



GS 134-4

CENTRIFUGAL PUMPS TO API 610

December 1997

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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SCOPE AND PURPOSE This BP Group Guidance for Specification covers requirements for Centrifugal Pumps and for pumps which are operating as hydraulic power recovery turbines. It is for use with a data sheet to adapt it for a specific application. It supplements API Standard 610 by defining optional clauses, substituting, qualifying, or substituting other clauses, and providing additional guidance.											
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Issued by:- Engineering Practices Group, BP International Limited, Research & Engineering Centre Chertsey Road, Sunbury-on-Thames, Middlesex, TW16 7LN, UNITED KINGDOM Tel: +44 1932 76 4067 Fax: +44 1932 76 4077 Telex: 296041											

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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

This Guidance for Specification defines a number of the optional API Clauses and may substitute, add to, or qualify other API Clauses using knowledge and experience from BP's worldwide operations

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Guidance for Specification, and may discuss alternative options.

This document may refer to local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirement lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. GENERAL

1.1 Scope

- 1.1.1. This BP Group RPSE specifies BP requirements for centrifugal pumps and hydraulic power recovery turbines conforming generally to [API 610](#). They shall meet the requirements of [API 610](#), eighth edition, August 1995, except as amplified and modified herein.

(Substitution for [API 1.1.1](#))

- 1.1.2 The use of pumps within the categories given in [API 610](#) shall be subject to the particular limitations given in the appropriate sub-section.

(Qualification of [API 1.1.2](#))

- 1.1.3. The requirements of this BP Group RPSE shall be met where pumps which fall within the limitations set out in [API 610](#) for non-hazardous and non-flammable service are deemed to be in a critical service

- 1.1.4. Where specified on the data sheet pumps that are not required to comply with [API 610](#) they shall meet the requirements of [BS EN25199](#).

1.2 Alternative Designs

This BP Group RPSE refers to national and international standards which are widely accepted. Codes and Standards of the country where the equipment is manufactured and/or operated will be considered and may be accepted where they can be used to achieve an equivalent technical result. The list of equivalent standards presented in Appendix A may be presumed to be equivalent. Applicable statutory and local regulations must be complied with.

(Addition to [API 1.2.2](#))

1.3 Conflicting Requirements

In case of conflict between this BP Group RPSE and inquiry or order, the order of precedence shall be:-

- (a) Local Authority or Statutory Regulations
- (b) The Equipment Requisition or Purchase Order, and Data Sheets
- (c) This BP Group RPSE
- (d) API Standards
- (e) Other Industry and National Standards and Specifications



2 BASIC DESIGN

2.1 General

2.1.1 *The definition of normal wear parts as set out in Table 6.1 includes a number of parts which can and should be designed for the service life. The exclusion of parts from the 20 year life basis should be considered on the basis of the particular design criteria, e.g. the impact of corrosion rates on casing material may preclude a 20 year life in particular instances but generally a casing should be capable of meeting the basic design criteria.*

2.1.2 The pump vendor shall co-ordinate the design, and ensure the satisfactory functioning of the complete unit, i.e. pump, driver, transmission, seals and other ancillaries. In cases where the pump vendor supplies equipment that he has not manufactured, he shall ensure that the designs of these are compatible with each other and with his own equipment in all respects. In particular, they shall be compatible dimensionally, in performance, in control and in vibration such that a fully integrated unit is achieved. The satisfactory functioning of the complete unit shall form part of the pump vendor's guarantee.

(Substitution for [API 2.1.2](#))

For pumps which are to be installed within the European Union the supplier is responsible for affixing the CE Mark. Where the pump vendor is not the supplier for the purpose of “The Supply of Machinery (Safety) Regulations” a certificate of conformity has to be issued. In such cases the supplier responsible for affixing the CE mark should be established.

2.1.11 All pumps shall have stable head/capacity curves which continuously rise to shutoff and shall be suitable for parallel operation. The head rise from the rated point to shutoff shall be a minimum of 10% of the head at rated capacity.

(Substitution for [API 2.1.11](#) 1st & 2nd sentences)

The objective of parallel operation is for the number of operating pumps to share the loading equally. To achieve this objective, pump characteristics must match and achieve the same duty point at the operating flow conditions. Allowing for a range of duties, including off-design conditions, this is best achieved by a performance characteristic which will equally share the loading when operating in a identical system. It has to be recognised that pump operating points are determined by the interaction of the system and pump operating points are determined by the interaction of the system and pump characteristics. In parallel

operation each characteristic's gradient and the extent by which the curves deviate from each other are factors in determining the load sharing. The flatter the pump characteristic the greater the flow deviation will be for a small head differential. As a general rule the duty point on each curve should match within 2% and the head rise to shut-off should not be less than 10%. The requirements for head rise should consider the impact of allowable tolerances during pump testing.

- 2.1.12 Pumps shall be selected with the best efficiency point as close as possible to the normal operating point. No operating point shall exceed 115% of the best efficiency point, nor be less than the minimum continuous stable flow. For variable speed pumps these requirements shall relate to the best efficiency point and minimum flows at the expected operating speed.

(Substitution for [API 2.1.12](#))

- 2.1.14 Noise limits will normally be specified in detail in the enquiry. However, in the absence of such requirements, noise levels at or beyond 1 m from the machine (plus driver, transmission and ancillaries) surfaces, shall not exceed 85 dB (A).

Note: The allowable noise level from the pump set (pump auxiliaries and driver will be affected by the operating pattern in the installation. Where 12 hour shifts are worked it may be necessary to reduce the noise limits accordingly.

The vendor shall provide the following details of the noise emission from his equipment ;

The SPL in octave bands, obtained by the methods of test as specified in [EEMUA Publication No. 140](#).

Narrow band or impulsive noise which is noticeable to the ear and the octave band or bands in which it occurs.

When the vendor cannot meet the foregoing limits without the addition of noise attenuation features, the levels with and without these features shall be stated in the proposal.

Noise attenuation measures proposed by the vendor shall not conflict with the other requirements of this BP Group RPSE. Noise attenuating enclosures will be accepted only when there is no alternative form of noise control and their use shall be subject to approval by BP.

The design of these enclosures shall be such that the normal operation and maintenance are not unduly compromised. In particular, all instrumentation and controls shall be either mounted externally to the enclosure, or clearly visible and controllable from outside the enclosure.



Enclosures shall be adequately purged and cooled. Instrumentation, sensors and cables installed enclosures shall not be subjected to an environment which causes the component to be operated outside the vendor's specified ambient temperature limits.

(Substitution for [API Section 2.1.14](#))

2.1.16 *The need for proven operational experience with pumps of high energy levels should be the first reassurance of suitability for an application. Where application experience is not available performance testing should be carefully evaluated.*

2.1.17 *Reliance on bearing housing cooling to achieve the operational capability of bearings, or to achieve the L10 life required must be considered a last resort.*

2.1.20 *The design basis for CW systems should always be obtained from the Utilities data sheet and should take account of the local CW Specification*

2.1.29 Boiler feed pumps shall be suitable for operation in wet and humid environments.

(Addition to [API 2.1.29](#))

2.2 Pressure Casings

2.2.6 Ring section casings with external tie bolts shall not be used for multistage pumps handling flammable and toxic fluids or for boiler feed pumps above 55 bar(g).

(Addition to [API 2.2.6](#))

The joint face of an axial split casing pump may prove difficult to make leak tight at high pressures. Where axial split casing pumps are proposed for multi-stage pumps the configuration and inter-stage tightness requirements of the joint face, and the operating experience with the design should be evaluated against the required duty, e.g. high pressure, high temperature water will be superheated steam under atmospheric conditions.

2.2.8 *The note appended to this paragraph in [API 610](#) emphasises that the piping loads should be restricted to the values quoted in section 2.4 or as agreed with the vendor*

2.2.9 *The effect of temperature on the alignment or on the loading that piping imposes on pumps should be considered to ensure that the design is compatible with the pumping temperatures*

2.3.2.2 *Where vent and drain connections are terminated with valves bracing may be necessary to ensure that the connection is not overloaded or subject to fatigue failure.*

2.3.3.11 *The provision of Pressure Gauge Connections on casings may be avoided if local connections are provided on piping.*



2.7 Mechanical Shaft Seals

- 2.7.2.10 Pumps working above atmospheric pressure shall be designed to have suction pressure on the stuffing box. For pumps operating under a vacuum, stuffing boxes shall be designed to operate at the minimum practical positive pressure.

(Addition to [API 2.7.2](#))

- 2.7.3.1 Shaft sleeves shall be hard faced where in contact with packing, or where in contact with the dynamic secondary seal of a mechanical seal assembly.

(Addition to [API 2.7.3.1](#))

- 2.7.3 The manufacturer, type, configuration and duty of mechanical seals shall be the subject of agreement between seal vendor and pump manufacturers, and shall be approved by the purchaser.

(Substitution for [API 2.7.3](#))

The initial approach in [API 610](#) is to comply with [API 682](#) which requires cartridge seals and, if implemented will give a consistent approach to the selection of mechanical seals. [API 682](#) sets out acceptable configurations for single and multiple seal installations. If [API 610](#), rather than [API 682](#), is followed the requirement is also for cartridge seals. The use of cartridge seals simplifies the installation and maintenance of pumps and allows assembly and maintenance of the seal to take place off line. The seals specified are all balanced seals.

The initial approach to mechanical seals should be to use cartridge seals as specified in [API 610](#) and [API 682](#). By adopting [API 682](#) it can be ensured that the seal will have been type tested. The requirements of the eighth edition of [API 610](#) are generally in line with those set out in [API 682](#).

Several of the clauses in [API 610](#) are taken from [API 682](#) with minor modifications. Consequently, even if [API 682](#) is not adopted review of its clauses may clarify the intention of the requirement.

For critical applications adopting [API 682](#), which has the stated intention of allowing a three year operating life to be achieved should be considered. Where relevant user operating experience is available it should be evaluated.

- 2.7.3.5 The static pressure rating of seals shall be no less than the maximum discharge pressure of the pump. Additionally, components shall be capable of withstanding corresponding hydrostatic test pressures. The seal should be suitable for the maximum allowable temperature of the pump.

(Amplification of [API 2.7.3.5](#))

The seal will generally be supplied by the pump supplier who should be required to ensure that all components are compatible with the maximum allowable working pressure of the pump.

- 2.7.3.6 *The minimum dimensions of the seal chamber given in [API 610](#) should be considered to be a basic requirement for the effective operation of the seal. It should be noted that work done by BHRA indicates that conical section seal chambers enable effective cooling and fluid circulation allowing the seal to function correctly.*

- 2.7.3.7 Copper or bronze filled carbon or other copper -bearing materials shall not be used for services involving contact with carbonates, high concentrations of H₂S, ammonia and acetylenes.

(Addition to [API 2.7.3.7](#))

- 2.7.3.19 Where filters are required in seal flushing lines, these shall be of the cyclone type.

(Addition to [API 2.7.3.19](#))

- 2.7.3.20 *The installation of a non-sparking floating throttle bush should be considered when there is a need for leakage to be minimised irrespective of the seal arrangement to be installed.*

Where leakage of the barrier fluid is itself hazardous a throttle bush should be installed.

- 2.7.3.21 *The use of dry running outer seals without a barrier liquid may avoid the need for a barrier fluid reservoir and ancillary instrumentation but the limitations on the operating life of the dry-running seal needs to be evaluated against response necessary in the event of a inner seal failure.*

Where there is an available, suitable, inert gas which the process can tolerate, gas barrier seals may be suitable for this application.

2.8 Dynamics

2.8.2 Lateral Analysis

- 2.8.2.1 The vendor shall perform a lateral critical speed analysis for all pumps with wet critical speeds likely to be below 120% maximum continuous speed with clearances double the maximum design values.



A damped unbalance response analysis shall be performed on such pumps with a rating above 1000 kW.

(Qualification of [API 2.8.2.1](#))

2.8.2 Torsional Analysis

2.8.2.1 The vendor shall perform a transient torsional vibration analysis for trains incorporating synchronous motors or variable speed motors.

(Qualification of [API 2.8.2.1](#))

The impact of torsional excitation during the start-up and shutting down of pumps which are driven by variable speed motors must be considered as potential excitations of torsional frequencies.

2.8.2.2 *Excitations of torsional frequencies shall be considered on the basis of the drive characteristics and the number of masses which have to be considered. The number of masses will dictate the number of frequencies that can be calculated, e.g. for a pump driven through a speed decreasing gear box by a single wheel turbine it is possible to describe the system by four masses and predict three torsional frequencies. For gears with hunting tooth combinations i.e. the number of teeth on both the wheel and the pinion are arranged so that the same teeth do not mesh on each revolution, the excitations considered should take account of the hunting tooth combinations*

2.8.3 Vibration

2.8.3.1 *The limitations on the operating region of a should be evaluated where there is a requirement for the pump to operate outside its preferred operating region. If high vibration, which will have an impact on bearing and seal life, cannot be avoided with the selected pump, consideration should be given to an alternative pump selection.*

2.8.3.2 Unfiltered vibration measurements shall be carried out during the performance test. FFT Spectra should be required if the pump is required for continuous operation outside its preferred operating region and for multi-stage pumps above 1000k W rating.

The requirement for a FFT on each pump is considered to be an excessive requirement where many pumps are operating within their effective operating range. In the case of critical pumps which are essential to continuous operation or where operating experience to support the performance of the pump at the proposed operating point is not available a more extensive vibration analysis should be carried out. Where an FFT is provided it is necessary to ensure that pump data required to facilitate the necessary analysis of the data is available.

2.8.4 Balancing



- 2.8.4.6 *Where the balancing machine calibration is carried out regularly and the calibration procedure can be audited it may not be necessary to complete a residual unbalance check.*

2.9 Bearings and Bearing Housings

- 2.9.1.1 *Where hydrodynamic radial bearings and rolling element thrust bearings are proposed the compatibility of the bearings should be examined.*

- 2.9.1.2 When hydrodynamic thrust bearings are proposed the following shall apply:-

- (a) Pump hydraulic designs shall be such that axial loads are uni-directional under all operating conditions.
- (b) The pump vendor shall submit with his bid, curves showing the variation of axial load with capacity (zero flow to 125% flow) for design internal clearances and two times design internal clearances. For variable speed units, similar curves for maximum continuous speed and minimum continuous speed shall be submitted.

(Addition to [API 2.9.1.2](#))

- 2.9.1.3-2.9.1.4 *The diametrical clearance in the housing will be of particular concern when rolling element thrust bearings are combined on a single shaft with hydrodynamic radial bearings. The clearances of typical arrangements such as back-to back angular contact bearings shall be of concern if combined with hydrodynamic radial bearings.*

2.9.2 Bearing Housings for Horizontal Pumps

- 2.9.2.2 *Attention is drawn to the need for a permanent indication of oil level. A Bull's eye indicator meets this requirement.*

- 2.9.2.5 Where estuarine or sea-water is specified by BP for cooling, the water velocities, and small bore connection sizes, as well as the materials to be employed in the cooling system, shall be subject to agreement between the supplier and the responsible engineer.

(Addition to [API 2.9.2.5](#))

- 2.9.2.6 *The “Inpro” design of seal is effective in retaining oil and minimising the entry of foreign material into bearing housings. Where turbine drives are to be used or where steam or water vapour is present in the area it may be necessary to use an inert buffer gas to prevent the ingress of water into the bearing housing.*

- 2.9.2.11 *The provision of threaded connections should be considered in conjunction with the overall approach to condition monitoring where the pumps are to be installed.*



2.10 Lubrication

2.10.1 *Where pumps use rolling element bearings consideration may be given to the suitability of the application for grease lubrication.*

2.10.2 *Oil rings should be limited to a journal speed of 10 metres per second unless proven experience can be cited in support of the application. The use of cooling to allow the use of oil ring lubrication is of benefit in only marginal cases. It is also necessary to ensure that the ring is sufficiently heavy to function. Consequently care should be taken where non-metallic rings are proposed.*

2.10.3 *Oil mist lubrication is applicable to units having rolling element bearings which are usually splash lubricated. Purge oil mist may be used in conjunction with other systems but may, in such cases, require specific attention.*

In an oil mist system the pressure in the bearing housing is marginally above atmospheric. There is therefore, the potential for a continuous escape of oil vapour to the atmosphere.

A purge oil mist system is used in conjunction with splash lubricated bearings to supplement the lubricant supply and reduce the possibility of contaminant ingress.

In a pure oil mist system the lubrication of bearings is achieved by the oil mist. Surplus oil is drained continuously from the bottom of the bearing housing to remove wear particles and contaminants.

2.11 Materials

2.11.1 General

2.11.1.1 For duties where 12% Cr steel is specified as the casing material, grade CA6NM shall be supplied.

(Qualification of [API 2.11.1.1](#) and Appendix H Table H-2)

2.11.1.7 The pump vendor shall furnish chemical and mechanical data for pressure-casing parts from the heat of the material supplied.

(Qualification of [API 2.11.1.7](#))

2.11.1.11 'Sour Service' shall be understood to be as defined in [GS136-1](#). Pumps for 'Sour Service' shall conform to the requirements of [GS136-1](#).

Pumps handling sea water or brine above 40°C (104°F) contaminated with oil and H₂S shall be fabricated in a super duplex stainless steel or a more corrosion resistant material.

(Addition to [API 2.11.1.11](#))



- 2.11.1.13 With reference to API Appendix G, Table G.1, the service: diesel oil; gasoline; naphtha; kerosene; gas oils; etc. at temperatures above 370°C (698°F), the material for construction of the casing shall be subject to approval. Austenitic stainless steel may be required to avoid problems of temper embrittlement.

(New Paragraph)

2.11.2 Castings

- 2.11.2.3 All weld repairs to pressure-containing castings except those classified as minor in the case of Inspection category A, shall be subject to prior approval. For categories B and C, a weld map showing the dimensions and location of all weld repairs shall be provided by the manufacturer.

Major weld repairs are defined as follows:-

- (a) Any repairs to cast iron components.
- (b) Repairs to leaks occurring on hydrostatic test.
- (c) Any repairs where the depth of excavation exceeds 20% of the wall thickness or 25 mm (1 in), whichever is the smaller.
- (d) Any individual repair where the area of excavation exceeds 65 square centimetres (10 square inches).
- (e) The total surface area of repairs exceeds 20% of the casting surface.

All other weld repairs are classified as minor.

Inspection categories are as defined in 4.2.1.3 of this BP Group RPSE.

(Addition to [API 2.11.2.3](#))

- 2.11.2.3.1 All weld repairs to as-cast or rough machined components shall be heat treated. As a minimum, a stress relief heat treatment shall be applied. In the event that final machining reveals the need for further weld repair, this shall be subject to approval by BP prior to rectification.

Heat treatment records shall be provided by the manufacturer.

Welding procedures and qualifications shall be subject to approval by BP.



No casting shall contain a weight of weld metal greater than 10% of the total mass.

(Addition to [API 2.11.2.3.1](#))



2.11.3 Welding

2.11.3.6 With reference to API Appendix G table G-1, welds for use in the following services shall be stress relieved:-

- (a) MEA, DEA, TEA-stock solutions,
- (b) MEA-lean solution (CO₂ only),
- (c) MEA-lean solution (CO₂ and H₂S),
- (d) MEA, DEA, TEA-rich solutions,
- (e) Hydrofluoric acid concentration greater than 96%.

(Addition to [API 2.11.3](#))

3. ACCESSORIES

3.1 Drivers

3.1.5 *For an electric motor driver the requirements for area classification and for the applicability of Standards should conform to the ruling specifications and regulations for the country of installation consequently the specifications referenced under (e) and (l) should only be adopted where authoritative*

3.1.9 Steam turbines shall conform to [API 611](#). They shall be sized to deliver continuously at least 112% of the maximum power required for the purchaser's specified operating conditions while operating at a corresponding speed with the specified steam conditions. They shall also be capable of delivering continuously 102% of the maximum power with the worst steam conditions.

(Substitution for [API 3.1.10](#))

3.2 Couplings and Guards

3.2.2 Flexible element couplings incorporating a spacer piece shall be of a design in which the spacer piece is retained if a flexible element ruptures.

(Addition to [API 3.2.2](#))

3.2.7 Couplings shall meet the balance requirements of BS 6861 Grade G 2.5.

(Substitution for [API 3.2.7](#))

3.2.12 All moving parts shall be guarded in accordance with [BS 5304](#) or equivalent national standard. The guard shall be steel unless conditions specifically require an alternative. Where alternative materials are proposed, these shall be subject to approval. Guards shall

be sufficiently robust to resist distortion in normal industrial use, to avoid risk of sparking due to contact with moving parts.

(Substitution for [API 3.2.12](#))

3.3 Mounting Plates

3.3.2 Base plate dimensions shall be such that overhang of the mounted equipment does not occur. A raised lip is required around the upper edge. Drain rims around the lower edge are not acceptable.

(Qualification of [API 3.3.2](#))

3.3.6 *The pipe loading test should be considered only when pipe loadings are likely to be close to the specified limits.*

3.3.12 Baseplates should not have to rely on grouting to achieve the necessary rigidity

3.4 Instrumentation

The instrumentation requirements for each pump should be compatible with the overall instrumentation requirements and philosophy for the plant where the pumps are to be installed. Where appropriate the BP Specifications should be applied.

3.4.5 Tachometers shall be fitted to pumps with variable speed drivers.

They shall be readable in the control room or, when specified, from the local control point.

(Addition to [API 3.4](#))

3.5 Piping and Appurtenances

3.5.1 General

3.5.1.4(f) All auxiliary piping carrying external services shall terminate with block valves, and shall be designed to permit ready disconnection of pipe-work from the pump.

(Addition to [API 3.5.1.4.f](#))

3.5.2 Auxiliary Process Fluid Piping

3.5.2.8 Valves shall be provided on all vent and drain connections. Vent outlets shall be taken down to the base plate.

(Substitution for [API 3.5.2.8](#))



- 3.5.2.10.1 For corrosive and sour services, attention is drawn to the possibility of crevice corrosion at socket welded fittings. For these services, the design of all welded joints shall be subject to approval.

(Addition to [API 3.5.2.10.1](#))

3.5.4 Cooling-Water Piping

- 3.5.4.3 Sight flow indicators of the floating ball type shall be provided for each flow path.

The location of sight flow indicators should allow them to be visible from the CW control valves

(Qualification of [API 3.5.4.3](#))

4. INSPECTION, TESTING AND PREPARATION FOR SHIPMENT

4.1 General

- 4.1.4 The vendor shall operate a quality management system to ensure that the technical requirements of this BP Group RPSE are achieved. The vendor's quality system should be based on the appropriate part of [ISO 9001](#). BP may require demonstration of the quality system, but this may be waived if the system has been verified recently by an accreditation scheme acceptable to BP.

The vendor shall ensure that QA requirements specified in the enquiry and purchase documents are applied to all materials, equipment and services provided by sub-contractors and to any free-issue materials.

Shop inspection by a BP nominated inspector will be required. The extent of inspection shall be subject to approval by BP for each order, but should normally include all level 1 and level 2 items from Appendix N of [API 610](#) ,plus items 1-6, of level 3.

The remaining items of level 3 depend upon the extent of supply and should be applied as appropriate.

(Substitution for [API 4.1.4](#))

4.2 Inspection

- 4.2.1 General



4.2.1.3 Pressure-containing castings shall be inspected in accordance with the requirements of the relevant inspection category. Figure A of this BP Group RPSE shows the inspection categories to be used where pressure/temperature are the determining factors in the inspection category. Where other factors such as the corrosive properties of the pumped fluid become dominant the inspection requirements shall be specified in the data sheet.

However, Category A shall be limited to casings manufactured from cast iron and cast steel. For other materials within the Category A envelope, Category B inspection is required.

The minimum inspection requirements shall be as follows:-

Category A Visual inspection in accordance with 4.2.2.6 of this BP Group RPSE.

Category B Visual inspection (category A) and magnetic particle or liquid penetrant inspection in accordance with 4.2.2.4 or 4.2.2.5 of this BP Group RPSE.

Liquid penetrant inspection shall be employed only when magnetic particle inspection is not feasible.

Category C Category B inspection, together with radiography or ultrasonic inspection in accordance with 4.2.2.2 or 4.2.2.3 of this BP Group RPSE.

Ultrasonic inspection shall be employed when radiography is not feasible, and its application shall always be considered when section thickness exceeds 50 mm.

(Substitution for [API 4.2.1.3](#))

4.2.2 Material Inspection

4.2.2.1 General

All NDT procedures shall be submitted to BP for approval and shall form an integral part of the manufacturers' QA documentation.

All persons performing and interpreting the results of any of the following NDT techniques shall possess an appropriate qualification, e.g. CSWIP or ASNT.

(Addition to [API 4.2.2.1](#))



4.2.2.2 Radiography

- 4.2.2.2.1 Areas of the casting to be examined by radiography shall be subject to approval by BP prior to examination, but shall include any regions of abrupt section change, weld ends, and areas adjacent to feeders and risers.

(Addition to [API 4.2.2.2.1](#))

- 4.2.2.2.2 Acceptance standards for castings shall be in accordance with [ASTM E446](#) and [ASTM E186](#) and the following table:-

Defect Category	Degree of Severity		
	Section Thickness		
	Below 25 mm	25.50 mm	51-114 mm
A Gas porosity	2	3	3
B Sand and slag	2	3	3
C Shrinkage (all types)	2	2	2
D&E Cracks and hot tears	Not acceptable		

(Substitution for [API 4.2.2.2.2](#), 2nd sentence)

4.2.2.3 Ultrasonic Inspection

- 4.2.2.3.2 Defect acceptance levels shall be subject to approval by BP.

(Addition to [API 4.2.2.3.2](#))

4.2.2.4 Magnetic Particle Inspection

- 4.2.2.4.1 Magnetic particle inspection shall be applied to all accessible surfaces, including those exposed by machining. Indications shall be investigated by light grinding (1 mm (0.039in) maximum depth).

(Addition to [API 4.2.2.4.1](#))



- 4.2.2.4.2 For each type of defect, the degree of severity shall not exceed the following limits.

Type	Defect	Maximum Severity
1	Linear discontinuities (hot tears and cracks)	Not acceptable
II	Shrinkage	2
III	Inclusions	2
IV	Internal chills and unfused chaplets	1
V	Porosity	1
VI	Welds	1

(Qualification of [API 4.2.2.4.2](#))

- 4.2.2.5 Liquid Penetrant Inspection

- 4.2.2.5.1 Liquid penetrant inspection shall be applied to all accessible surfaces, including those exposed by machining.

(Addition to [API 4.2.2.5.1](#))

- 4.2.2.5.2 Defect acceptance levels shall be subject to approval by BP.

(Addition to [API 4.2.2.5.2](#))

- 4.2.2.6 Visual Inspection

All surfaces that will remain in the as-cast condition shall be visually inspected to ensure conformity with the requirements of [MSS SP-55](#).

Prior to inspection, the surfaces shall be prepared by shot blasting, grinding, or both.

(Addition to [API 4.2.2](#))

4.3 Testing

- 4.3.1 General

- 4.3.1.1 Performance and NPSH tests shall be carried out in accordance with [ISO 2548 \(BS 5316: Part1\)](#).

(Substitution for [API 4.3.1.1](#))



4.3.3 Performance Test

4.3.3.2.3 Variable speed pumps shall be tested additionally at maximum continuous speed and at minimum allowable speed.

(Addition to [API 4.3.3.2.3](#))

4.3.3.2.5 Tests shall include a 4 hour run at maximum continuous speed and rated capacity.

(Addition to [API 4.3.3.2](#))

4.3.3.3.1 Vibration shall be measured at +10% to -10% of rated flow, at all specified operating flows, at minimum continuous stable flow and at 125% rated flow.

(Substitution for [API 4.3.3.3.1](#))

4.3.3.3.2 Bearing oil temperature rise shall be within the limits specified in API 2.9.2.3.

When pumps are fitted with hydrodynamic thrust bearings, axial loads shall be measured during the performance test. The flow rates at which axial loads are to be measured shall be subject to agreement between BP and the vendor, but should normally be shut-off, minimum continuous stable flow, midway between minimum and rated flow, and 125% of rated flow. For variable speed units, axial loads shall be measured at maximum continuous speed and minimum continuous speed.

(Additions to [API 4.3.3.3.2](#))

4.3.4.1 An NPSHR test shall be required where $NPSHA - NPSHR < 0.8$ m

4.3.4.4 Where auxiliary systems, such as oil systems are required to operate the pump the auxiliary system test should be incorporated in the performance test

(Addition to [API 4.3.4.4](#))

4.3.4.5 *A bearing housing resonance test is not normally required. However, where a completely new pump design is being used, or if application experience indicates that a resonance may exist between running speed or vane passing frequency and the bearing housing natural frequency this test may be necessary.*



5. SPECIFIC PUMP SELECTIONS

- 5.1.2.1 Vertical in-line close coupled centrifugal pumps-type OH5 shall conform to the hydraulic ratings and dimensional requirements of [BS 4082](#): Part 1 or Part 2 as applicable.

(Addition to [API 5.1.2.1](#))

- 5.1.4.3 *A lateral analysis shall be provided if required by [API 5.2.4.1](#)*

5.2. Between Bearing Pumps

- 5.2.2.2 Impellers for multistage pumps shall be individually secured against axial movement in either direction along the shaft.

(Qualification of [API 5.2.2.1](#) 1st Sentence & 5.2.2.2)

- 5.2.3.2 Where multi-stage pumps require a balancing device, this shall be of a type not involving close axial clearances.

(Addition to [API 5.2.3.2](#))

- 5.2.6.2(b) Facilities shall be provided to regulate the lubricating oil temperature.

(Addition to [API 2.10.3.1\(b\)](#))

- 5.2.6.2.(e) The duplex filter shall be provided with a continuous flow transfer valve and a pressure equalisation line.

(Addition to [2.10.3.1\(e\)](#))

- 5.2.6.2.(f) The auxiliary oil pump shall be arranged to ensure adequate lubrication to all main bearings before the main shafts start to rotate. The auxiliary oil pump driver shall be electric motor or steam turbine as specified on the data sheet.

- 5.2.6.6 *It is likely that an [API 614](#) oil system will only be economically viable where large pumps, variable speed drives, or machine trains are to be used.*

- 5.2.8.5 Hydrodynamic bearings shall be examined after the performance test is completed.

6. VENDORS DATA

- 6.1.3 For pumps to be supplied into or within the European Union the agenda for the co-ordination meeting should include the need for the supplier responsible for the co-ordination of the complete unit to meet the requirements and mount the CE Mark.

The requirement for a co-ordination meeting at the vendor's works will depend upon the number and complexity of the pumps to be purchased. However, for multi-stage pumps and pumps with particular requirements it will be advantageous to ensure that all requirements are clearly understood.

- 6.2.3 *For new applications or service requirements or to support the proposal of duties which are approaching operational limits a list of similar machines should be required.*

- 6.3.6. Manuals

It should be noted that the requirement of the Machinery Directive as implemented by the statutory requirements of the European Union Member States requires the Operation, Installation Operation and Maintenance manuals to be provided in both the language of the supplier and of the country of installation as part of the necessary documentation required for the CE Mark.

Where equipment is imported from outside the EU it is required that the importer affixes the CE mark and takes responsibility for ensuring that the machine is suitable for its function and is not a hazard (Pumps do not require certification from an independent authority).

7. GUARANTEE AND WARRANTY

(Addition to API)

7.1 Mechanical

- 7.1.1 Unless exception is recorded by the vendor in his proposal, it shall be understood that the vendor agrees to the following guarantees and warranties:-

During a period of 12 months after the date of commissioning, the vendor shall, with all possible speed and without cost to the purchaser, replace or repair the goods or any part thereof found to be defective due to faulty material, workmanship or design (other than design specified in detail by the purchaser) or to any act or omission of the vendor. In particular the vendor shall reimburse any transportation and other charges incurred by the purchaser in effecting such replacement or repair at the point of use.



7.2 Performance

7.2.1 The pump shall be guaranteed for satisfactory performance at all operating conditions specified on the data sheet.

7.2.2 Performance tolerances should be as detailed in [API 4.3.3.3.3](#).



DEFINITIONS AND ABBREVIATIONS**Definitions**

Standardised definitions may be found in the BP Group RPSEs Introductory Volume

Abbreviations

API	American Petroleum Institute
BS	British Standards
SPL	Sound Pressure Level
EEMUA	The Engineering Equipment and Materials Users Association
CW	Cooling Water
BHRA	British Hydromechanics Research Association
FFT	Fast Fourier Transform
MEA	Monoethanolamine
DEA	Diethylamine
TEA	Tri Ethylamine
NDT	Non Destructive Testing
CSWIP	Certification Scheme for Welding and Inspection Personnel
ASNT	American Society for Non Destructive Testing
NPSH	Net Positive Suction Head
NPSHR	Net Positive Suction Head Required
NPSHA	Net Positive Suction Head Available



LIST OF REFERENCED DOCUMENTS

Referenced Publications

A reference in this BP Group RPSE to any other document invokes the latest published issue or amendment unless otherwise stated.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

ISO 1940 (BS 6861 Pt. 1)	Mechanical vibration - Balance quality requirements of rigid rotors. Part 1: Determination of permissible residual unbalance.
ISO 2548 (identical to BS 5316 Pt. 1)	Centrifugal, mixed flow and axial pumps - Code for acceptance tests - Class C.
BS EN25199	Technical Specification for Centrifugal Pumps Class II
ISO 2954 (identical to BS 4675 Pt. 2)	Mechanical vibration of rotating and reciprocating machinery - Requirements for instruments for measuring vibration severity.
BS EN ISO 9001	Quality systems - Model for quality assurance in design/development, production, installation and servicing.
BS EN ISO 9002	Quality systems - Model for quality assurance in production and installation.
BS 4082	Specification for external dimensions for vertical in-line centrifugal pumps. Part 1 : 'I' Type Part 2 : 'U' Type
BS 5304	Code of practice for safety of machinery.
API 610 Eighth Edition August 1995	Centrifugal pumps for general refinery service.
API 611	General Purpose Steam Turbines for Refinery Service



ASTM A 448	Practice for steel castings, welding qualification of procedures and personnel.
ASTM A 609	Practice for castings, carbon, low-alloy, and martensitic stainless steel, ultrasonic examination thereof.
ASTM E 94	Guide for radiographic testing.
ASTM E 125	Reference photographs for magnetic particle indications on ferrous castings.
ASTM E 165	Practice for liquid penetrant inspection method.
ASTM E 186	Reference radiographs for heavy-walled 2 to 4.1/2 in (51 mm to 114 mm) steel castings.
ASTM E 446	Reference radiographs for steel castings up to 2 in (51 mm) in thickness.
ASTM E 709	Practice for magnetic particle examination.
EEMUA Pub. No 140	Noise procedure specification.
MSS SP-55	Quality standard for steel castings for valves, flanges and fittings and other piping components (visual method).
BP GS 136-1	Materials for sour service to NACE Std MR-01-75 .



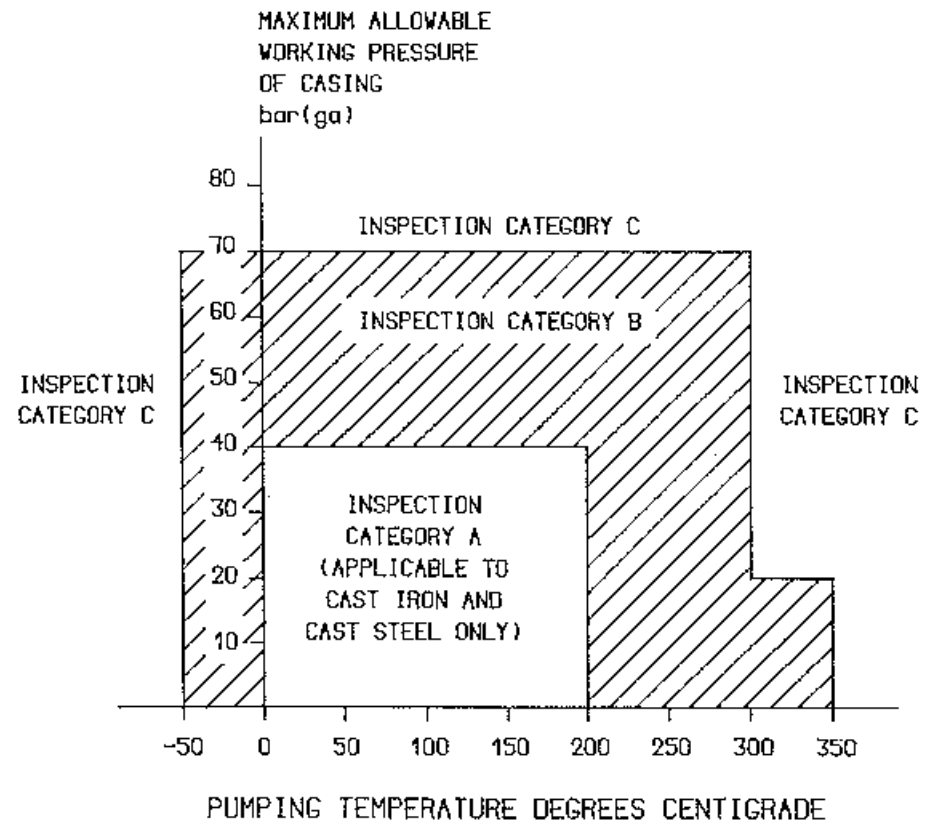


FIGURE A
INSPECTION CATEGORIES FOR PRESSURE-CONTAINING CASTINGS