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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

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 12132:1992), which has been technically revised.

Introduction

FMEA (Failure Mode and Effects 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 document. 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 document gives guidelines for the preparation of a Design FMEA for thin-walled half bearings used in machinery, e.g. internal combustion engines (the Process FMEA is 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 occurrence, 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 document. General guidance on statistical assessment can be obtained from the references.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60812 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

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

3.2
Design FMEA
FMEA (3.1) 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* (3.3) on the bearing system and equipment condition and operation

3.5
failure cause
deficiency or defect which causes a *failure mode* (3.3)

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

The connecting rod and main half bearing shells of a machine 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 ISO 7146-1:2008, 6.3)	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 Bearing system contaminated by foreign particles or wear debris from other components
2	Accelerated wear (Insufficient oil film thickness or debris contamination) (see ISO 7146-1:2008, 6.6 and 6.7.1)	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 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 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

Table 1 *(continued)*

No.	Potential failure mode	Potential effects of failure	Potential cause of failure	
			Bearing-related	**System-related**
				Contamination by wear debris from other components Excessive 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 ISO 7146-1:2008, Clause 8)	Reduced bearing durability and/or bearing seizure	Incorrect bearing thickness (inadequate clearance 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 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)	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) 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 lubrification system, poor sump baffing, poor oil pick up, etc.) Insufficient “running-in” Insufficient axial clearance at ends of bearing

Table 1 *(continued)*

No.	Potential failure mode	Potential effects of failure	Potential cause of failure	
			Bearing-related	**System-related**
4	Excessive localized wear (see ISO 7146-1:2008, 6.4 and Clause 8)	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 Poor bearing alignment (engine block alignment, connecting rod straightness or twist) Excessive off-set connecting rod loading Poor journal geometry (ovality, axial form, lobing) Poor crankshaft main journal alignment
5	Damage to the bearing back (see ISO 7146-1:2008, 7.2 and 7.3)	Reduced bearing durability and/or bearing seizure Connecting rod breakage	Inadequate circumferential length (interference fit) Inadequate bearing back contact Excessive differential thermal expansion between housing and bearing shells or housing and shaft (loss of interference fit) Incompatible housing material and bearing back material	Insufficient housing dynamic stiffness (circumferential, radial or axial) Insufficient housing clamping (bolt) load Incorrect housing diameter (interference fit) Unsupported bearing areas

Table 1 *(continued)*

No.	Potential failure mode	Potential effects of failure	Potential cause of failure	
			Bearing-related	**System-related**
6	Corrosion (see ISO 7146-1:2008, 6.7.2)	Reduced bearing durability and/or bearing seizure Increased wear and/or noise	Incorrect material selection (poor corrosion resistance)	Incorrect lubricant choice Incorrect oil additive specification Poor oil and/or oil additive stability Excessive oil temperature and/or insufficient oil cooling Infrequent oil change intervals Excessive coolant contamination Excessive contamination by fuel and combustion products
7	Cavitation erosion (see ISO 7146-1:2008, 6.8 and ISO 7146-2)	Poor cosmetic appearance but not normally damaging on overlay plated bearings Corrosion of substrate in extreme cases Localized fatigue failure in bimetallic bearings Reduced oil supply or pressure Subsequent scoring, indenting and embedment by removed lining material	Incorrect bearing calculation Inadequate oil groove chamfers Inadequate “run-in” grooves Excessive clearance Incorrect groove positions Inadequate groove detail design Incorrect material selection	Incorrect lubricant choice 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.) Vibration

Bibliography

[1] ISO 7146-1:2008, *Plain bearings — Appearance and characterization of damage to metallic hydrodynamic bearings — Part 1: General*

[2] ISO 7146-2, *Plain bearings — Appearance and characterization of damage to metallic hydrodynamic bearings — Part 2: Cavitation erosion and its countermeasures*

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