiple PARADOX.NET files found`

More than one PARADOX.NET file is found in the directories that are listed in the PATH statement of the AUTOEXEC.BAT file. You should retain only one such file.

`Not enough disk space to complete operation`

Not enough room on disk to perform operation with data base. Delete some files from the disk and try again.

`Not enough memory to complete operation`

Not enough memory to perform operation with data base. Close currently running programs and try again.

`No more file handles available`

Close other applications or increase the value of FILES parameter in the CONFIG.SYS file.

```
Primary index corrupted
```

Data base index file is corrupted. Use backup copy to restore data base.

```
Primary index out of date
```

Data base index file is corrupted. Use backup copy to restore data base.

```
Table is corrupted
```

Data base table is corrupted. Use backup copy to restore data base.

```
Table is locked
```

Table is locked by another task. Close this task to unlock the table.

```
Table not found
```

Data base cannot find the required table in the working directory (the directory where BEAR.EXE is located). All the tables must be in the working directory.

Any other message, related with data base can be caused by one of the following reasons.

1) You have attempted to work with data in the network environment. The described version of APM Bear is not intended to work in the network environment.

2) The data base files are corrupted in one or another way. To minimize the consequences of data base damage, we strictly recommend you to make the backup copies. To save the data base, you should copy all files with extensions *.DB and *.PX.