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**Calculation methods for externally
pressurised (hydrostatic) journal
bearings with capillary restrictor control
(Guide to use of computer program
A9237)**

Associated software: ESDUpac A9237

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THE PREPARATION OF THIS DATA ITEM

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The Tribology Steering Group, which first met in September 1973, is continuing the work that was previously the responsibility of the former Bearing and Lubrication Committee, which first met in July 1964.

CALCULATION METHODS FOR EXTERNALLY PRESSURISED (HYDROSTATIC) JOURNAL BEARINGS WITH CAPILLARY RESTRICTOR CONTROL (GUIDE TO USE OF COMPUTER PROGRAM A9237)

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CALCULATION METHODS FOR EXTERNALLY PRESSURISED (HYDROSTATIC) JOURNAL BEARINGS WITH CAPILLARY RESTRICTOR CONTROL (GUIDE TO USE OF COMPUTER PROGRAM A9237)

1. INTRODUCTION

ESDUpac A9237 is a FORTRAN 77 computer program for the design and analysis of externally pressurised (hydrostatic) journal bearings. The program implements the calculation method of ESDU 92026 entitled "Calculation methods for externally pressurised (hydrostatic) journal bearings with capillary restrictor control". In order to use the program effectively, ESDU 92026 must be referred to for the theoretical limitations of the method and for discussion of practical considerations.

2. NOTATION AND UNITS

The symbols (variable names) used in the source code for ESDUpac A9237 and in the associated data files (see Sections 4 and 5) conform to the requirements of FORTRAN 77 and, in general, differ from those used in ESDU 92026. Both sets of symbols are listed in this Notation. Note also that the International System of units is used.

Symbol used by ESDUpac A9237	Symbol used by ESDU 92026	Description	Units
b	b	bearing width	m
bdRat	—	bearing width to diameter ratio	—
CdMax	c_d	maximum diametral clearance	m
CdMin	c_d	minimum diametral clearance	m
d	d	bearing diameter	m
dr	d_r	capillary restrictor bore diameter	m
e	e	eccentricity	m
eccR	ε	eccentricity ratio	—
eLoad	—	journal displacement in load direction	m
eS	e_s	permissible journal displacement	m
etaS	η_s	dynamic viscosity at supply temperature	N s/m ²
eTrans	—	journal displacement in transverse direction	m
Hf	H_f	frictional power loss	W
HfDash	H'_f	non-dimensional frictional power loss	—

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Hp	H_p	pumping power	W
Ht	H_t	total power loss	W
Kdash	K'	non-dimensional stiffness factor	—
L	L	length of capillary restrictor	m
lubDat	—	name of lubricant database file	—
lubID	—	identifier for lubricant used	—
M	M	rotor mass associated with bearing	kg
N	N	rotational speed	rev/s
Ncrit	N_{crit}	critical speed	rev/s
Nf	N_f	speed factor	—
nr	n	number of recesses	—
Ps	p_s	lubricant supply pressure	N/m ²
psi	ψ	attitude angle	deg
Q	Q	lubricant flow rate	m ³ /s
Re	Re	bearing Reynolds number	—
Rer	Re_r	capillary Reynolds number	—
rho	ρ	density of lubricant	kg/m ³
rhoC	—	volumetric heat capacity	J/m ³ K
s	s	side-sill width	m
sbRat	—	side-sill to bearing width ratio	—
Tb	T_b	lubricant temperature at bearing	deg C
Ts	T_s	lubricant supply temperature	deg C
W	W	applied load	N
z0	z_0	flow resistance from a recess	N s/m ⁵
zr	z_r	capillary restrictor flow resistance	N s/m ⁵

3. RUNNING THE PROGRAM

The supplied executable version of the ESDUpac program is suitable for Microsoft Windows operating systems.

To run the executable version of the program from the keyboard, type the program name[†], A9237V11, at the operating system prompt and press “return”. The program will prompt for the name of the input data file and the name of the output data file. Alternatively, the name of the input data file and the name of the output data file can be specified on the command line using the operating system redirection symbols as in,

```
A9237V11 < EXP1.IN > EXP1.OUT
```

If a problem occurs in reading the data from the input file or if the data are invalid in any way, error messages are sent to the output file. These error messages describe the error and indicate the number of the line at which the error occurred in the input data file.

A number of example input data files are supplied with the program (files with the extension “.IN”). The corresponding output data files (with the extension “.OUT”) can be examined using a text editor.

[†] The program name used here is that of Version 1.1 (V11) which may not be the latest.

4. THE INPUT DATA FILE

Input data files are prepared using a text editor and, in most cases, new input files will be produced by editing existing input files. If ESDUpac A9237 is to be used to analyse the performance of an existing bearing design, it is necessary to provide a full specification for the bearing in the input data file. An example input data file for a complete bearing specification is shown here.

```
* This input file contains a full specification for a bearing.

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* Lubrication parameters:
* -----
lubDat  name of lubricant database file   = C:\esdu\lub.dat
lubID   lubricant identifier              = VG22

Ts      lubricant supply temperature      = 50          deg C
Ps      lubricant supply pressure         = 7.0E6        N/m^2

* Bearing dimensions:
* -----
d       bearing diameter                  = 0.12         m
b       bearing width                     = 0.12         m
s       side-sill width                   = 0.03         m
nr      number of recesses                = 5

CdMin   minimum diametral clearance       = 63.0E-6      m
CdMax   maximum diametral clearance       = 79.0E-6      m

dr      capillary restrictor bore diameter = 0.838E-3     m
L       length of capillary restrictor    = 0.22         m

* Operational parameters:
* -----
N       frequency of rotation             = 16.7         rev/s
W       total applied load                = 20000        N
M       rotor mass associated with one bearing = 2000        kg
```

The following points should be noted.

- (i) All lines beginning with an asterisk, '*', are comment lines. Such comment lines may be freely inserted for documentation purposes.
- (ii) The first non-comment line in the input file specifies the name of the ESDUpac program that is to be used for the analysis. This line must be present in all input data files.
- (iii) Input parameters can be specified in any order and each parameter has an identifying symbol. The explanatory text following the parameter symbol may be omitted in which case the '=' sign is not strictly necessary.
- (iv) This particular ESDUpac program requires access to a lubricant database file, the name of which is specified in the input file. The lubricant database file supplied with this ESDUpac program is called "LUB.DAT" and can be examined using an ASCII text editor capable of handling text lines longer than 80 characters. Full instructions on editing the file (to add further lubricants, for example) are included as comments within the file.
- (v) Each of the lubricants in the lubricant database file has an identifier and the identifier of the required lubricant must be specified in the input file. The identifiers for other lubricants can be seen by examining the file with a text editor.

- (vi) Instead of specifying the bearing width, b , directly it is permissible to specify the ratio of the bearing width to the bearing diameter. Likewise, the ratio of the side-sill width to the bearing width can be specified instead of s . Thus the specifications of b and s in the above example input data file could be replaced by, for example,

```
bdRat bearing width to bearing diameter ratio= 1.0
sbRat side-sill width to bearing width ratio = 0.25
```

If ESDUpac A9237 is to be used to design a bearing then only the expected operating parameters and the design requirements should be specified in the input data file. Only the bearing diameter, d , is required to be specified and the other bearing dimensions may be left unspecified. The program will then assign preliminary values to these unspecified bearing dimensions before analysing the performance. An example input data file for a required bearing design is shown here.

```
* This input file specifies the design requirements for a bearing.
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* Lubrication parameters:
* -----
lubDat name of lubricant database file = C:\esdu\lub.dat
lubID lubricant identifier = VG22

Ts lubricant supply temperature = 50 deg C
Ps lubricant supply pressure = 7.0E6 N/m^2

* Bearing dimensions:
* -----
d bearing diameter = 0.12 m
b bearing width = ?
s side-sill width = ?
nr number of recesses = ?
CdMin minimum diametral clearance = ?
CdMax maximum diametral clearance = ?

dr capillary restrictor bore diameter = ?
L length of capillary restrictor = ?

* Operational parameters:
* -----
N frequency of rotation = 16.7 rev/s
W total applied load = 20000 N

eS permissible journal displacement under load= 25.0E-6 m
```

The following points should be noted.

- (i) The bearing dimensions, with the exception of the diameter, have been left unspecified by placing a "?" in place of the value. The program determines suitable values for these dimensions (using the preliminary design method of ESDU 92026) before proceeding to analyse the performance of the bearing. Suggested dimensions for the capillary restrictors are determined after this analysis (see ESDU 92026).
- (ii) The permissible journal displacement under load, eS , has been specified as a design requirement.
- (iii) Default values are assigned to certain of the parameters if left unspecified as detailed in Table 4.1.

TABLE 4.1 DEFAULTS FOR UNSPECIFIED PARAMETERS

Parameter symbol	Default value
lubDat	lubricant database file "LUB.DAT" is assumed
Ts	lubricant supply temperature of 40 °C is assumed
Ps	lubricant supply pressure of 7.0E6 N/m ² is assumed
nr	number of recesses is assumed to be 5

4.1 Specification of Input Data

Input parameters can be specified in any order and each parameter has an identifying symbol. Input parameters are specified with the symbol of the parameter followed by the value (with optional comment text). An input parameter may be left unspecified in any one of three ways.

- (i) Put a question mark, "?", in place of the parameter value.
- (ii) Comment-out the parameter by placing an asterisk, "*", at the start of the line.
- (iii) Omit the parameter specification entirely.

The input parameters for this ESDUpac program fall naturally into three groups and the following table, arranged in the format of an input data file, includes comments on the purpose of all input parameters.

```

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* Lubrication parameters:
* -----
* ESDUpac A9237 requires access to a lubricant database file the name of
* which can be specified in the input data file (see lubDat below). The
* name of the lubricant database file supplied with this ESDUpac is
* 'LUB.DAT'. The lubricant database file can be examined using an ASCII
* text editor capable of handling text lines longer than 80 characters.
* Each lubricant in the lubricant database file has an identifier of up to
* 6 characters (see lubID below).

lubDat  name of lubricant database file   = C:\esdu\lub.dat
*       The name of the lubricant database file that is to be accessed
*       for lubricant properties can be specified as simply a file name
*       or a path. If lubDat is left unspecified then the default
*       database name, 'LUB.DAT', is assumed.

lubID    lubricant identifier              = VG22
*       The identifier corresponding to the required lubricant in the
*       lubricant database file must be specified.

Ps       lubricant supply pressure         = 8.0E6      N/m^2
*       The lubricant supply pressure may need to be specified to suit
*       the requirements of other hydrostatic bearings or of hydraulic
*       actuator components. Where there is a free choice of supply
*       pressure, consideration should be given to the higher capital
*       cost of high pressure supply systems. A default value of
*       7.0E6 N/m^2 is assumed for Ps if left unspecified.

Ts       lubricant supply temperature     = 50          deg C
*       The lubricant supply temperature provides the datum used in

```