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Plain bearings — Quality assurance of thin-walled half bearings — Design FMEA

Paliers lisses — Assurance qualité des demi-coussinets minces — AMDE à la conception

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 12132 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 5, *Quality analysis and assurance*.

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Introduction

FMEA (Failure Mode and Effect Analysis) is a form of analytical method that helps to define potential defects of the designed products and to eliminate these defects at the stage of designing.

FMEA is based on combining the experience gained in practice in designing and operation of plain bearings with the theory of probability.

FMEA increases reliability and quality of the product in question and that of its technology and also reduces the expenses for testing the product and for improving the technological process.

Systems for the implementation of a Design FMEA are well documented elsewhere and are outside the scope of this International Standard. These systems aid in the analysis of complex designs, both existing and projected.

Plain bearings — Quality assurance of thin-walled half bearings — Design FMEA

1 Scope

This International Standard provides guidelines for the preparation of a Design FMEA for thin-walled half bearings used in internal combustion engines (the Process FMEA should be the responsibility of the supplier). It lists the common potential failure mode(s), potential effect(s) and potential cause(s) of failure.

The numerical evaluation of risks in terms of occurence, severity and detection can be specific to each application, manufacturer and customer.

Since they have to be assessed in each case the numerical data are not included in this International Standard. General guidance on statistical assessment can be obtained from the references.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 7146:1993, *Plain bearings — Terms, characteristics and causes of damage and changes in appearance.*

IEC 60812:1985, *Analysis techniques for system reliability — Procedure for failure mode and effects analysis (FMEA).*

3 Terms and definitions

For the purposes of this International Standard the terms and definitions in IEC 60812 and the following apply.

3.1
FMEA
Failure Mode and Effects Analysis is a method of reliability analysis intended to identify failures which have significant consequences affecting the system performance in the application considered

3.2
Design FMEA
FMEA carried out by designers when developing the product

3.3
failure mode
effect by which a failure is observed in the bearing

3.4
failure effect
consequence of a failure mode on engine

3.5
failure cause
deficiency or defect which causes a failure mode

4 Common potential failure modes, effects and causes for half bearing shells

The connecting rod and main half bearing shells of an internal combustion engine are only one part of an integrated system involving the lubricating oil, the lubrication system, the crankshaft, the engine block, the connecting rods and the half bearing shells themselves. Even the cylinder head material, bolt tightening and cylinder head gasket material have been known to influence bearing performance. Hence any consideration of internal combustion engine bearing design shall include all elements of the system not just the half bearing shells.

Table 1 gives a list of common potential bearing failure modes and the effects of bearing failure together with possible causes of failure. It is rare for failures to be encountered uniquely but rather they are found in combination such that the actual initial failure mode, and hence the causes, may be difficult to determine. Failure modes of the other bearing system components are not included.

Table 1 — Potential Failure Modes of half bearings and their effects and causes

No.	Potential failure mode	Potential effects of failure	Potential cause of failure	
			bearing-related	system-related
1	Fatigue (see 2.4 of ISO 7146:1993)	Reduced bearing durability and/or bearing seizure; Contamination of oil by fatigue debris; Engine inoperative.	Insufficient bearing diameter; Insufficient bearing length; Incorrect material selection (fatigue resistance); Localized overloading due to presence and location of bearing features (holes, grooves, etc.); Excessive bearing material thickness; Excessive overlay thickness; Unsupported bearing areas.	Incorrect specification of cylinder pressures firing load; Oil pump capacity calculation; Insufficient effective journal length; Poor journal geometry (ovality, axial form, lobing); Poor housing geometry (ovality, lobing); Insufficient housing dynamic stiffness (circumferential, radial or axial); Excessive oil temperature and/or insufficient oil cooling.
2	Accelerated wear (Insufficient oil film thickness or debris contamination) (see 2.2 of ISO 7146:1993)	Reduced bearing durability and/or bearing seizure; Noise; Reduction of oil pressure.	Insufficient bearing length; Insufficient bearing diameter; Incorrect material selection (wear resistance, embeddability); Inappropriate overlay thickness (wear resistance, embeddability); Poorly located bearing features (holes, grooves, etc.); Inadequate oil grooves and holes; Incorrect bearing thickness (inadequate clearance and/or excessive clearance); Incorrect bearing thickness geometry (taper, eccentricity, etc.).	Incorrect lubricant choice; Incorrect oil additive specification; Poor oil and/or oil additive stability; Poor lubricant supply (inadequate oil pressure or supply capacity, drilling diameters too small or poorly positioned, etc.); Aerated or "poor quality" oil supply (rough drillings or sharp bends in lubrication system, poor sump baffling, poor oil pick up, etc.); Inadequate oil filtration; Insufficient effective journal length; Insufficient journal diameter;

(*continued*)

Table 1 (*continued*)

No.	Potential failure mode	Potential effects of failure	Potential cause of failure	
			bearing-related	system-related
2				Poor journal geometry (ovality, axial form, lobing); Poor journal surface topography (finish, lay, etc.); Poor engine balance; Poor housing geometry (ovality, lobing); Unsupported bearing areas; Insufficient oil temperature and/or insufficient oil cooling; Contamination by wear debris from other components; Expressive ingested debris; Infrequent oil and/or oil filter change intervals; Excessive coolant contamination; Excessive contamination by fuel and combustion products.
3	Excessive wear and scuff (over-heating) (see 2.9 of ISO 7146:1993)	Reduced bearing durability and/or bearing seizure.	Incorrect bearing thickness (inadequate clearance and/or excessive clearance, poor bearing back conformability with housing); Incorrect bearing thickness geometry (taper, eccentricity, etc.); Poorly located bearing features (holes, grooves, etc.); Inadequate oil grooves and holes.	Incorrect journal diameter (clearance); Poor journal geometry (ovality, axial form, lobing); Unsuitable journal surface topography; Incorrect fillet radius geometry; Incorrect housing diameter (interference fit); Poor housing geometry (ovality, axial form, lobing).

(*continued*)

Table 1 (*continued*)

No.	Potential failure mode	Potential effects of failure	Potential cause of failure	
			bearing-related	system-related
3			Inadequate circumferential length (inadequate interference fit); Inadequate bearing back contact; Incorrect material selection (conformability, compatibility); Incorrect diffusion barrier material; Excessive differential thermal expansion between housing and bearing shells or housing and shaft (loss of interference fit).	Insufficient housing clamping (bolt) load; Poor lubricant supply (inadequate oil pressure or supply capacity, drilling diameters, too small or poorly positioned, etc.); Excessive oil drain down or delayed oil supply; Aerated or "poor quality" oil supply (rough drillings or sharp bends in lubrication system, poor sump baffing, poor oil pick up, etc.); Insufficient "running-in"; Insufficient axial clearance at ends of bearing.
4	Excessive localized wear (see 2.2 and 2.9 of ISO 7146:1993)	Reduced durability; Reduced oil pressure.	Poorly located bearing features (holes, grooves, etc.); Incorrect bearing thickness geometry (axial form, eccentricity, etc.); Incorrectly specified internal chamfers (fillet ride); Incorrectly specified bearing bore relief; Incorrectly specified locating tang (notch, lug or nick); Inadequate bearing back contact;	Insufficient blending of crankshaft oil drilling into journal; Incorrect fillet radius geometry; Insufficient build cleanliness; Poor housing geometry ovality, axial form, lobing); Inadequate bearing housing cap location; Poorly located housing features (holes, grooves, etc.); Insufficient housing stiffness (radial and axial). Incorrectly positioned bearing tang pockets in housing.

(*continued*)