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Guide for the mechanical balancing of marine main steam turbine machinery for merchant service

Guide pour l'équilibrage mécanique des turbines marines principales des navires de commerce

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3080 was drawn up by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, and circulated to the Member Bodies in April 1973.

It has been approved by the Member Bodies of the following countries :

Australia	Japan	Thailand
Austria	Netherlands	Turkey
Belgium	New Zealand	United Kingdom
Czechoslovakia	Romania	U.S.A.
France	South Africa, Rep. of	U.S.S.R.
Germany	Spain	
Italy	Sweden	

No Member Body expressed disapproval of the document.

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Guide for the mechanical balancing of marine main steam turbine machinery for merchant service

1 SCOPE

This International Standard furnishes guidance in applying the recommendations of ISO 1940 to the balancing of marine main steam turbine machinery (for example turbine rotors, gears and shafts), explaining the importance of the concentricity of these rotors and gears with their associated shafts and couplings. By these means, limits may be set to the rotating unbalance forces acting upon turbine and gear bearings, even under consideration of magnifying effects of bearings and supporting structures. This International Standard is based upon general principles for comparative evaluation of vibration in machinery.[1] Because of the particular conditions of installation of marine turbines, this International Standard contains information concerning the special factors that have to be taken into account if satisfactory balance quality is to be achieved.

Details of the methods of test by which the limits of accuracy may be verified should be agreed between the manufacturer and purchaser, or inspecting authority. Where the use of a balancing machine is required, this should meet the provisions of ISO 2953 as far as its general features and tolerances are concerned.

NOTE – The term "manufacturer" as used throughout this International Standard refers to the turbine machinery manufacturer.

2 FIELD OF APPLICATION

This International Standard applies to the rotors of main propulsion steam turbines of merchant ships and to the associated reduction gear elements, couplings and torsion shafts, excluding propeller shafting.

This application is limited to rotors and gear elements supported in two bearings whose maximum service speeds are sufficiently below their flexural critical speeds so that any residual unbalances are not dynamicaly magnified to such a degree as to exceed the recommended tolerance.

3 REFERENCES

published 1974

ISO 1925, *Balancing — Vocabulary.*[2]

ISO 1940, *Balance quality of rotating rigid bodies.*

ISO 2953, *Balancing machines — Description and evaluation.*[2] published 1975

4 TERMS AND DEFINITIONS

The terms used in this International Standard are in accordance with those defined in ISO 1925.

5 BALANCING REQUIREMENTS

5.1 Balancing equipment

The manufacturer shall state to the purchaser the method and means of balancing employed, for example dynamic balancing machine, knife edges, etc., and shall give the following information as applicable :

a) the rotor was balanced to the appropriate quality grades of ISO 1940 and the balancing machine met the requirements of ISO 2953;

b) location of the correction planes;

c) method of supporting and driving the workpiece;

d) state of assembly when balancing was carried out.

NOTE – The annex gives details of the information required to provide a complete instruction to the balancing machine operator and assist the inspector or surveyor in confirming that the limits and procedure are in accordance with this International Standard.

5.2 Environmental conditions

5.2.1 The manufacturers shall take adequate precautions to ensure that, where applicable :

a) the workpiece, for example high pressure turbine rotor, has been thermally stabilized to an agreed level before final balancing;

b) the workpiece has attained a uniform ambient temperature before balancing.

5.2.2 Where applicable, the workpiece shall be overspeed tested. If, during the overspeed test, a 10 % change in unbalance is detected, the unbalance shall be corrected.

1) The preparation of an International Standard on this subject is envisaged.

2) At present at the stage of draft.

6 STEAM TURBINE ROTORS

6.1 Maximum service speed

The manufacturer shall state the maximum service speed, in revolutions per minute, of the rotor.

6.2 Dynamic balancing

All rotors shall be dynamically balanced when ready for assembly in the turbine casing.

6.3 Design tolerances

The manufacturer shall state the following :

a) the design tolerances on roundness, parallelism and co-axiality for the finish machined rotor journals, and the means by which these are assessed;

b) any deviation from these design tolerances as found by measurement.

6.4 Correction for unbalance

Correction for unbalance shall normally be made in not less than two transverse planes. It is recommended that, where a significant known unbalance exists, correction for this unbalance should preferably be effected in the plane in which it occurs.

6.5 Residual unbalance

6.5.1 The residual specific unbalance after correction for dynamic unbalance referred to each correction plane shall be stated and the associated balance quality grade shall not be inferior to the balance quality grade recommended in ISO 1940.

6.5.2 After a rotor has been finally corrected for unbalance, it shall be examined again for unbalance to ensure that the requirements of 6.5.1 have been met.

7 GEARS

7.1 Maximum service speed

The manufacturer shall state the maximum service speed, in revolutions per minute, of the gear elements to be balanced.

7.2 Balancing

All gear elements shall be checked for balance when ready for assembly in the gear casing.

Gears shall be dynamically balanced, except that, for design speeds of 1 000 rev/min or below, they may be either statically or dynamically balanced.

7.3 Correction of unbalance

7.3.1 Where static balancing is employed for gear wheels, correction for unbalance shall normally be made by affixing weights or removing metal; it is recommended that the total amount required for correction be suitably distributed between the forward and after sides of the wheel.

7.3.2 Correction for unbalance of pinions shall preferably be made by removal of metal at approximately the same radius at each end of the pinion.

7.3.3 In both cases the method of permanent correction shall be stated.

7.4 Residual unbalance

7.4.1 The residual specific unbalance after correction for unbalance referred to each correction plane shall be stated and the associated balance quality grade shall not be inferior to the balance quality grade recommended in ISO 1940.

7.4.2 After a gear element has been finally corrected for unbalance, it shall be examined again for unbalance to ensure that the requirements of 7.4.1 have been met.

8 TORSION (OR QUILL) SHAFTS

8.1 Maximum service speed

The manufacturer shall state the maximum service speed, in revolutions per minute, of the shafts to be balanced. For design speeds below 1 000 rev/min, balancing would not normally be necessary, provided that the manufacturer confirms that the shafts are fully symmetrical about their axes and are finish machined all over, also that the maximum departure from straightness, in terms of total indicator reading, does not exceed the design tolerances, which shall be stated.

In general, this should be limited to a value such that the magnitude of the unbalance forces applied to the bearings supporting the adjacent rotor, gear or shaft resulting from this departure from straightness does not exceed that which corresponds to the balance quality grade of those components.

8.2 Correction for unbalance

Correction for unbalance shall normally be made in not less than two transverse planes. It is recommended that, where a significant known unbalance exists, correction for this unbalance should preferably be effected in the plane in which it occurs.

The method of providing permanent correction shall be stated.

8.3 Residual unbalance

8.3.1 The residual specific unbalance after correction for dynamic unbalance referred to each correction plane shall be stated and the associated balance quality grade shall not be inferior to the balance quality grade recommended in ISO 1940.

8.3.2 After a shaft has been finally corrected for unbalance, it shall be examined again for unbalance to ensure that the requirements of 8.3.1 have been met.

8.4 Assembly check

After final assembly, the manufacturer shall check that the shaft is co-axial with the rotor or gear to which it is attached to within the design tolerance, which shall be stated.

In general, this should be limited to a value such that the magnitude of the unbalance forces applied to the bearings supporting the adjacent rotor, gear or shaft resulting from lack of co-axiality does not exceed that which corresponds to the balance quality grade of those components.

9 TORQUE TUBES

This clause applies to tubes transmitting power between the turbine and gear, or between two gears, and where a connection at one end or both ends of the tubes is through a flexible coupling.

9.1 Maximum design speed

The manufacturer shall state the maximum design speed, in revolutions per minute, of the tubes to be balanced.

9.2 Dynamic balancing

The tubes shall be dynamically balanced.

9.3 Correction for unbalance

Correction for unbalance shall normally be made in not less than two transverse planes. It is recommended that, where a significant known unbalance exists, correction for this unbalance should preferably be effected in the plane in which it occurs.

The method of providing permanent correction shall be stated.

9.4 Residual unbalance

9.4.1 The residual specific unbalance after correction for dynamic unbalance referred to each correction plane shall be stated and the associated balance quality grade shall not be inferior to the balance quality grade recommended in ISO 1940.

9.4.2 After a tube has been finally corrected for unbalance, it shall be examined again for unbalance to ensure that the requirements of 9.4.1 have been met.

9.5 Radial run-out

If, for balancing, the tube is supported on two reference surfaces, generated at the same setting as the cutting of the coupling teeth, the radial run-out of the pitch circle of the teeth at each end of the tube relative to the two reference surfaces, chosen one at each end of the tube, shall not exceed the design tolerance, which shall be stated.

In general, this should be limited to a value such that the magnitude of the unbalance forces applied to the bearings supporting the adjacent rotor, gear or shaft resulting from this eccentricity, does not exceed that which corresponds to the balance quality grade of those components.

10 COUPLINGS

This clause applies to fine tooth couplings between turbine gears, torsion shafts and the sleeves of flexible shaft couplings, as appropriate. The requirements apply only to those aspects of coupling manufacture and assembly which are necessary to ensure that no unacceptable amount of unbalance is applied to the parts connected by the couplings.

10.1 The radial run-out of the pitch circle diameter of the coupling teeth of both external and internal members, relative to the axis of rotation of the gear rotor, or of the torsion shafts or sleeve, shall not exceed the design tolerance, which shall be stated.

The maximum radial movement resulting from the clearances between the meshed teeth when a tooth coupling has been finally assembled shall not exceed the design tolerance, which shall be stated.

In general, these tolerances should be limited to values such that the magnitude of the unbalance forces applied to the bearings supporting the adjacent rotor, gear or shaft resulting from the eccentricity or radial movement do not exceed those which correspond to the balance quality grade of those components.

11 SHAFT ASSEMBLIES

This clause applies to assemblies which transmit power between turbines and gears, or between gears, and which are supported in their own bearings (for example shafts to which are attached halves of hydraulic couplings or clutches), and whose maximum service speed of rotation exceeds 1 000 rev/min.

11.1 Maximum service speed

The manufacturer shall state the maximum service speed of rotation, in revolutions per minute, of the assembly.

11.2 Dynamic balancing

The assembly shall, wherever possible, be dynamically balanced in the fully assembled condition.

11.3 Correction for unbalance

Correction for unbalance shall normally be made in not less than two transverse planes. It is recommended that, where a significant known unbalance exists, correction for this unbalance should preferably be effected in the plane in which it arises.

The method of providing permanent correction shall be stated.

11.4 Residual unbalance

11.4.1 The residual unbalance after correction for dynamic unbalance referred to each correction plane shall be stated and the associated balance quality grade shall not be inferior to the balance quality grade recommended in ISO 1940.

11.4.2 After an assembly has been finally corrected for unbalance, it shall be examined again for unbalance to ensure that the requirements of 11.4.1 have been met.

11.5 Degree of concentricity

Where an assembly is solidly connected to a rotor, gear or shaft, the degree of concentricity of the axes of rotation of the assembly and of the rotor, gear or shaft (shaft axis) at the point of attachment after final assembly shall be within the design tolerance, which shall be stated.

In general, this should be limited to a value such that the magnitude of the unbalance forces applied to the bearings supporting the adjacent rotor, gear or shaft resulting from this eccentricity, does not exceed that which corresponds to the balance quality grade of those components.

ANNEX

BALANCING INFORMATION

When a workpiece is to be balanced, whether statically or dynamically, adequate information should be given to provide a complete instruction to the balancing machine operator and to assist the inspector or surveyor in confirming that limits and procedure are in accordance with this International Standard.

The information may either be given on the manufacturing drawing of the workpiece or provided on a special data sheet.

The information provided shall include :

a) mass of the workpiece;

b) maximum service speed, in revolutions per minute;

c) whether it is to be statically or dynamically balanced;

d) numerical value of acceptable residual unbalance and balance quality grade;

e) position of, and radius in, correction planes;

f) method of correction (for example adding or removing metal);

g) balancing machine or equipment to be used;

h) type of support bearings and location on the rotor;

i) whether any drive adaptor mandrels or temporary stub shafts are required;

j) if so, details including acceptable residual unbalance for these items, method of ensuring concentricity, positions and tolerances for concentricity checks on the workpiece;

k) particulars of any separate parts to be attached to the workpiece in service; whether these are to be in place for balancing, method of ensuring their concentricity, and eccentricity tolerance allowed.