



GUIDE FOR

ENHANCED SHAFT ALIGNMENT

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**American Bureau of Shipping
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Foreword

The *ABS Guide for Enhanced Shaft Alignment* has been developed to address requests from owners and operators who wish to perform a more detailed shaft alignment analysis and installation assessment.

Vessels designed, constructed and operated in compliance with the requirements of this Guide may be assigned the Class Notation **ESA**.

Assignment of the **ESA** Notation requires the review of plans and calculations by an ABS Engineering Office and the attendance of an ABS Surveyor during additional shafting alignment efforts.

The intention of the Guide is to address shafting arrangements that may benefit from a more detailed analysis and a more accurate and structured procedure so as to optimize the shaft alignment and improve the service life of the vessel's powertrain. This Guide is intended to apply mainly to shaft alignment-sensitive vessels, as defined in this Guide, although it could apply to a wider range of powertrains including geared installations.

The main aspects that distinguish compliance with this Notation from the standard Rule application are:

- A final Shaft Alignment sighting is to be conducted after the engine or gearbox and other heavy machinery are installed on board and all major steel works are completed at the aft part of the vessel.
- Shaft alignment optimization calculations are required.
- Compulsory inclusion of hull deflections to be taken into account in the analysis.
- Requirement for Lateral Vibration (Whirling) analysis of the powertrain shafting system.
- Shaft alignment verification at more than one service condition.
- The vessel must be assigned the Tailshaft Condition Monitoring **TCM** Notation.

The *ABS Guide for Enhanced Shaft Alignment* is to be used in conjunction with all other applicable Rules, Guides and Guidelines published by ABS.

This Guide becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.



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SECTION 1 General

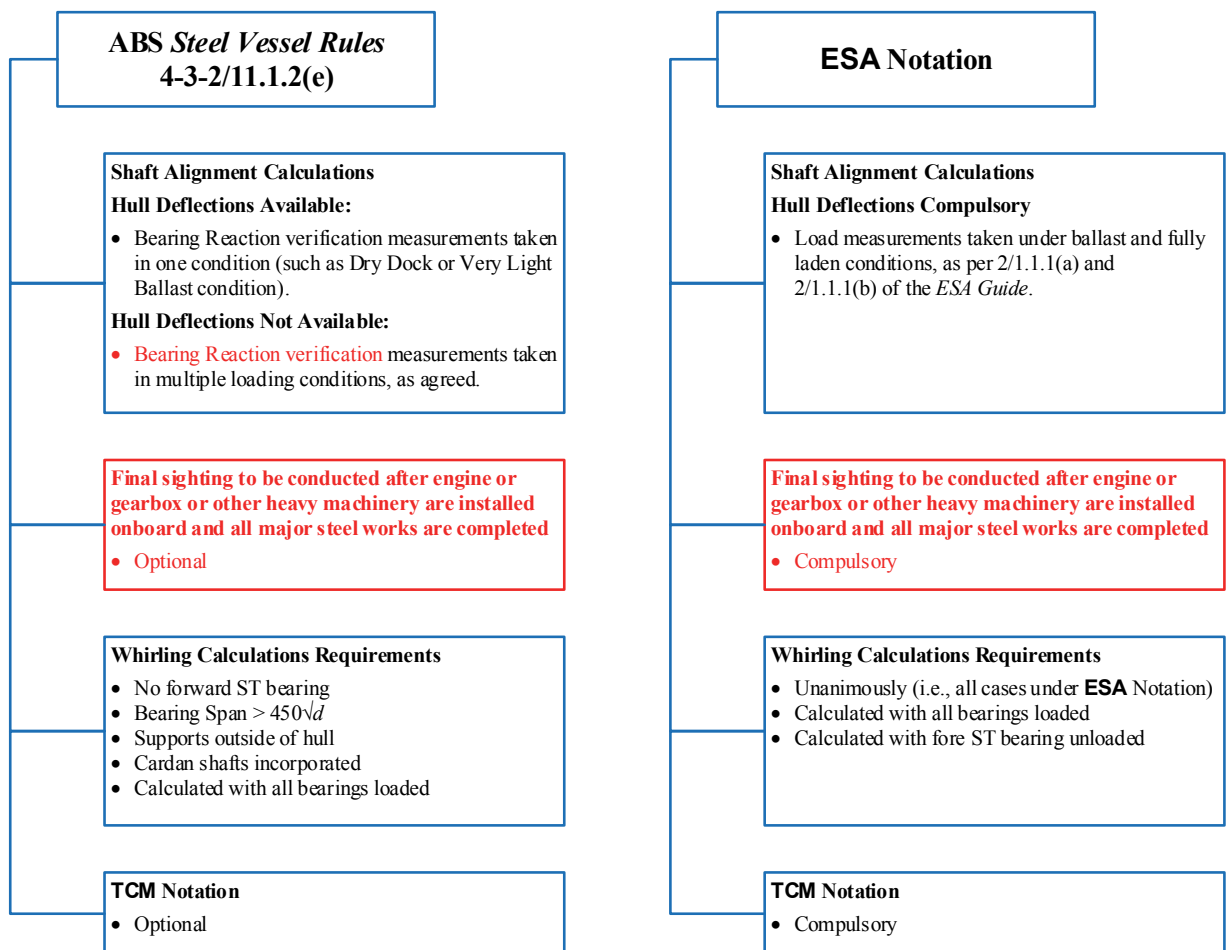
1 Introduction

1.1 ESA Notation

Requirements of this Guide are optional for classification purposes. However, where assignment of the optional notation **ESA** – Enhanced Shaft Alignment is being requested, provisions of this Guide are compulsory.

This Guide provides criteria for additional calculation requirements, such as design optimization, as well as more detailed requirements regarding the shaft alignment procedures in support of the optional notation **ESA** - Enhanced Shaft Alignment. Typical differences can be explained through the flowchart examples of Section 1, Figure 1.

FIGURE 1
Selected Differences between ESA Notation Requirements
and ABS Rules (1 November 2016)



1.1.1 Objective

The objective of this Guide is to identify additional requirements and procedures beyond the minimum requirements currently specified in the *ABS Rules for Building and Classing Steel Vessels* so as to further enhance the shaft alignment. Vessels designed, constructed and operated in compliance with the requirements of this Guide may be assigned the Class Notation **ESA**.

1.1.2 General Requirements (1 November 2016)

The shaft alignment procedure for vessels with the **ESA** Notation requires that the final shaft alignment sighting is to be carried out after the vessel stern blocks are fully welded and all of the heavy stern structure is in place, such as any stern accommodation block, including the main engine and/or gearbox. This is to be verified by the attending Surveyor.

1.3 Definitions

1.3.1 ABS Rules

The *ABS Rules for Building and Classing Steel Vessels* is hereafter referred to as “*Steel Vessel Rules*”.

1.3.2 ESA Notation

The notation granted based upon compliance with the requirements described in this Guide.

1.3.3 FEA

Finite Element Analysis.

1.3.4 MCR

Maximum Continuous Rating.

1.3.5 Very Light Ballast Condition

The condition in which the vessel is either in dry-dock or afloat at a quay with minimum ballast nearing a “lightship” condition. This condition is expected to have the least influence in the calculations with hull deflections that would affect the shaft alignment and therefore, it is considered as a condition without hull deflections.

1.3.6 Global Reference Line

In the shaft alignment sighting, the global reference line is the 0 (zero) datum used as the reference for all bearing offsets. All bearing offsets values are recorded based on this datum.

1.3.7 Shaft Alignment

The configuration of the shafts and bearings relative to the centerlines of the bearings from the theoretical straight line condition, so as to achieve an acceptable bearing load distribution.

1.3.8 Alignment Optimization

Alignment optimization is a condition where a mathematically predicted set of bearing offsets produces a satisfactory bearing load distribution for more than one alignment condition.

The shaft alignment optimization estimates the most possible uniform bearing load distribution for any given vessel loading case. It will produce an optimum set of bearing offsets, which will satisfy the vessel loading conditions from very light ballast to the fully-laden condition.

Knowing the hull deflections envelope together with the required operating conditions (e.g. fully loaded, hot dynamic), a bearing offsets range can be defined within which acceptable bearing load distribution.

Performing a reverse engineering calculation with the desired bearing load distribution as input and the bearing offsets range also as input, a specific set of bearing offsets can be calculated (usually more than one) as output, which is to be acceptable under all loading conditions.

This set of bearing offsets is said to be optimal and the shaftline is said to be optimum for alignment purposes, in accordance to the definition given to the alignment optimization.

1.3.9 M/E

Main Engine.

1.3.10 TCM

ABS Tailshaft Condition Monitoring Notation.

1.3.11 Shaft Alignment Sensitive Vessels

Large tank vessels such as Suezmax, VLCC, ULCC, LNGC, large bulk carriers, such as Capesize and VLOC, and large container vessels, i.e. above 9000 TEU are considered to be shaft alignment sensitive vessels.

In addition, the following propulsion systems are considered to be potentially shaft alignment-sensitive installations:

- Directly driven propeller installations
- Low speed diesel installations
- Systems with relatively short and rigid shafting
- Vessels with a relatively flexible hull structure
- Vessels with twin screw installations

3 Application

3.1 General (1 November 2016)

3.1.1 Notation Assignment

Vessels designed and constructed in compliance with the optional requirements of this Guide may be assigned the Class Notation **ESA**.

While the notation has been developed primarily for shaft alignment sensitive vessels and propulsion systems, other types of vessels and other types of powertrains may be granted the **ESA** Notation.

3.1.2 Survey

The Surveyor is to attend all stages of alignment as described herein.

The shipyard is to produce a log with the recordings of all the shaft alignment installation steps, including the sighting data recorded along with the manufacturers' acceptance criteria. The same is to be submitted to the ABS Engineering Office for review and for future reference.

3.1.3 Correlation with Calculations

The onboard shaft alignment is to be consistent with the system description and input parameters as listed in the approved calculations. Correlation between measurements and calculations for various shaft alignment conditions is to be verified at all times and stages of the process. The correlations criteria between calculations and measurements are defined in 3/3.5xxiv).

3.1.4 Other Powertrains

The Class Notation **ESA** is not applicable to ships designed with azimuthal thrusters or nonconventional shaft lines intended for main propulsion, or as otherwise deemed inappropriate by ABS.

3.1.5 Applicability Requirements

Class Notation **ESA** may be assigned to ships designed with one or more propulsion shaft lines that comply with the following:

- i) Propulsion types of direct drives and geared drive installations, as shown in Section 1, Table 1

- ii) The additional calculation requirements of Subsection 2/1 including hull deflections and shaft alignment optimization
- iii) The shaft alignment processes described in Section 3 of this Guide.
- iv) Possess the **TCM** Notation as per 4-3-2/13 of the *Steel Vessel Rules*

3.1.6 Geared Installations

For geared installations, as the low speed shaft will be stiffer than the high speed shaft, only the propeller to gearbox shaft alignment is required to be submitted to ABS for approval.

3.1.7 Alternative Shafting Arrangements

Shafting arrangements applicable for the **ESA** Notation are shown in Section 1, Table 1 below.

In cases of specific shafting arrangements not covered by this Guide, ABS may require additional calculations to verify compliance with the **ESA** Notation requirements.

TABLE 1
Propulsion Types and Shaft Alignment Systems
that can be Covered by the ESA Notation

<i>Propulsion Type</i>	<i>Prime Mover</i>	<i>Alignment System</i>
Direct drive installation	Low-speed diesel/gas engine	from propeller to crankshaft
	Electric motor	from propeller to rotor shaft
Geared drive installation	Medium-speed diesel/gas engine	from propeller to main gearbox output shaft
	Steam/gas turbine	
	Electric motor	

5 Documentation

5.1 Documentation to be Submitted

5.1.1 Drawings

- i) Shafting arrangement
- ii) Intermediate shaft, propeller shaft drawings
- iii) Couplings – integral, demountable, keyed, or shrink-fit, coupling bolts and keys' drawings
- iv) Shaft bearing drawings
- v) Shaft seals' drawings
- vi) Propeller drawings
- vii) Gearbox drawings, as applicable, as necessary
- viii) Stern tube bearing and intermediate bearing drawings

5.1.2 Data (1 November 2016)

- i) Rated power of main engine and shaft rpm
- ii) Allowable bearing loads
- iii) Actual Propeller mass and inertia
- iv) Hull deflections data for light ballast, ballast and fully laden condition. **Hull deflections data for light ballast, ballast and fully laden condition. In the ballast condition hull deflections are to be analyzed with the aft peak tanks full.**