Foreword

The formulation of this National Standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) under the project entitled "Enhancing the Implementation of the AFMA Through Improved Agricultural Engineering Standards" which was funded by the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA).

This standard has been technically prepared in accordance with PNS 01-4:1998 (ISO/IEC Directives Part 3:1997) – Rules for the Structure and Drafting of International Standards. It provides specifications and proper application of journal bearings.

The word “shall” is used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted.

The word “should” is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that certain course of action is preferred but not necessarily required.

In the preparation of this standard, the following references were considered:

Baumeister, Theodore (ed.) 1997. Mark’s handbook for mechanical engineers. 10th Edition. Mc Graw Hill Book Company, USA.

Faires, V. M. 1969. Design of Machine Elements. Macmillan Company, New York USA.

Miller, W. S. (Ed.) 1974. Machine design, Bearings, Vol. 39 No. 34. Penton Publishing Co., Cleveland, Ohio.

Shigley, Joseph, E. 1977. Mechanical engineering design. 3rd Edition. Mc Graw Hill Book Company, USA.

Quayle J. P. (Ed.) 1971. Kempe’s engineer’s yearbook. Volume 1. Morgan-Grampian Book Publishing Co. Ltd, London.

Engineering Materials – Journal Bearings for Agricultural Machines – Specifications and Applications

1 Scope

This standard establishes specifications and provides sufficient technical information for the proper application of journal bearings for agricultural machinery.

2 Reference

The following normative reference contains provisions which, through reference in this text, constitute provisions of this standard:

PAES 305:2000, Engineering Materials – Shafts for Agricultural Machines – Specifications and Applications

3 Application

Journal bearings are designed to support and mount rotating shafts. They are used in drives where quietness in operation and rigidity is a requirement. Other advantages of journal bearings are low cost, less space requirement, good capacity to absorb shock loading, and its life is generally not limited by fatigue.

4 Definitions

4.1
journal bearing
sleeve bearing
a cylinder which surrounds the shaft and is filled with some form of fluid lubricant

4.2
journal
the part of the rotating shaft , axle, roll or spindle that turns in a bearing

4.3
lubricant
a medium that supports the shaft preventing metal to metal contact

5 Nomenclature

Nomenclature of journal bearings is presented in Figure 1.

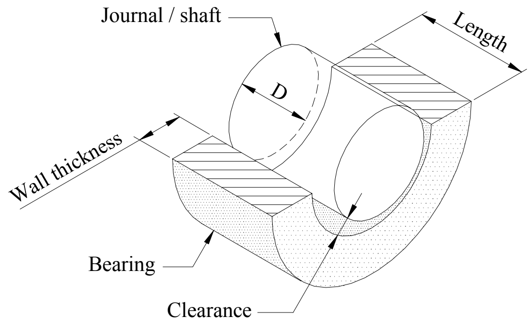

Figure 1 – Nomenclature of journal bearings

6 Types

6.1 Hydrodynamic bearings

In a hydrodynamic bearing, fluid is drawn into the region between the moving parts of the bearing by virtue of its adhesion to the surfaces of the bearing and of its viscosity and due to the shape of the bearing surfaces, pressure is generated within the fluid, which keeps the bearing surfaces separated. In a fully hydrodynamic bearing therefore there is no contact between the moving parts of the bearing, and theoretically no wear.

6.2 Hydrostatic bearings

In a hydrostatic bearing, the load is carried by fluid pressure generated outside the bearing, unlike the hydrodynamic bearing where the load is sustained by fluid pressure self-generated by the bearing. The essential requirement for hydrostatic lubrication is therefore that a sufficient fluid pressure can be supplied and retained. It is not necessary that the working fluid shall have viscosity or shall adhere to the bearing materials, or in fact that there shall be relative motion in a bearing. A hydrostatic bearing will operate whether the bearing is rotating or not, so that this type of lubrication is peculiarly suitable for cases where loads must be carried statically or with very slow motion, and where low friction is required.

6.3 Boundary lubrication bearings

The essential requirements of a boundary lubrication system are such that the lubricant shall "wet" the surfaces involved, and that the shapes and surfaces roughness of these shall be such as to keep the load to acceptable peak values.

6.4 Dry bearings

Dry bearings operate without significant fluid film to separate the moving surfaces therefore low friction materials, or materials impregnated with a lubricant, must be used.

7 Designation

Journal bearings are designated by its bore diameter, length, and wall thickness (see Figure 1 for dimensions of journal bearings).

8 Materials

Materials and properties of journal bearings are presented in Table 1.

Table 1 – Properties of journal bearing materials

Material	Hardness, BHN	Tensile strength, MPa	Material	Hardness, BHN	Tensile strength, MPa
Metals			**Plastics**		
Lead babbitt	21	68.95	TFE	D60	20.68
Tin babbitt	25	75.84	Nylon	M79	75.84
Copper lead	25	55.16	Phenolic	M100	68.95
Silver	25	158.58	Acetal	M94	68.95
Cadmium	35	-	Polycarbonate	M70	58.61
Aluminum alloy	45	151.68	Polymide	E52	68.95
Lead bronze	60	234.42	**Other nonmetallics**		
Tin bronze	70	310.27	Rubber	-	-
Steel	150	517.11	Wood	-	7.58
Cast iron	180	241.32	Carbon-graphite	75	13.79
Porous metals			Cemented tungsten carbide	A91	896.32
Bronze	40	124.11	Fused aluminum oxide	A85	206.84
Iron	50	172.37			
Aluminum	H55	103.42			

9 Specifications

Specifications of journal bearings are presented in Table 2.

Table 2 – Size ranges of journal bearings

Bore mm	Wall thickness, mm	Length-bore ratio
4.8 - 127	**Cast bronze** 1.6-12.7 (for small bores to 25.4mm) 6.4-12.7 (for bores to 127 mm)	1 to 3 (can be as large as 6 for small bores)
3.2 - 101.6	**Porous metal (Plain)** 0.8-6.4 (for small bores to 25.4) 3.2-6.4 (for bores to 101.6)	1 to 2
4.8 - 50.8	**Porous metal (Flanged)** 1.6 - 3.2	1 to 2
4.8 - 177.8	**Plastic** Varies with type of backing for plastic 0.8 - 6.4	
NOTE Sizes shown in the table are only representative. Bearing catalogs should be consulted for accurate dimensions		

10 Recommended design practices

10.1 Bearing clearance

Bearing clearances for steady and dynamically loaded cases are given in Figures 2 and 3, respectively.

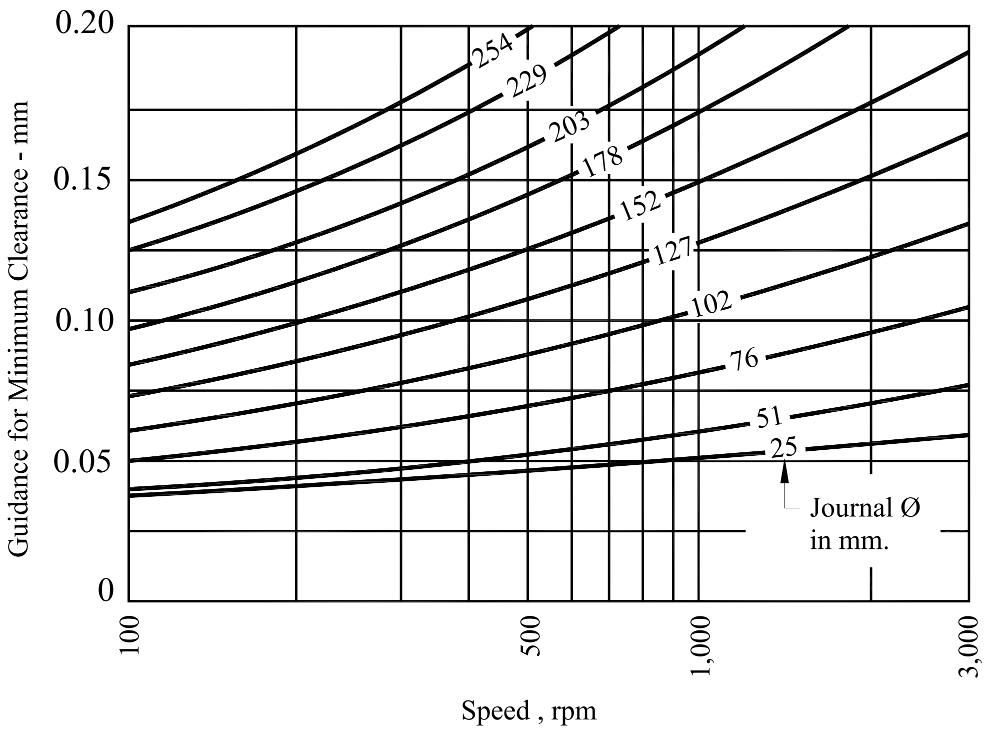

Figure 2 – Minimum clearance guidance curve: Steadily loaded bearings

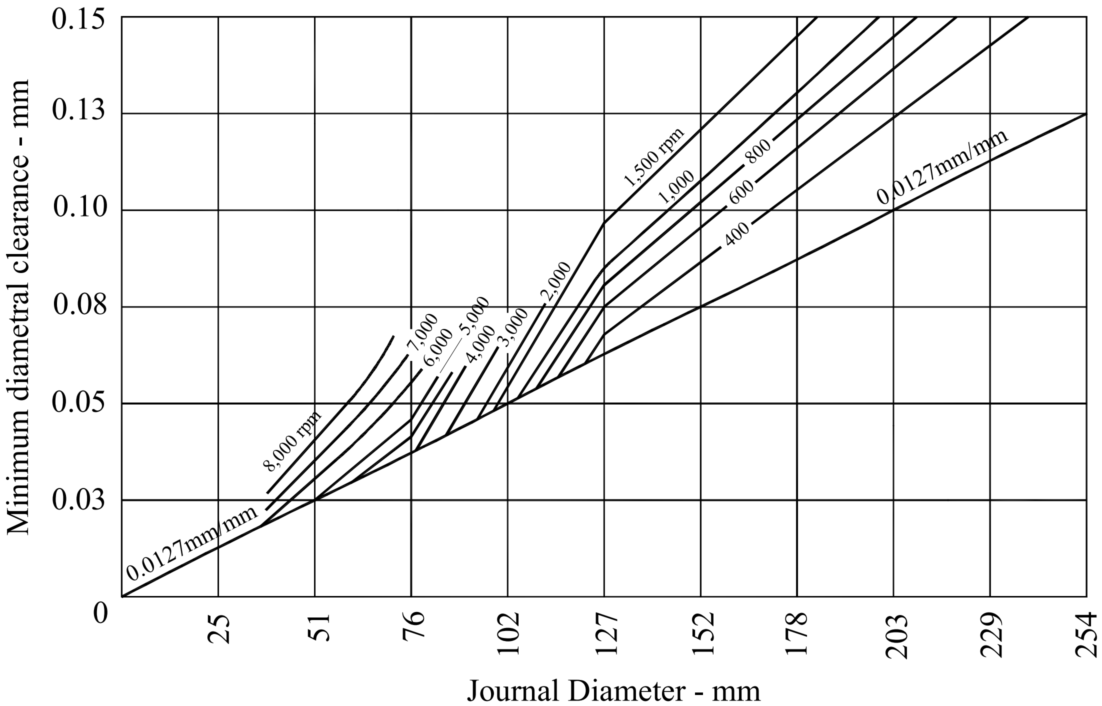

Figure 3 – Minimum clearance guidance curve: Dynamically loaded bearings

10.2 Heat generation

Frictional heating, a most common cause of bearing failure, is a function of sliding velocity, bearing pressure, and coefficient of friction. Therefore if the coefficient of friction remains constant for a range of loads and speeds, a rough indication of heat load is provided by the *PV* factor. PV limits for different bearing materials are presented in Tables 3 and 4. Exceeding any of these four factors (see Table 3) affects normal bearing life. Under certain conditions they can be exceeded. The maximum load that can be carried for various *PV* can be determined through Figure 6.

Table 3 – *PV* limits for porous-metal bearing materials

Material	*PV* (MPa *x* m/s)	Bearing Pressure, (MPa)		Sliding velocity (m/s)
		Static	Dynamic	
Bronze	1.751	55.158	13.789	6.10
Lead-bronze	2.802	24.131	5.515	7.62
Copper-iron	1.225	137.896	27.579	1.14
Hardenable copper-iron	2.626	344.740	55.158	0.18
Iron	1.050	68.948	20.684	2.03
Bronze-iron	1.225	72.395	17.237	4.06
Lead-iron	1.751	27.579	6.894	4.06
Aluminum	1.751	27.579	13.789	6.10

Table 4 – *PV* limits for non-metallic bearings

Material	Load Capacity (MPa)	Temperature (°C)	Sliding velocity (m/s)	*PV* (MPa *x* m/s)
Phenolics	41.368	93	12.70	0.525
Nylon	6.894	93	5.08	0.105
TFE	3.447	260	0.52	0.350
Filled TFE	17.237	260	5.08	0.350
TFE Fabric	413.688	260	0.76	0.875
Polycarbonate	6.894	104	5.08	0.105
Acetal	6.894	93	5.08	0.105
Carbon-graphite	4.136	399	12.7	0.525
Rubber	0.344	67	20.32	-
Wood	13.789	71	10.16	0.420

11 Markings

11.1 The following information shall be marked on the casing:

a) Manufacturer's name, trademark and address

b) Manufacturer's designation

11.2 The following information shall be marked on the bearings:

a) Manufacturer's name and/or its trademark

b) Manufacturer's designation

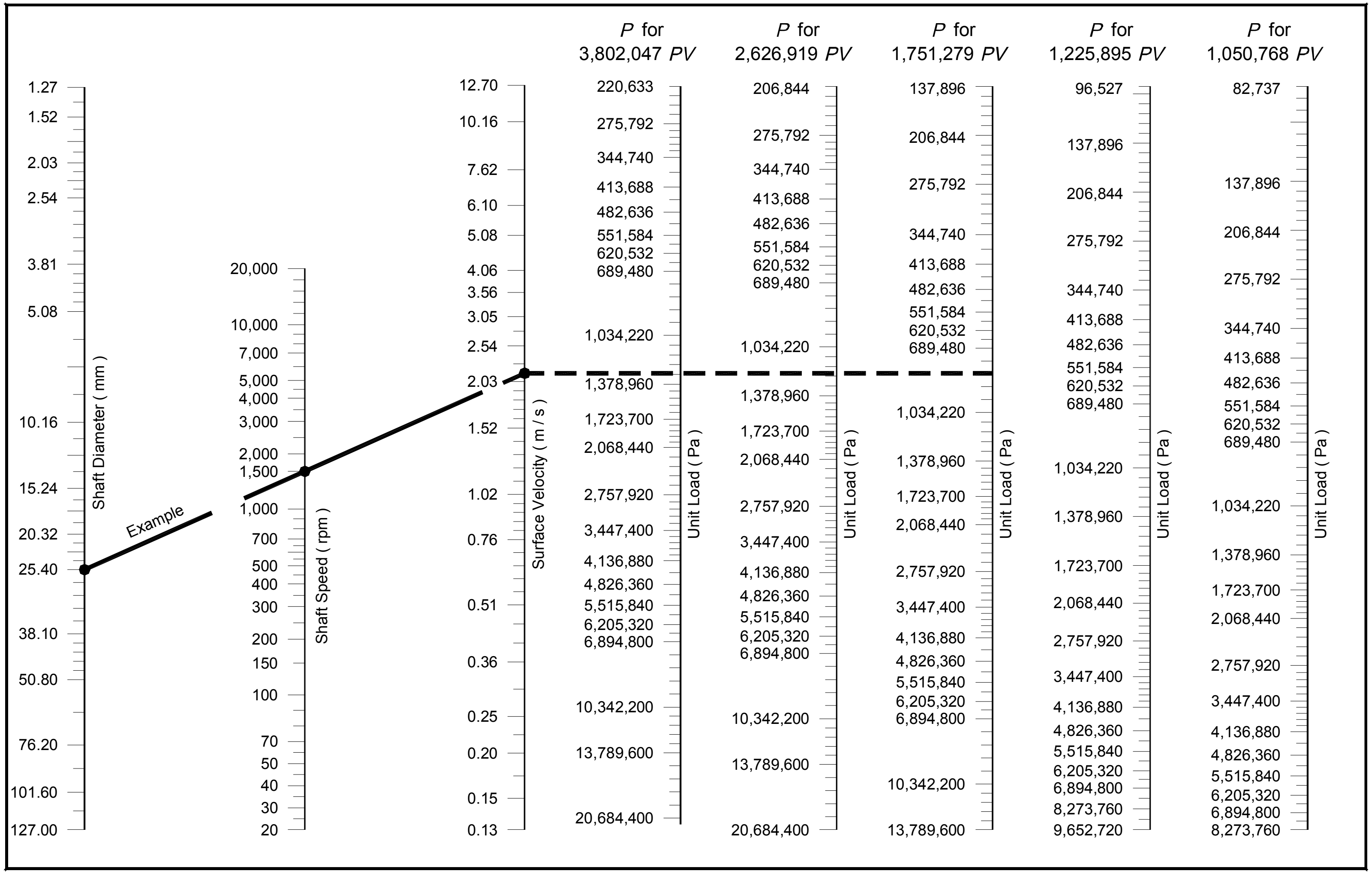

Figure 6 – Load speed chart for determining bearing dimensions or load according to *PV* limit

12 Safety

12.1 Make drive inspection on a periodic basis. Inspect bearings for wear and tear, for quality of lubricant, and for its alignment. Tightness setscrews should also be inspected periodically. Screws used for mounting should also be inspected regularly.

12.2 Use bearings with proper markings.

12.3 Use shafts as specified in PAES 305:2000: Shafts for Agricultural Machines.

Annex A
(informative)

Procedure for determining bearing dimensions

A.1 Given parameters

Determine the size, material of a steadily loaded bearing for a drive with a shaft speed of 1,500 rpm, a shaft diameter of 25 mm and a load of 6.5 MPa.

A.2 Surface velocity

The surface velocity can be determined through Figure 6. At 1,500 rpm and shaft diameter of 25 mm, the surface velocity is 2.16 m/s.

A.3 *PV* limits and bearing material`

Using Figure 6, the acceptable PV limit at a load of 6.5 MPa is 1,751,279 *PV*. With this *PV* limit, the bearing material can be selected using Tables 3 and 4, select the material with a higher *PV* value. Thus the material that can be used is lead bronze.

A.4 Wall thickness

From Table 2, wall thickness for bronze may range from 1.6 mm to 12.7 mm. For specific dimensions of thickness, consider requirements for the drive then refer to bearing catalogs.

A.5 Minimum clearance

Using Figure 2, the minimum clearance for 1,500 rpm and 25 mm shaft diameter is approximately 0.055 mm.

A.6 Bearing specification

For the given drive, use a lead bronze bearing with a 25 mm bore diameter, and wall thickness range of 1.6 mm to 12.7 mm. Bearing length depends on space limits, availability of bearing, and cost. Bearing catalogs shall be consulted for detailed specifications.