International Association of Oil & Gas Producers

SPECIFICATION
IOGP S-713J

May 2024
Version 1.1

Supplementary Specification to API Standard 613 for Special-purpose Gears

NOTE This version (S-713J) of the specification document provides the justification statements for each technical requirement, but is otherwise identical in content to S-713.

JIP33
JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	PURPOSE
1.1	May 2024	Issued for Public Review
1.0	July 2020	First Edition

Acknowledgements

This IOGP Specification was prepared by a Joint Industry Programme 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

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Foreword

This specification was prepared under Joint Industry Programme 33 (JIP33) "Standardization of Equipment Specifications for Procurement" organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Companies from the IOGP membership participated in developing this specification to leverage and improve industry level standardization globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, resulting in a common and jointly agreed specification, building on recognized industry and international standards.

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The CPC vision is to standardize specifications for global procurement for equipment and packages. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardization initiatives and provide step change benefits in the sector's capital projects performance.

This specification has been developed in consultation with a broad user and supplier base to realize benefits from standardization and achieve significant project and schedule cost reductions.

The JIP33 work groups performed their activities in accordance with IOGP's Competition Law Guidelines (November 2020).

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Introduction

The purpose of the IOGP S-713 specification documents is to define a minimum common set of requirements for the procurement of special-purpose gears in accordance with API Standard 613, Sixth Edition, July 2021, Special-purpose Gears for Petroleum, Chemical and Gas Industry Services, for application in the petroleum and natural gas industries.

The IOGP S-713 specification documents follow a common structure (as shown below) comprising a specification, also known as a technical requirements specification (TRS), a procurement data sheet (PDS), an information requirements specification (IRS) and a quality requirements specification (QRS). These four specification documents, together with the purchase order, define the overall technical specification for procurement.

JIP33 Specification for Procurement Documents
Supplementary Technical Requirements Specification (TRS)

This specification is to be applied in conjunction with the supporting PDS, IRS and QRS as follows.

IOGP S-713: Supplementary Specification to API Standard 613 for Special-purpose Gears

This specification defines technical requirements for the supply of the equipment and is written as an overlay to API 613, following the API 613 clause structure. Clauses from API 613 not amended by this specification apply as written. Modifications to API 613 defined in this specification are introduced by a description that includes the type of modification (i.e. *Add*, *Replace* or *Delete*) and the position of the modification within the clause.

NOTE Lists, notes, tables, figures, equations, examples and warnings are not counted as paragraphs.

IOGP S-713D: Procurement Data Sheet for Special-purpose Gears (API)

The PDS defines application-specific requirements. The PDS is applied during the procurement cycle only and does not replace the equipment data sheet. The PDS may also include fields for vendor-provided information required as part of the purchaser's technical evaluation. Additional purchaser-supplied documents may also be incorporated or referenced in the PDS to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-713L: Information Requirements for Special-purpose Gears (API)

The IRS defines information requirements for the scope of supply. The IRS includes information content, format, timing and purpose to be provided by the supplier, and may also define specific conditions that invoke the information requirements.

IOGP S-713Q: Quality Requirements for Special-purpose Gears (API)

The QRS defines quality management system requirements and the proposed extent of purchaser conformity assessment activities for the scope of supply. Purchaser conformity assessment activities are defined through the selection of one of four generic conformity assessment system (CAS) levels on the basis of evaluation of the associated service and supply chain risks. The applicable CAS level is specified by the purchaser in the PDS or in the purchase order.

The specification documents follow the editorial format of API 613 and, where appropriate, the drafting principles and rules of ISO/IEC Directives Part 2.

The PDS and IRS are published as editable documents for the purchaser to specify application-specific requirements. The TRS and QRS are fixed documents.

The order of precedence of documents applicable to the supply of the equipment, with the highest authority listed first, shall be as follows:

a) regulatory requirements;

b) contract documentation (e.g. purchase order);

c) purchaser-defined requirements (e.g. PDS, IRS and QRS);

d) this specification;

e) API 613.

3 Terms, Definitions, Acronyms, Abbreviations, and Symbols

3.3 Symbols

Table 1—Symbols

Add symbol "d_{w1}"

Symbol	Term	SI Units	USC Units
d_{w1}	operating pitch diameter of pinion 2a/(u + 1)	mm	in.

Delete second occurrence of symbol "u"

Symbol	Term	SI Units	USC Units
~~u~~	~~helix angle at reference diameter~~	~~degrees~~	~~degrees~~

6 Basic Design

6.1 General

6.1.7 Sound Pressure Level

6.1.7.4

Delete "If specified,"

Justification

A sound pressure map is used in plant-wide noise simulations for design sign off and future sound surveys to obtain a permit to start up the plant. This deletion makes the provision of a map of points for sound pressure measurement mandatory for all items.

6.1.7.5

Replace first paragraph with

During testing, the gear vendor shall measure the sound intensity level, the sound pressure level and relative sound spectrum.

Justification

The original requirement provides an option for measuring the sound intensity level rather than the sound pressure level and relative sound spectrum. Sound pressure level and relative sound spectrum are the usually recognized acceptance criteria. This replacement clarifies that all three sound measurements (i.e. sound pressure level, relative sound spectrum and the sound intensity level) are mandatory.

6.1.14

Delete "If specified,"

Justification

This is a mandatory document that needs to be submitted.

Add new section

6.1.23

The limits of speed, torque and duration for reverse rotation of the gear unit shall be provided.

Justification

The gear unit is part of the train and consists of driver and driven equipment. In the event of stoppage of the driver and failure of the check valve, leakage of fluid through the driven equipment may cause reverse rotation. This may damage the bearings of the gear unit. Gear elements and bearings can have unidirectional design. It is important for the operator to be aware of the limits imposed by the design of the gear unit. The purpose of this requirement is for the operator to know how long a gear unit can spin backwards if operating conditions cause reverse rotation.

Add new section

6.1.24

Unless otherwise specified, gears shall be double-helical.

Justification

Double-helical design provides significantly reduced thrust load compared to single-helical gear units, resulting in improved reliability.

6.2 Rating

6.2.1 Gear Unit Rated Power

Add to third sentence

for all configurations, i.e. whether the gear unit is connected directly to the driver or located between two items of the driven equipment.

Justification

The original sentence may imply that the requirement to have all modes of normal and transient operation examined is only applicable to the second sentence of the paragraph (gear units connected directly to the driver). This replacement ensures that the requirement for gear units between two items of driven equipment in the fourth sentence is also included in the examination.

6.2.3 Minimum Gear Tooth Service Factor

Replace Table 4 title with

Table 4—Minimum Gear Tooth Service Factors (C_{SF} and K_{SF})

Add new NOTE

Driven Equipment	Induction Motors	Synchronous and Variable Speed Motors	Steam and Gas Turbines	Reciprocating Engines
NOTE Same value to be used for C_{SF} and K_{SF}.				

Justification

In API 613 fifth edition, there was only one gear tooth service factor. API 613 sixth edition, following ANSI/AGMA, has introduced two different gear service factors for the minimum specified bending service factor and the minimum specified contact stress service factor (although the same value is used). This note clarifies that Table 4 is to be used for both values (C_{SF} and K_{SF}), which consequently will result in no change from API 613 previous edition.

6.2.5 Tooth Pitting Resistance Power Rating

6.2.5.5

In first paragraph, replace "Table 4, grade 2" with

Table 3, grade 2

Justification

The correct reference is Table 3, grade 2 in ANSI/AGMA 2101-D04 (or ANSI/AGMA 2001-D04 when using USC units). This replacement points to the correct reference and prevents errors in calculations.

6.2.8 Pinion Length to Diameter Ratio

6.2.8.2

Add to section

Unmodified leads shall have a minimum contact of 80 % across the tooth length.

Justification

Gear mesh contact is critical to the reliability of the load-carrying of the gear box, lubrication and heat transfer capabilities. API 613 does not contain a minimum contact requirement. A standardized minimum value of 80 % is derived from the operator's experience. Gear mesh inspection in a loaded condition would provide a more accurate representation of contact. This inspection will give a good indication even in unloaded conditions.

6.3 Casings

6.3.1 Design Parameters

6.3.1.1

Add to section

Shims shall not be used between the gear housing and the bearing shell.

Justification

The use of shims between the housing and the bearing introduces flexibility into the bearing system. This flexibility could result in the loss of the intended gear mesh alignment.

6.3.1.5

Add to section

Gear casings shall have provision for two earthing connections at diagonally opposite locations.

Justification

Earthing of each piece of equipment is an essential electrical system safety requirement which is not covered in API 613. Therefore, suitable provision needs to be made on the gear unit casing to carry out earthing work.

6.3.1.6

Add to section

If specified, thermo-structural finite element analysis (FEA) of the gear casing shall be performed.

Justification

Finite element analysis verifies that the casing is not damaged due to distortion caused by temperature, torque, and allowable external forces and moments.

6.3.1.8

In first sentence, replace "ASTM A312/A312M" with

316L stainless steel

Justification

316L stainless steel is typically preferred over ASTM 312/312M for piping in upstream oil and gas applications due to its superior corrosion resistance in marine environments.

In third sentence, replace "ASTM A269/A269M" with

316 stainless steel

Justification

316 stainless steel is typically preferred over ASTM A269/A269M for tubing in upstream oil and gas applications due to its superior corrosion resistance in marine environments.

6.3.1.13 Filter Breather

6.3.1.13.2

Replace "300 stainless steel" with

316 stainless steel

Justification

This replacement ensures that the material of construction provides adequate corrosion resistance. For oil and gas facilities installed in marine environments, 316 stainless steel offers superior corrosion resistance compared to other common 300 series stainless steels.

Add new section

6.3.1.13.4

The filter breather shall be flanged.

Justification

A flanged filter breather offers operational and maintenance benefits. A screwed connection may get damaged during removal and reassembly. A flanged connection is more robust, allowing for easier removal and cleaning without damaging the connection. A flanged connection also provides the ability to extend the outlet connection in the field if needed.

6.3.1.14

Add to section

The top surface of the inspection opening shall be raised at least 25 mm (1 in.) from the gear casing.

Justification

Inspection covers are located on the top of the gear casing upper half and tend to accumulate dirt and water. This accumulation may affect the life of the gasket between the casing upper half and the inspection cover. Raising the inspection opening protects the gasket and prevents the ingress of dirt or water inside the gear casing when the cover is opened.

6.3.3 Bolting

6.3.3.1

Replace section with

Case bolting shall use through-bolting or studs.

Justification

This replacement removes the usage of cap screws from the requirement. Cap screws do not produce the same amount of pre-stretch compared to that achieved by the use of bolts or studs. Cap screws do not permit verification of bolt pre-stretch. It is also difficult to maintain joint tightness with cap screws. Cap screws are difficult to maintain for long-term operation.

Add new section

6.3.3.7

Fasteners internal to the gearbox shall be positively locked or retained.

Justification

Loose fasteners can result in high consequence asset damage. Internal fasteners that are positively locked or retained ensure that the fasteners do not become loose with time.

6.4 Casing Connections

6.4.9 Threaded Plugs

6.4.9.2

Replace section with

Plugs shall be 316 stainless steel.

Justification

This replacement ensures that plugs are manufactured from a suitable corrosion-resistant material for the offshore marine environment. In addition, the original API 613 requirement is only applicable to plugs requiring removal. The requirement has been modified to be applicable to all plugs. It is not practical to ask the vendor to determine which plugs will be removed in the future.

6.5 Gear Elements

6.5.3 Fabrication

6.5.3.2

Add to section

Double-helical gear wheels shall be made from a single forging.

Justification

Double-helical gears constructed from two separate forged gear wheels could result in teeth misalignment during assembly on the shaft due to manufacturing tolerances. This requirement is added to ensure that double-helical gears are made from a single forging, preventing the risk of misalignment.

6.5.4 Shafts

6.5.4.1

Add new list section e)

e) the heat treatment of shaft forgings and hot-rolled barstock shall include stress relieving.

Justification

Heat treatment of shaft forgings and hot-rolled barstocks may not include stress relieving. Residual stresses may affect the shaft dimensions and gear geometry after machining.

6.6 Dynamics

6.6.1 General

6.6.1.3

Add to section

The structural dynamic analysis report shall include the calculation of structural resonance, mode shapes and dynamic stiffnesses.

Justification

Structural dynamic analysis report is needed by the gearbox manufacturer and the result is used in the lateral analysis calculation. This requirement provides verification of 6.6.1.3 by ensuring that the structural analysis is performed and reviewed by the purchaser. The effective stiffness of the structural support is to be considered in the analysis of the dynamics of the rotor-bearing-support system.

6.6.2 Lateral Analysis

6.6.2.2 Undamped Analysis

6.6.2.2.3

Add new list item c)

c) bearing dynamic stiffness curves for the 10 %, 50 % and 100 % power levels to be plotted as in Figure 5.

Justification

The bearing load is dependent upon both the rotor weight and the gear power level. The undamped analysis needs to account for the varying load on the journal bearings at the power levels required. This plot allows all the three power levels to be seen as in Figure 5.

6.6.2.3 Damped Unbalanced Response Analysis

6.6.2.3.1

Add to list item e)

Damped rotor analysis shall include the normal operating point of the driven equipment and any other operating point specified.

Justification

Special-purpose gear units are utilized for critical applications. Damped rotor lateral analysis is essential to demonstrate by calculations that the gear unit rotors provide adequate separation margin from the rotor critical speeds, acceptable vibration levels and stable operating conditions.

6.6.2.3.5

Add new list section d)

d) If the AF at a particular critical speed is greater than or equal to 2.5, the operating speed of the gearbox rotor is not within (+/-) 10 % of the critical speed of the other rotors (cross talk between gear and pinion).

Justification

Vibration energy is transferred by gear tooth contact from one rotor to the other. This requirement maintains a typical margin of 10 %. 10 % is considered an adequate margin and is consistent with API 684 for low damping criteria.

6.6.2.3.6

Add to section

The actual critical speeds determined on the mechanical running test shall not deviate from the corresponding critical speed ranges predicted by analysis (see 6.6.2.3.4) by more than ± 5 %.

Justification

This requirement is added to be consistent with API rotor dynamic requirements on accuracy of critical speed prediction. See API 684, specifically SP6.8.3.2 a) for the reference to ± 5 %.

6.6.2.4 Stability Analysis

6.6.2.4.5

Delete "For some rotors," from second sentence

Justification

This deletion clarifies that stability analysis with the minimal load conditions is to be performed for all rotors.

6.6.2.4.6

Replace "final log decrement greater than 0.1" with

log decrement greater than 0.1 for all conditions defined in 6.6.2.4

Justification

This replacement clarifies that the stability analysis is for each individual calculated log decrement (see all load conditions in 6.6.2.4), not a single final log decrement.

6.7 Bearings and Bearing Housings

6.7.1 General

6.7.1.3

In first sentence, replace "at rated speed" with

at all operating conditions

Justification

The bearing design temperature is within the control of the supplier by their bearing selection, and lower temperatures mean higher reliability and service life of the gear and lubricating oil.

6.7.1.5

Delete "When specified," from first sentence of first paragraph

Justification

UT is typically the non-destructive testing performed to verify the proper bonding between babbitt and backing material.

6.7.3 Thrust Bearings

6.7.3.2

Add new list section e)

e) be removable without the need to remove the gear rotor.

Justification

Removing the rotor to access the thrust bearing adds significant downtime and maintenance activities. Additionally, there is an increased risk of damaging the rotor during removal and re-installation.

6.7.4 Bearing Housings

6.7.4.6

Replace list item c) with

c) two radial probes per radial bearing;

Justification

Radial vibration probes provide information for monitoring and analyzing the condition of the machine. Vibration signals from both shaft ends are needed for a complete overview of the dynamic operation of the machine and for troubleshooting.

6.9 Materials

6.9.2 Welding

6.9.2.1

Add before first sentence

Welding of rotating parts shall not be permitted.

Justification

Welding of rotating parts is not permitted as these components are highly stressed and are operating under dynamic loading. Welding introduces additional stresses, uncontrolled residual stress under centrifugal loading and uncertainty in gear mesh alignment in the welded components.

In first paragraph, replace "Welding of rotating parts and other highly stressed parts" with

Welding of highly stressed parts

Justification

Welding of rotating elements is not permitted as these components are highly stressed and operate under dynamic loading. Welding introduces additional stresses, uncontrolled residual stress under centrifugal loading and uncertainty in gear mesh alignment in the welded components. This replacement aligns with the new requirement added before the first sentence of this section.

6.9.2.3

Add to section

Weld repairs shall be defined as major when the depth of the cavity after the preparation for repair exceeds 20 % of the wall thickness or 25 mm (1 in.), whichever is smaller, or when the extent of the cavity exceeds 65 cm^2 (10 $in.^2$).

Justification

API 613 specifies purchaser approval for major weld repairs but does not provide a definition or criterion for major vs minor defect. This definition of major weld defect is consistent with IOGP S-615 and many of the major operating companies' current requirements for gear boxes.

8 Inspection, Testing, and Preparation for Shipment

8.2 Inspection

8.2.3 Mechanical Inspection

8.2.3.3

Add to section

Gear tooth and pinion tooth hardness tests (see 6.2.4), checks and associated documentation shall be mandatory.

Justification

This requirement ensures that the optionality of hardness testing does not apply to the gear tooth and pinion tooth. Gear tooth and pinion tooth hardness testing is mandatory (i.e. not an option). Inspection levels for gear tooth and pinion tooth hardness testing are provided in IOGP S-713Q.

8.3 Testing

8.3.2 Mechanical Running Tests

8.3.2.1 Mechanical Test Requirements

Add new section 8.3.2.1.0 before section 8.3.2.1.1

8.3.2.1.0

The following records shall be made available before the start of the mechanical run test:

— tooth contact in both the checking stand and the gear casing;

— plots of mechanical and electrical run out;

— residual unbalance records;

— test stand shaft alignment (face, rim and axial spacing) for each test setup;

— as-built clearances;

— results of tooth profile, lead, pitch circle run out and tooth-to-tooth spacing tests.

Justification

These records are held at the manufacturing facility and are not part of the manufacturing record book. The review of this documentation allows the purchaser to verify that the testing or inspection of the bulleted items meets the acceptance criteria prior to the start of testing.

8.3.2.2 Performing Running Tests

8.3.2.2.7 Critical Speed Test Results

8.3.2.2.7.2

Replace section with

The data in 8.3.2.2.7.1 shall be furnished in Bode plots for radial vibration probes, polar plots for radial vibration probes and Bode plots for accelerometers during run up and coast down.

Justification

Machine critical speeds and casing resonance conditions are detected using Bode and polar plots. Such plots are produced during run up and coast down of the gear unit. Proximity probes (radial vibration on bearings) and accelerometers (casing vibration) are best suited for specific frequency ranges and fault diagnoses. The radial vibration provides information about the shaft movement and the accelerometers detect high-frequency vibration data such as gear mesh forcing frequencies.

8.3.2.2.8

Delete "If specified," from first sentence

Justification

Conducting a mechanical run test by varying the lube oil pressure and temperature is required in all cases to demonstrate that the gear can operate through the minimum and maximum temperature and pressure conditions of the lube oil.

8.3.2.2.12

In third sentence of first paragraph, replace "frequency exceeds 20 % of the allowable vibration amplitude" with

frequency exceeds 20 % of the allowable vibration amplitude or 6.5 µm (0.25 mil)

Justification

This additional value of 6.5 µm (0.25 mil) provides a more consistent approach for non-synchronous vibrations across API standards.

8.3.2.2.15

Delete "If specified,"

Justification

Real-time vibration data records are mandatory and to be included in mechanical running test records.

8.3.4 Optional Tests

8.3.4.4

Add to section

The sound-level test shall be mandatory.

Justification

Sound level testing is mandatory for these special-purpose gearboxes because of their inherently high noise level.

Annex A
(informative)

Special-purpose Gear Unit Datasheets

Replace Annex A with

IOGP S-713D shall be used as the special-purpose gear PDS.

Justification

IOGP S-713D is to be used as the special-purpose gear PDS as part of the IOGP S-713 set of specification documents (see introduction of this specification).

Annex E
(normative)

Vendor Drawing and Data Requirements

Add to start of annex

The contents of IOGP S-713L shall be used to define vendor drawing and data requirements.

Justification

IOGP S-713L is to be used as the special-purpose gear IRS as part of the IOGP S-713 set of specification documents (see introduction of this specification). IOGP S-713L takes precedence as the source for all documentation requirements and takes some of its requirements from this annex.

Annex G
(informative)

Gear Tooth Quality Inspection

G.3 Modified Tooth Flanks

G.3.1 Helix Modification (Lead Modification)

G.3.1.2

In NOTE, replace "Table 4" with

6.2.8.1

Justification

This requirement points to the correct reference and prevents errors in calculations.

Bibliography

Add to start of Bibliography

The following documents are informatively cited in the text of this specification, API 613, the PDS (IOGP S-713D) or the IRS (IOGP S-713L).

Add to Bibliography

[49] API Specification Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

[50] API Specification Q2, *Specification for Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries*

[51] EN 10204, *Metallic products — Types of inspection documents*

[52] IOGP S-615 *, *Supplementary Specification to API Standard 610 for Centrifugal Pumps*

[53] ISO 9001, *Quality management systems — Requirements*

[54] ISO 10005, *Quality management — Guidelines for quality plans*

[55] ISO 10474, *Steel and steel products — Inspection documents*

[56] ISO/IEC 17000, *Conformity assessment — Vocabulary and general principles*

[57] ISO/IEC Directives, Part 2, *Principles and rules for the structure and drafting of ISO and IEC documents*

* Cited in IOGP S-713J only.

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