API 685 – Specification Overview

Sundyne ***HMD Kontro***

Sealless Pumps

Sealless Centrifugal Pumps for Petroleum, Petrochemical, and Gas Industry Process Service

API STANDARD 685
SECOND EDITION, FEBRUARY 2011

API 685 – Specification Overview

API 685 2nd Edition - Standard API format

1. Scope
2. Normative References
3. Definition of Terms
4. General
5. Requirements
6. **Basic Design**
7. **Accessories**
8. Inspection, Testing, and Preparation for Shipment
9. **Specific Pump Sections**
10. Vendors Data

Annexes A to R (informative and normative)

API 685 – Specification Overview

(Page vi)

API 685 2Nd Edition – Bulleted (•) paragraphs

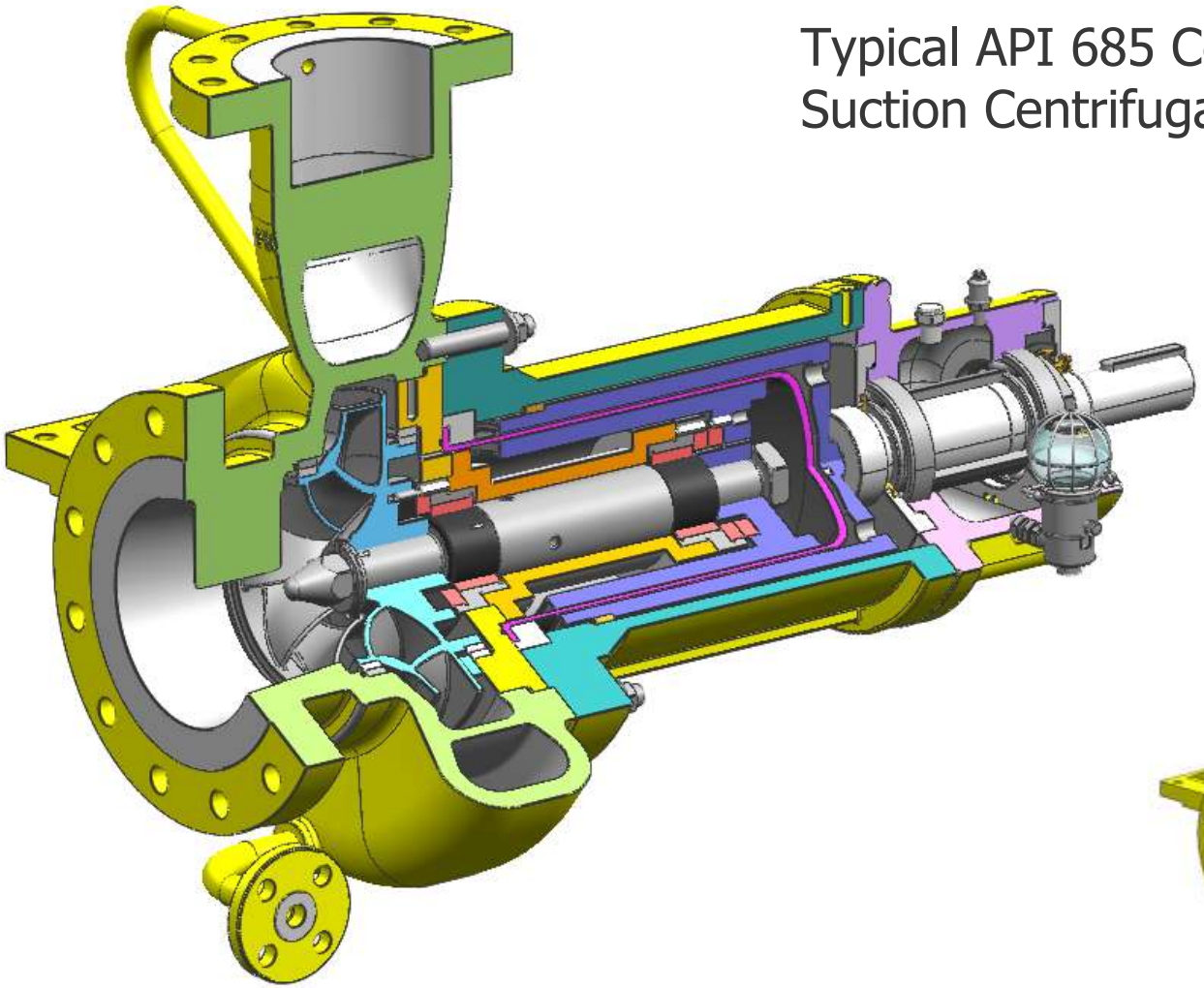
A bullet (•) at the beginning of subclause or paragraph indicates that either a decision by, or further information form, the purchaser is required. Further inform should be shown on the data sheets or stated in the quotation request and purchase order.

API 685 – 1. Scope

(Page 1)

- Self explanatory section – Standard applies to
  - Single stage overhung pumps
  - Mag Drive Pumps (MDP) and Canned Motor Pumps (CMP)
  - Relevant industry operating experience suggest seal less pumps produced to API 685 may be used for many applications, and should be applied when conditions exceed
    - Discharge Pressure 1900 kPa (275 psig)
    - Suction Pressure 500 kPa (75 psig)
    - Pumping Temperature 150 DegC (300 DegF)
    - Rotative Speed 3600 r/min
    - Rated total head 120 m (400 ft)
    - Impeller diameter 330mm (13 in.)

Typical API 685 Compliant End Suction Centrifugal Pump



API 685 – 2. Normative References

(Pages 2 to 4)

- A listing of specifications that need to be used when applying API 685.
- Too many to list – in excess of 40.
- Some of the key ones:
  - ASME B16.5 Pipe Flanges and Flanged Fittings
  - HI 1.6 Centrifugal Pumps – Centrifugual Tests
  - ISO 9906 Rotordynamic pumps – Hydraulic performance acceptance tests
  - NACE MR0103 and NACE MR0175 for H2S services

API 685 – 3. Definition of Terms

(Pages 4 to 12)

- Many manufacturers use different terminology, this list tries to standardise.
- Where applicable, the terms are directly from API 610.
- More seal less nomenclature can be found in Annex C.

API 685 – 4. General, 5. Requirements

(Pages 12 to 13)

4. General

- States the pump Vendor has unit responsibility.

5. Requirements

- Units of measurements – Purchaser to specify either:
  - SI (Metric)
  - USC (US Customary)

API 685 – 6. Basic Design

(Pages 13 to 19)

6.1 General

- 20 year design life
- Emphasises that fluid properties are key
- Outlines why a **heat balance calculation** is needed (temperature and pressure profiles) 6.1.3.4
- Pumps sized so a 5% head increase can be achieved with a larger impeller
- Fully self venting and draining design
- (•) Stable head/flow curves are preferred
- 10% HRSO if pumps are in parallel
- Gives operating regions – with qualifiers
- Section on Cooling (Not applicable to HMD)
- Bolts and thread requirements

API 685 – 6. Basic Design – Heat Balance Calcs

Validation of internal feed system

- Takes VP, Specific Heat, SG into account ensures product vaporisation does not occur in the internal flow regime.
- Particularly relevant to high VP or liquids nearly at boiling point.

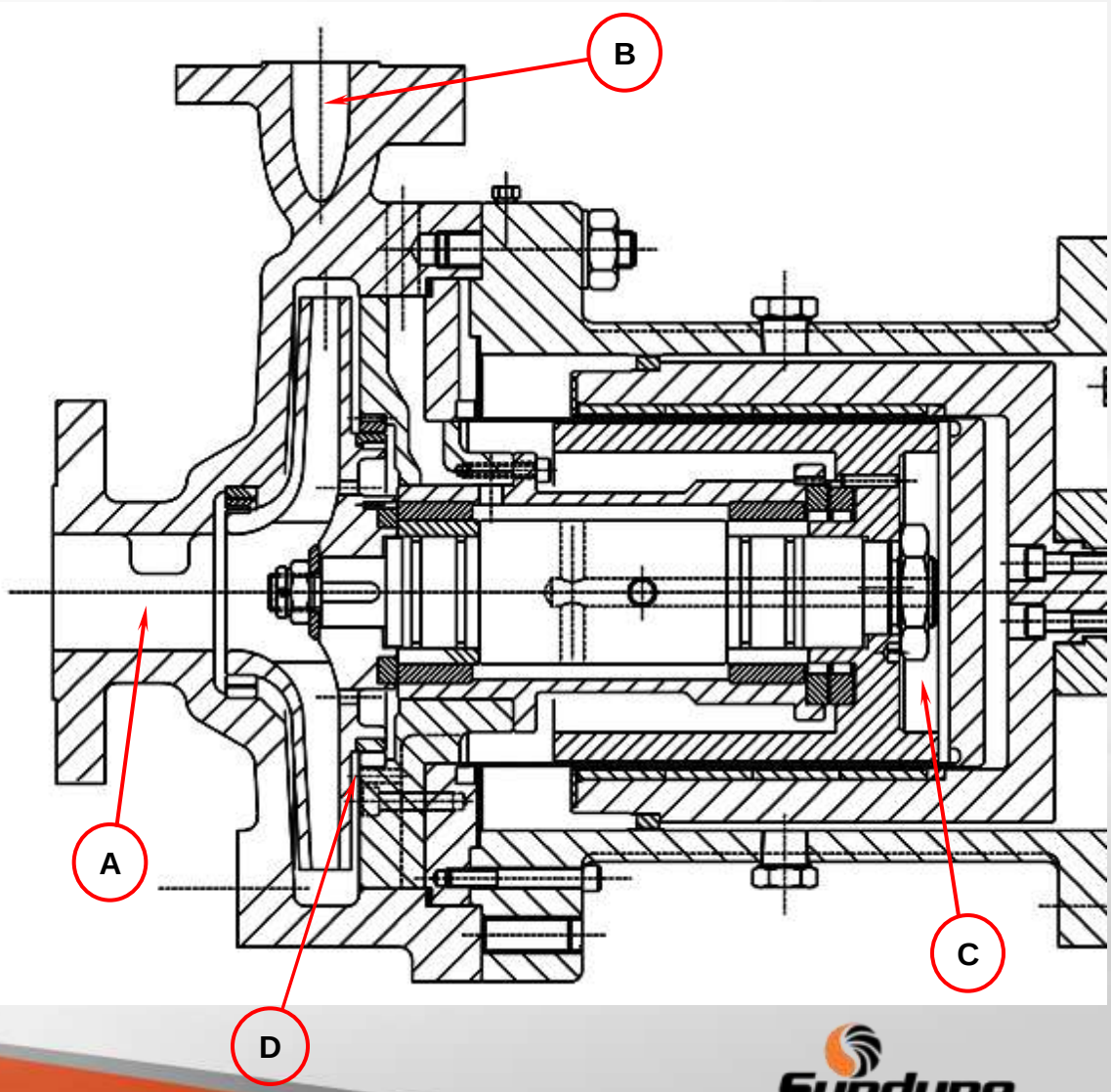
A - Suction Pressure

B – Discharge Pressure

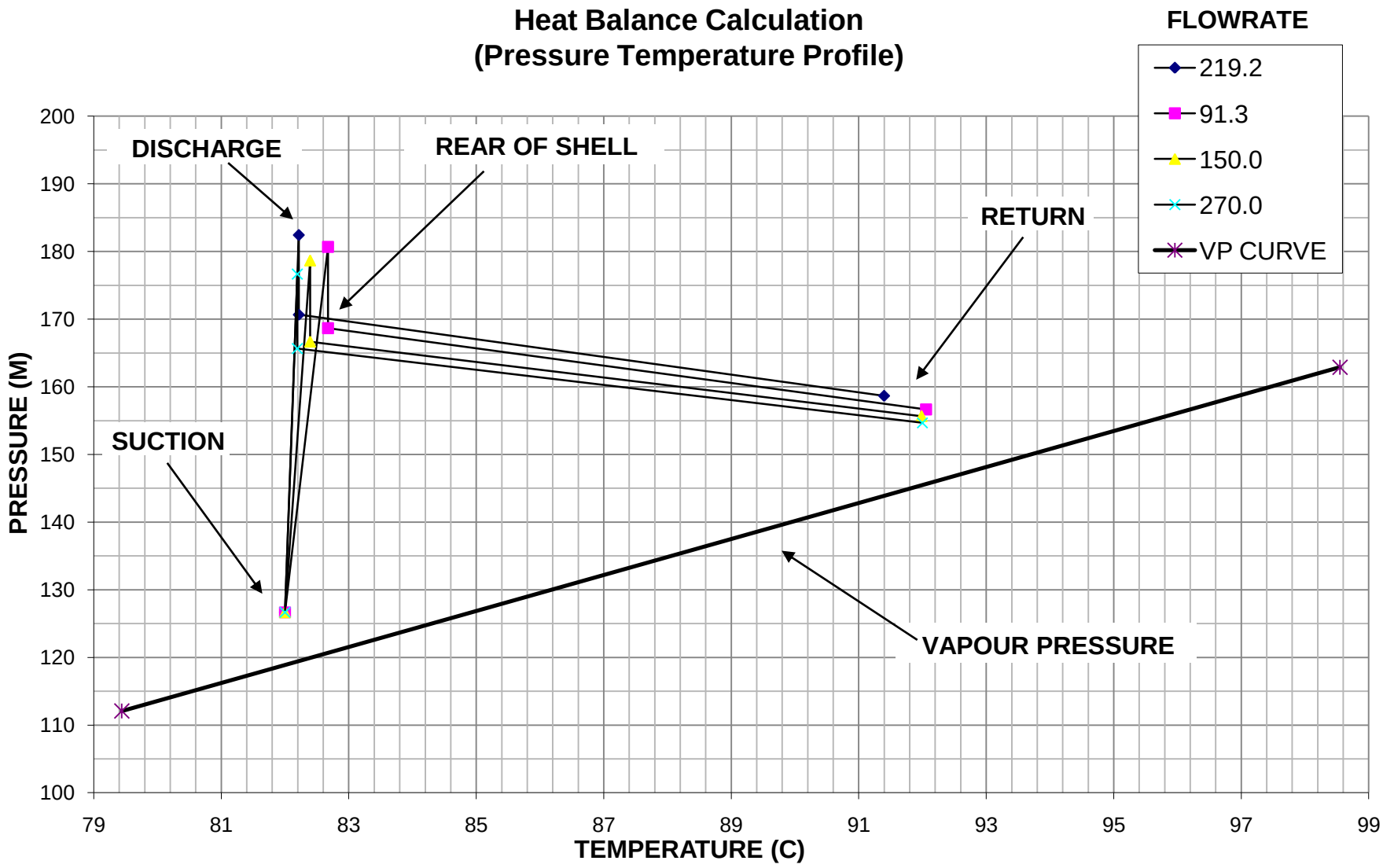
C – Pressure at rear of Containment Shell

D – Pressure at return feed point

(Also see Annex K)



API 685 – 6. Basic Design – Heat Balance Calcs



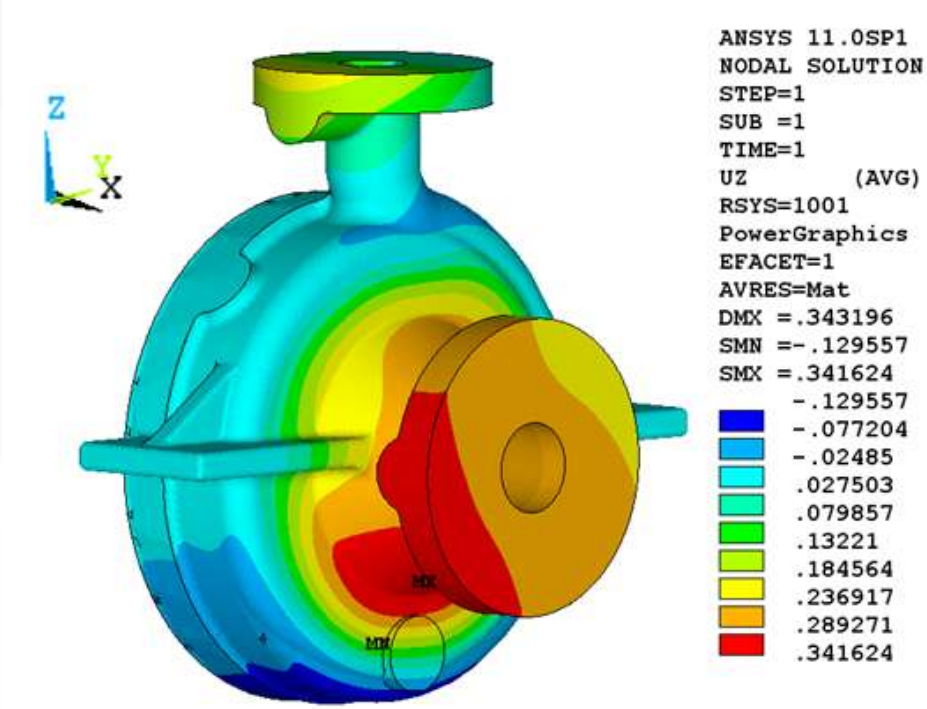
API 685 – 6. Basic Design

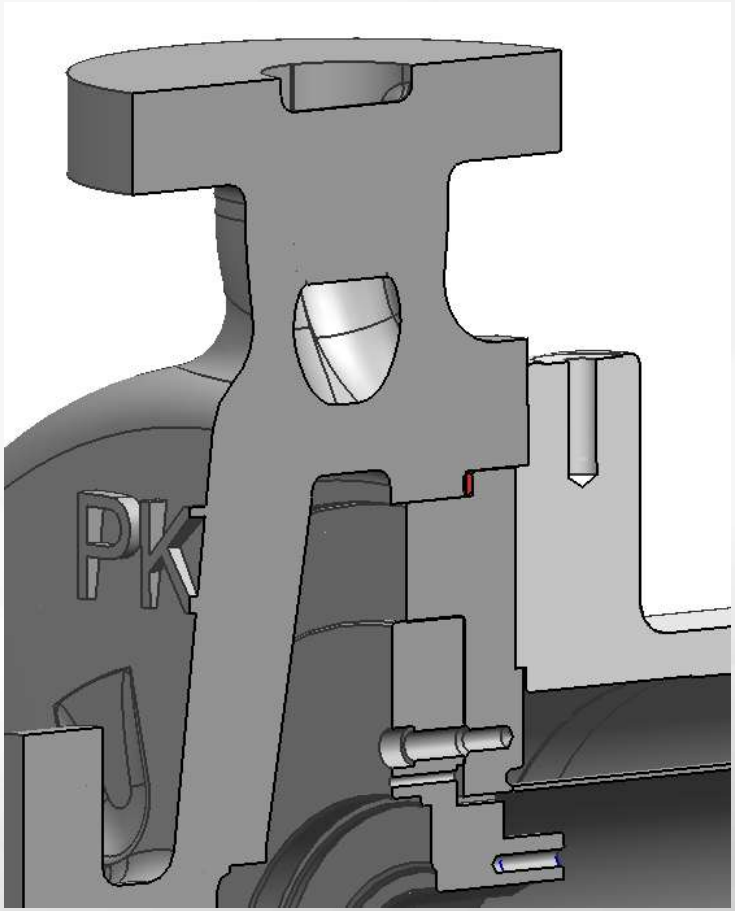
(Pages 19 to 21)

6.2 Pressure Casings

- Ability to withstand 2 x nozzle loads in Table 4
  - NOTE: This is a casing design criterion, not an allowable nozzle load
- Provides criteria for design stresses
- Minimum MAWP shall be 4 MPa (40 bar) at 38 DegC
- Corrosion allowance of 3 mm (0.12 in.)
- Metal to metal fits – confined controlled compression gaskets
- Centreline supported above 175 DegC (350 DegF)
- Jack Screws to aid disassembly

Pump casing model – pressure and nozzle load analysis





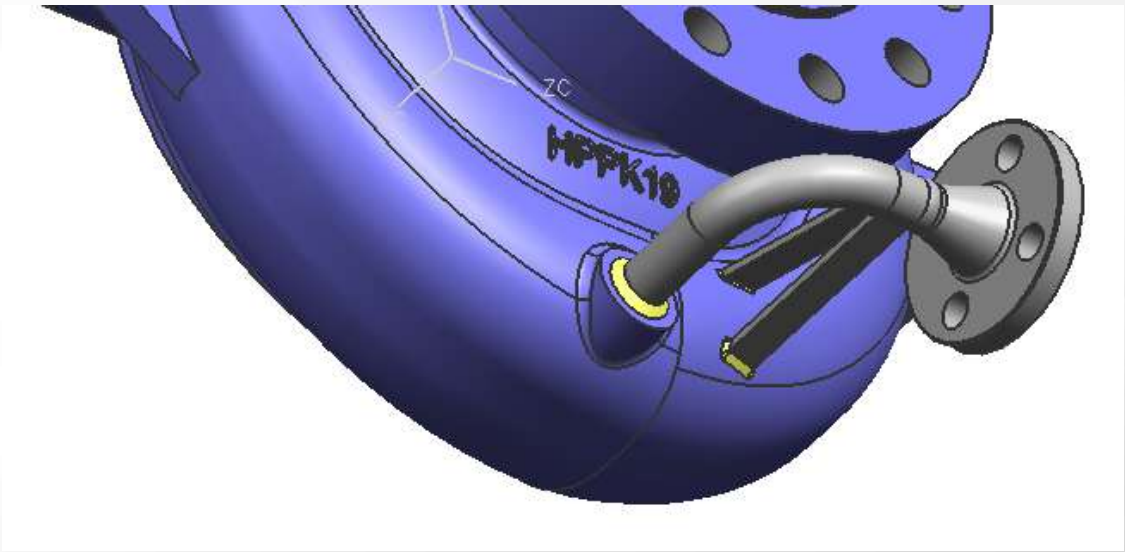
Confined controlled compression gasket

API 685 – 6. Basic Design

(Pages 21 to 23)

6.3 Nozzles and Pressure Casing Connections

- Flange finish requirements of ASME B16.5
- Full or spot faced on the back for through bolting
- No threaded connections into primary pressure casing
- (•) Provides details of gusseted pipe connections – Flanged drains



API 685 – 6. Basic Design

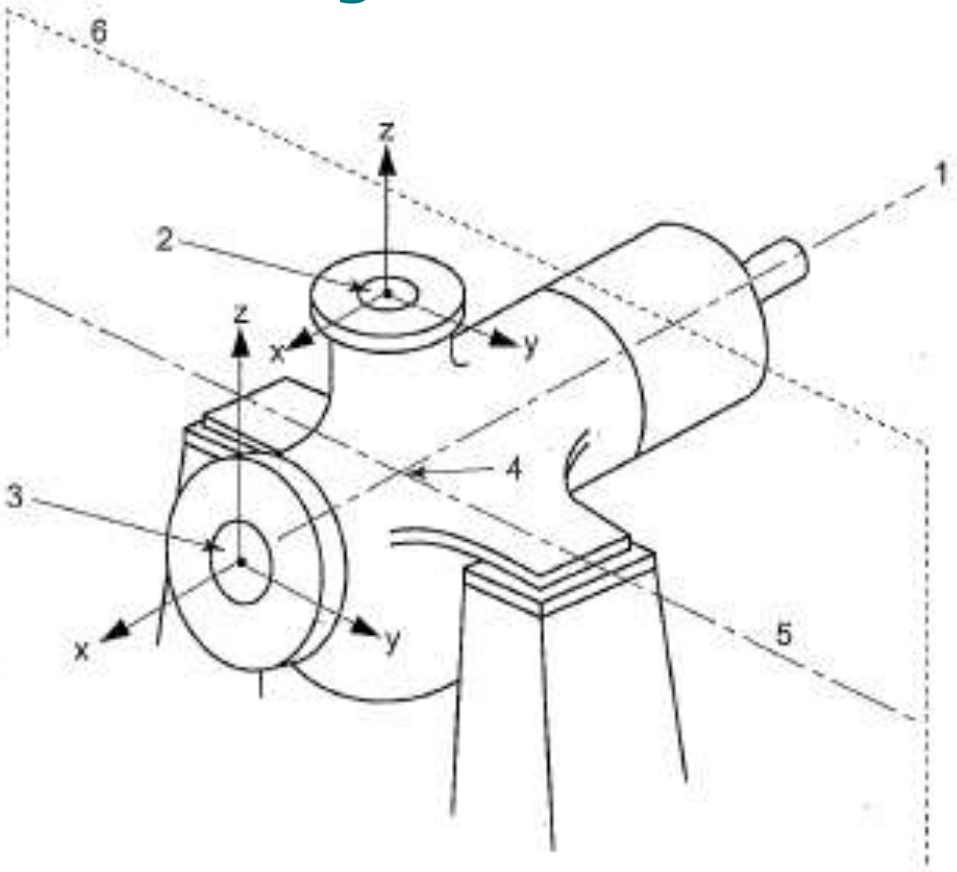
(Pages 23 to 26)

6.4 External Nozzles Forces and Moments

- Pumps to be designed to perform whilst under simultaneously applied nozzle loads given in Table 4.
- This includes misalignment of pump and motor shafts, and distortion of the pump casing.
- The allowable loads applied to the pump from the pipe are those listed in Table 4.
- Coordinate system to be used in also given

API 685 – 6. Basic Design

Casing Nozzle – Coordinate System



Key
1 shaft centerline
2 discharge nozzle
3 suction nozzle
4 center of pump
5 pedestal centerline
6 vertical centerline

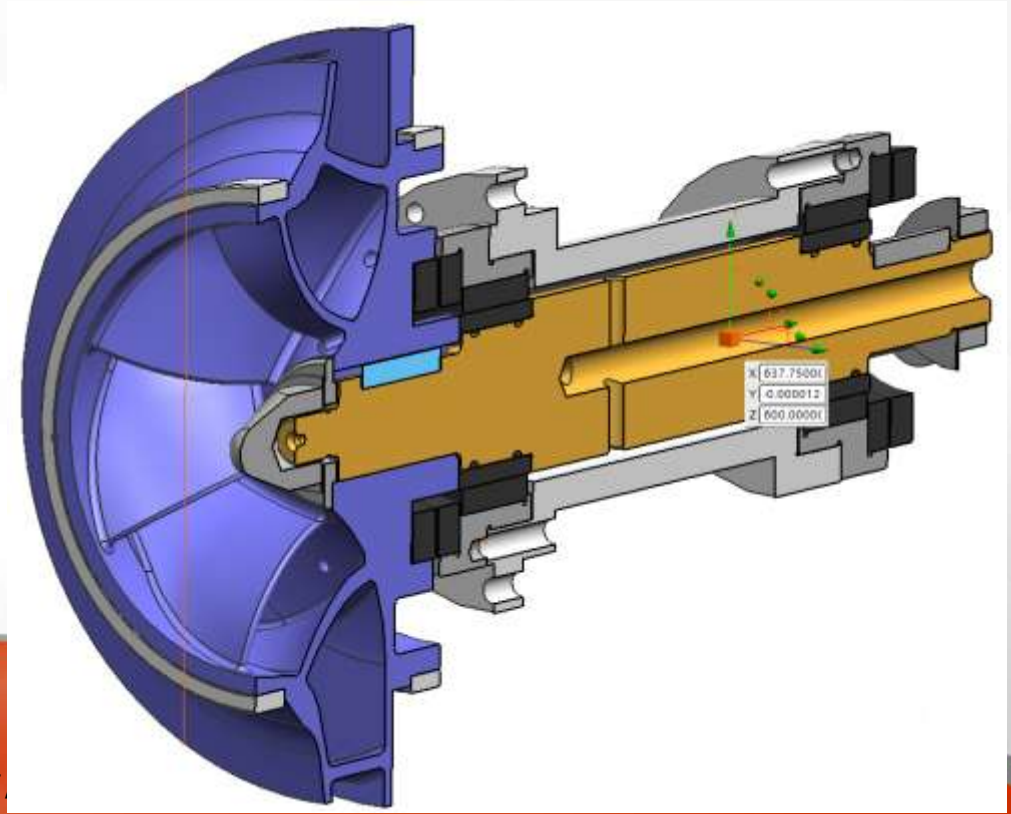
Figure 4—Coordinate System for the Forces and Moments in Table 4: Horizontal Pumps

API 685 – 6. Basic Design

(Page 27)

6.5 Rotors

- Impellers shall be single-piece casting, forgings or fabrications
- Impellers to be keyed to the shaft
- Shaft threads shall not be exposed, impeller nuts shall be locked

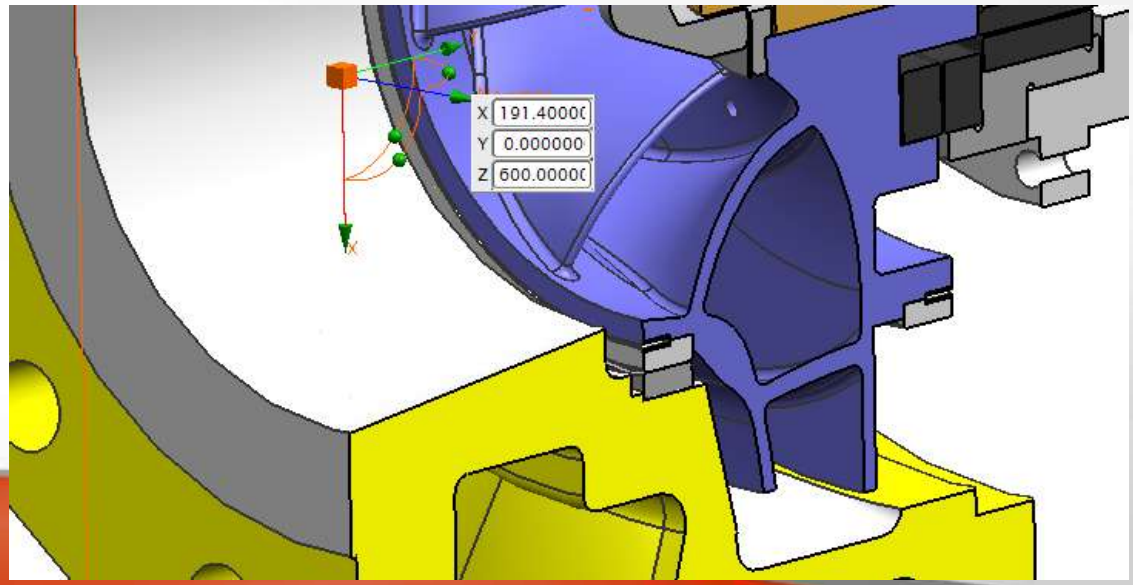


API 685 – 6. Basic Design

(Pages 27 to 28)

6.6 Wear Rings and Running Clearances

- Renewable wear rings are required in the pump casing
- Impellers shall have either renewable wear rings, or integral wear surfaces. 50 HRB differential for hardenable materials
- Wear rings pinned or tack welded
- Running clearances requirements given



API 685 – 6. Basic Design

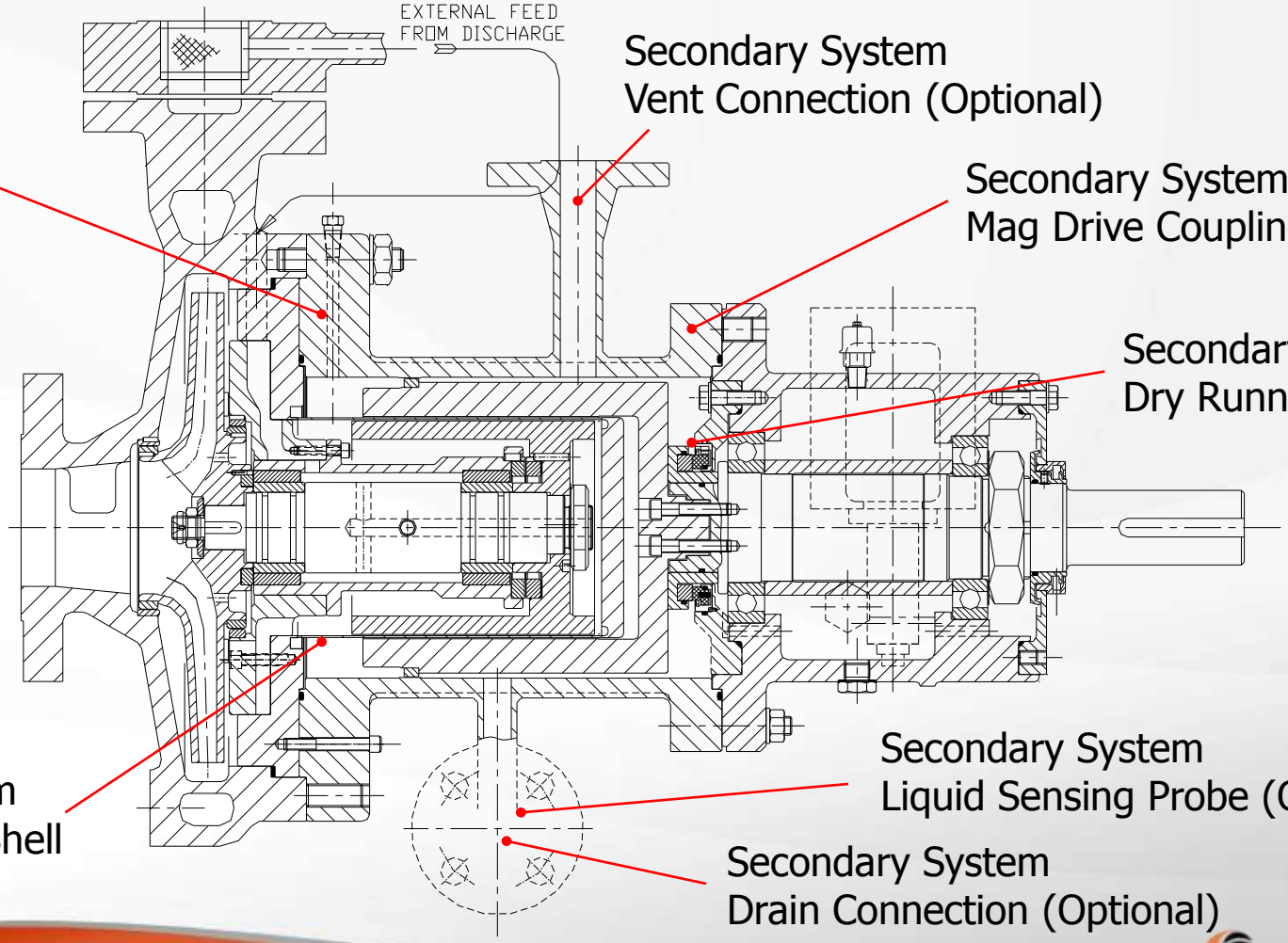
(Pages 28 to 30)

6.7 Secondary Control/Containment

- (•) The purchaser needs to specify what type of secondary control or containment system shall be offered
- Annex B – *Hazard-Based Specification of Control/Contamination Guidelines* provides a method of establishing what method should be specified
- Secondary system needs to be rated for the same pressure as the pump casing
- Secondary system to be Carbon Steel or better
- System to feature controlled compression gaskets and or O rings

API 685 – 6. Basic Design

Secondary Sealing System



Primary System
Shell RTD
(Optional)

Secondary System
Vent Connection (Optional)

Secondary System
Mag Drive Coupling Housing

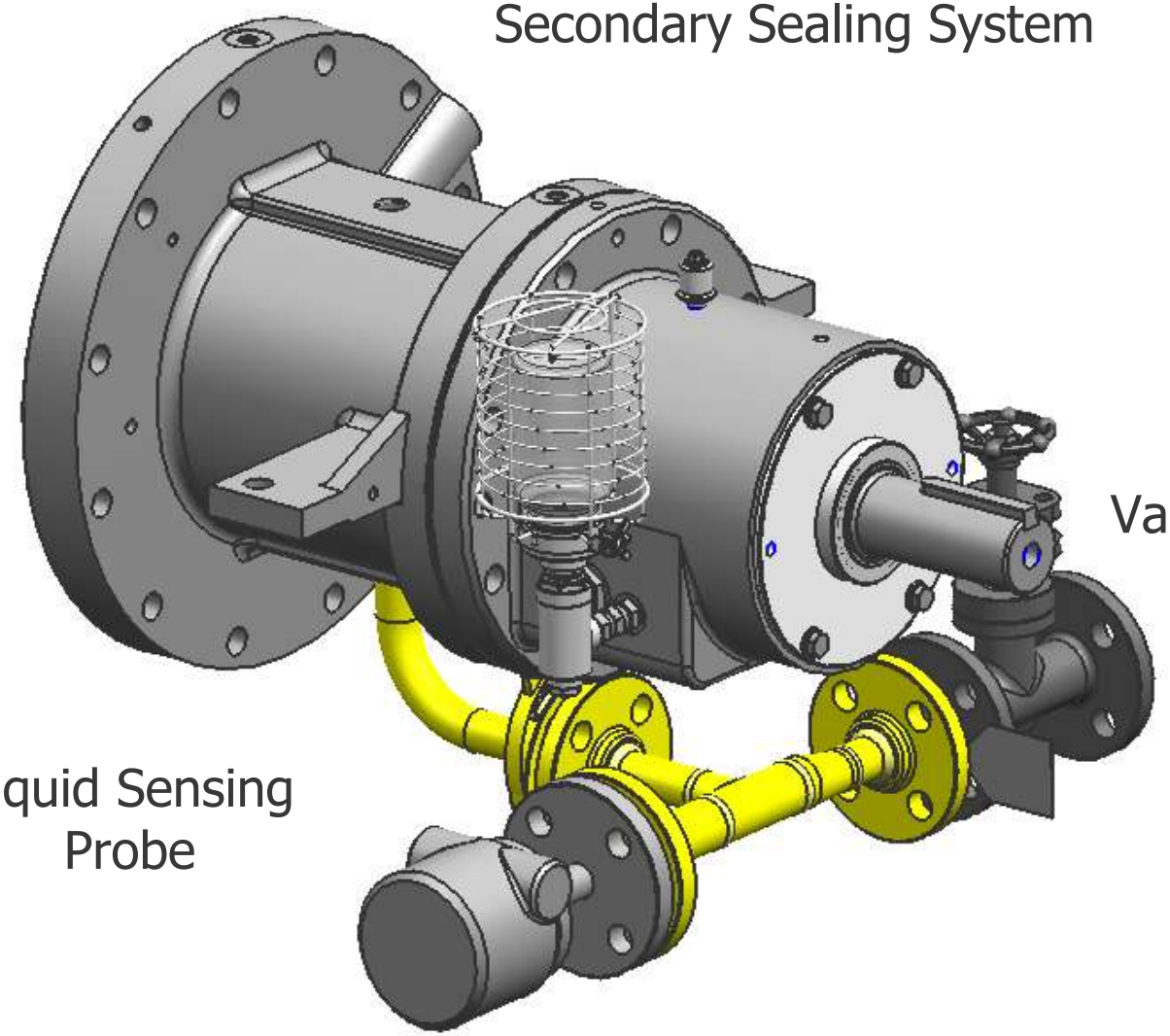
Secondary System
Dry Running Seal

Primary System
Containment Shell

Secondary System
Liquid Sensing Probe (Optional)

Secondary System
Drain Connection (Optional)

API 685 – 6. Basic Design



API 685 – 6. Basic Design

(Pages 30 to 34)

6.8 Dynamics

- During performance test vibration test (5 to 1kHz) and FFT spectrum for each test point except shut-off
- Vibration not to exceed 3.0 mm/sec RMS within the preferred operating region
- Impellers and rotors (IMR's) to be balanced to G2.5
- (•) Impeller and rotors to be balanced to G1.0 – but is not repeatable

API 685 – 6. Basic Design

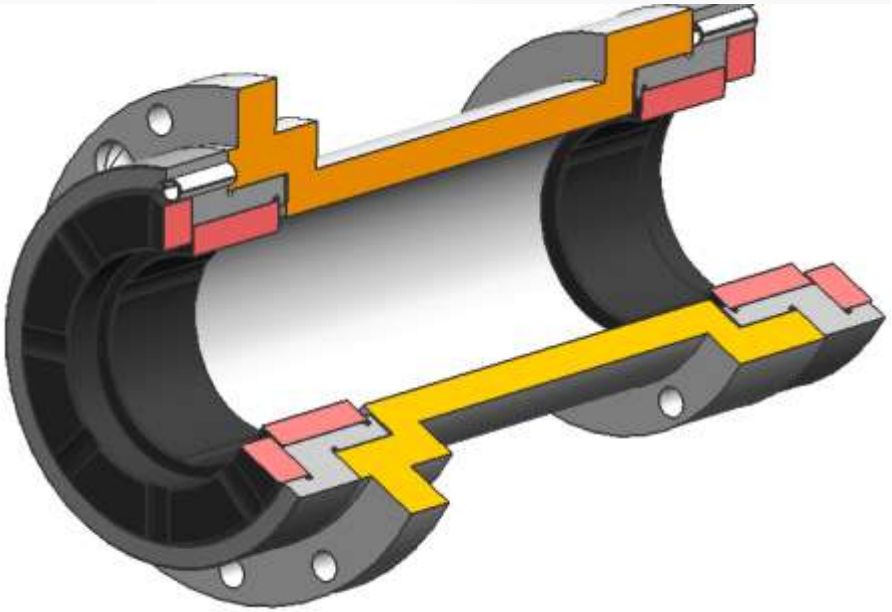
(Pages 34 to 35)

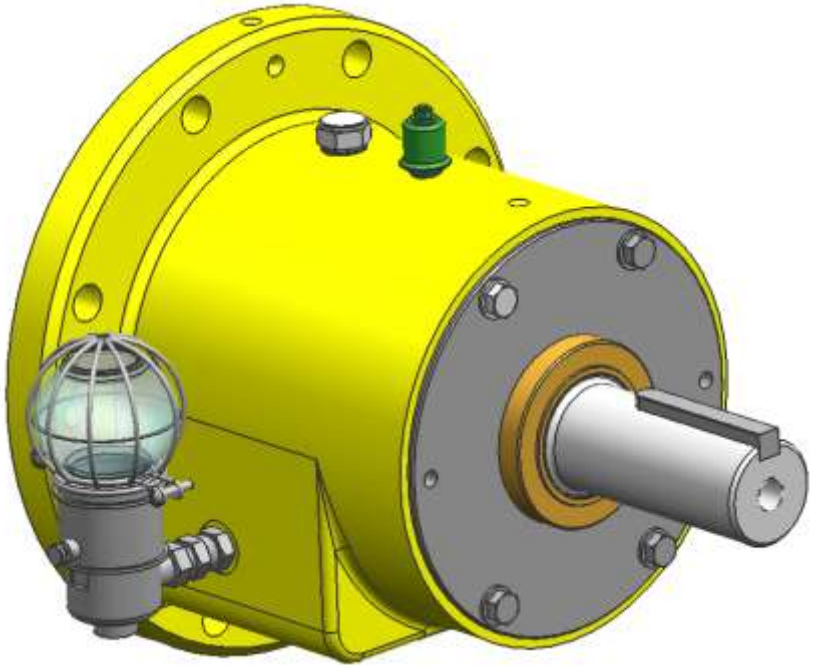
6.9 Process Cooled/Lubricated Bearings and Bearing Housings

- Precision bored type, secured securely axially and radially
- Bearings mounted to allow for relative thermal expansion
- Twin bearing design required above 7.5kW
- Thrust bearings to cater for thrust in both directions across the operating range
- Lubrication of internal bearings is by the pumped fluid
- Vibration measurement dimples required on external bearing housing and bearing holder flange (front bush holder flange, or mating part)

API 685 – 6. Basic Design

Precision bored type, secured securely axially and radially





Vibration measurement dimples on external bearing housing

API 685 – 6. Basic Design

(Pages 35 to 40)

6.10 Materials

- Materials to be in accordance with table H.1.
- Details of materials shall be provided in the proposal
- Purchaser to specify if NACE materials are to be provided

Castings

- Surfaces to be cleaned by blasting and meet visual requirements of MSS SP-55

Welding

- Table 7 provides weld and welder requirements
- Pressure containing welds shall be full-penetration

API 685 – 6. Basic Design

(Pages 39 to 40)

6.10 Materials

Low Temperature Service

- (•) Vendor needs to specify minimum design metal temperature
- Specific section outlining requirements for low temperature service
- Covers impact testing requirements

API 685 – 6. Basic Design

(Pages 40 to 41)

6.11 Nameplates and Rotation Arrows

- Stipulates what data is needed on nameplate
- Pump serial number to be stamped on the pump casing
- Plates and arrows to be of Austenitic Stainless steel

API 685 – 7. Accessories

(Pages 41 to 42)

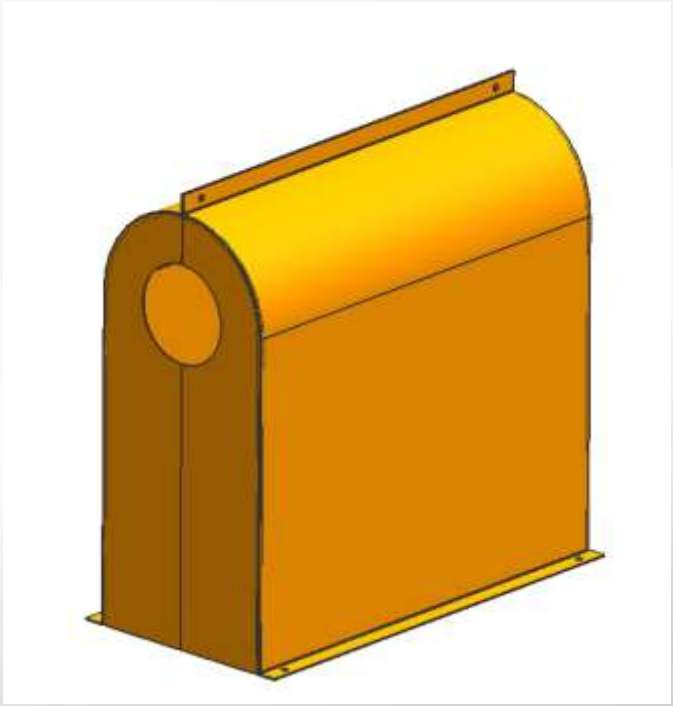
7.1 Drivers

- Table 8 gives power ratings for motor drivers relative to pump rated conditions

7.2 Couplings and Guards

7.3 Baseplates

- All covered in the MDP section 9.3



API 685 – 7. Accessories

(Pages 42 to 44)

7.4 Controls and Instrumentation

- Unless specified otherwise, following should be considered:
- Pump power monitoring (PCM)
- Leakage detection in Secondary pressure area (Low VP liquids)
- Pressure detection in Secondary pressure area (High VP liquids)
- Temperature monitoring of the Containment Shell
- Also refer to Annex E

7.6 Special Tools

- None required

API 685 – 8. Inspection, Testing, and Preparation for Shipment

(Pages 44 to 53)

8.2 Inspection

- Pressure casing materials to be inspected in accordance with table 9, Inspection standards are given in table 10

8.3 Testing

- Performance test to be in accordance to ISO 9906 grade 1 (ANSI/HI 1.6)
- Performance tolerances in accordance with Table 11:
  - Head ± 3%, (Shut-off varies with magnitude)
  - Power + 4%
  - NPSHr + 0%
- Hydrostatic test to 1.5 x MAWP

API 685 – 8. Inspection, Testing, and Preparation for Shipment

(Pages 44 to 52)

8.3 Testing - Continued

- 5 Test points
- Tested within 3% of rated speed.
- Other test speeds to be agreed with Purchaser
- Vibration levels recorded at each test point
- External Bearing temperatures recorded during test
- Test data to be corrected for site conditions (SG and Viscosity)

Optional tests

- (•) Thrust Bearing load test
- (•) NPSH3 test
- (•) Complete unit test
- (•) Sound level test
- (•) Control system
- (•) Secondary pressure systems

API 685 – 8. Inspection, Testing, and Preparation for Shipment

(Pages 53 to 54)

8.4 Preparation for shipment

- Suitable for 6 months outdoor storage
- Underside of baseplate prepared for grout
- Exterior surfaces coated with corrosion inhibitor
- Flanged openings, covered with min. 5mm metal blanks, elastomeric gasket and 4 bolts
- Copy of standard installation instructions in crate

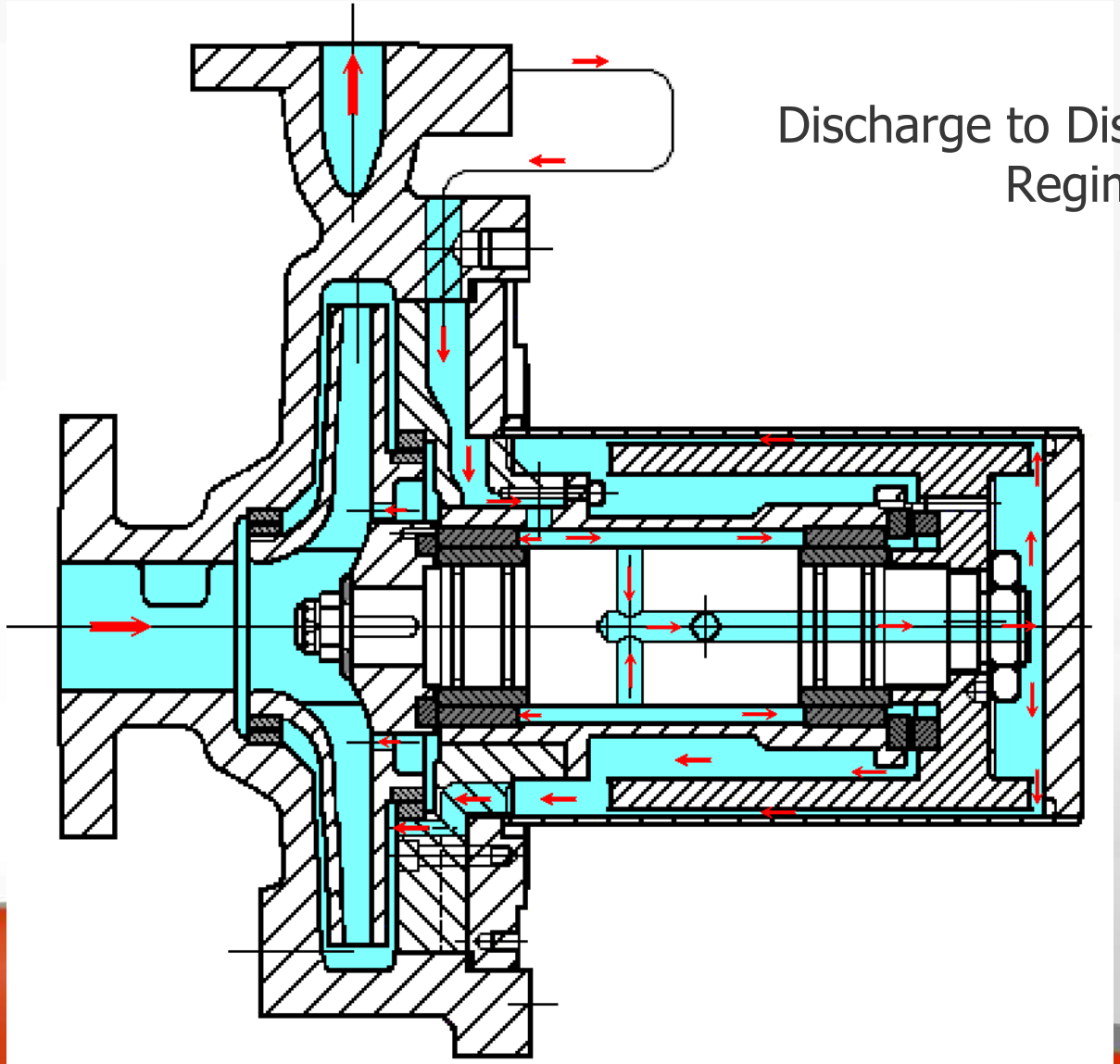
API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

(Page 54)

9.1.1 General

- (•) Close coupled pumps require specific approval and are not covered by the standard
- Design shall allow maintenance on power frame bearings and OMR without disturbing the casing
- Internal bearing shall not be supported by the containment shell
- Cooling and lubrication in accordance with Annex D. Note:
  - HMD's system is technically better than Annex D
  - Return to suction is avoided
  - Less likely to cause VP issues
  - Does not interfere with flow into suction, improving NPSH performance

API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps



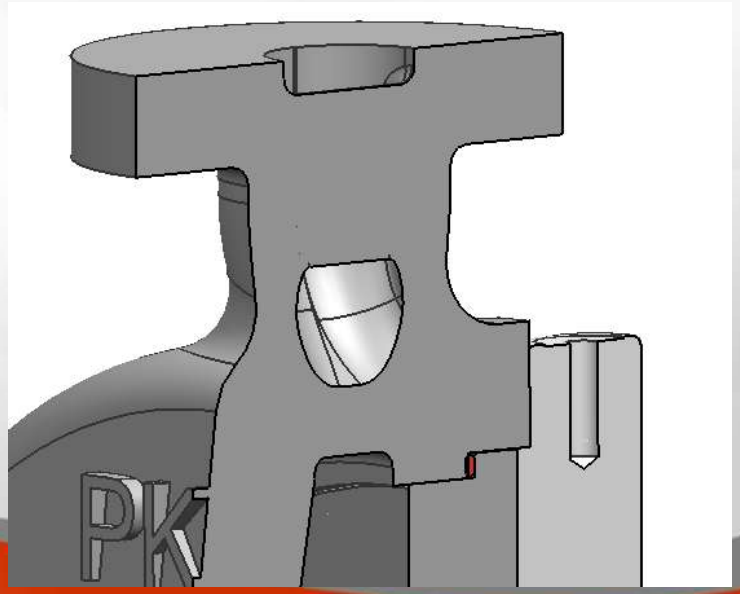
Discharge to Discharge Flow Regime

API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

(Pages 54 to 55)

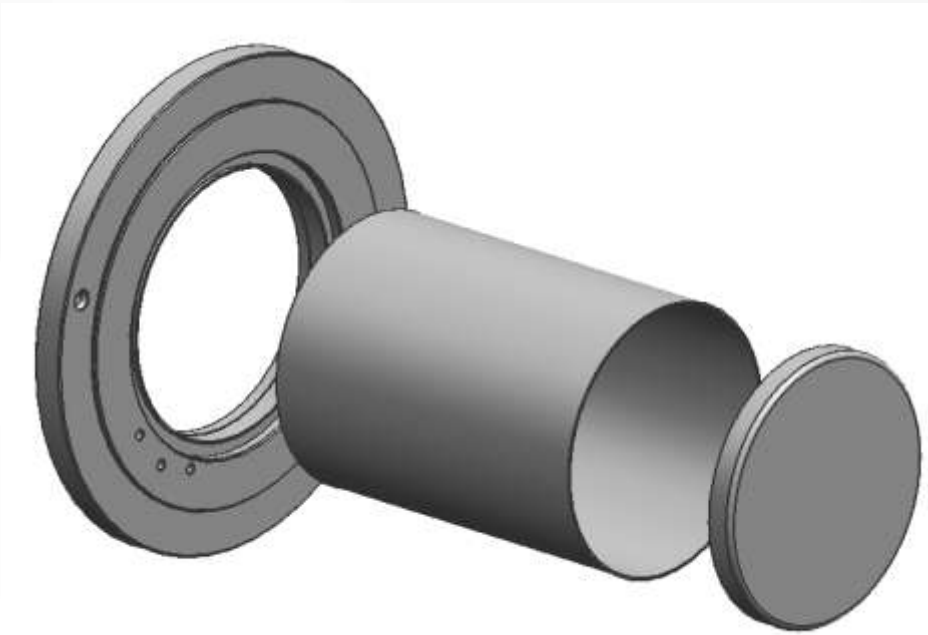
9.1.2 Containment shell

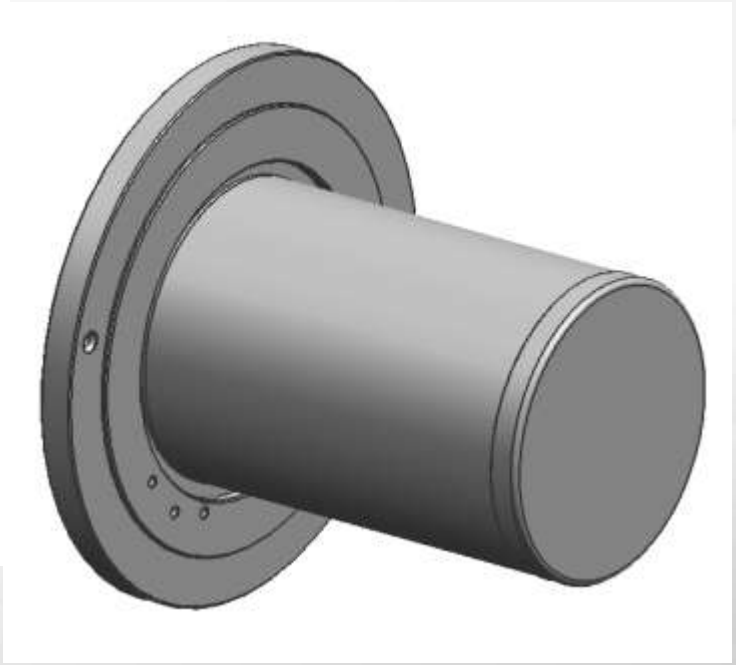
- Minimum corrosion/erosion allowance 0.4 mm
- Minimum thickness 1.0 mm
  - HMD standard thickness is 1.6 mm
- Shell to casing to be rabbeted metal to metal fit, with confined compression gasket
- Alternative shell material are subject to Purchaser approval
  - ZeroLoss shell
  - Peek Composite 40 bar design



API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

Containment Shell design





API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

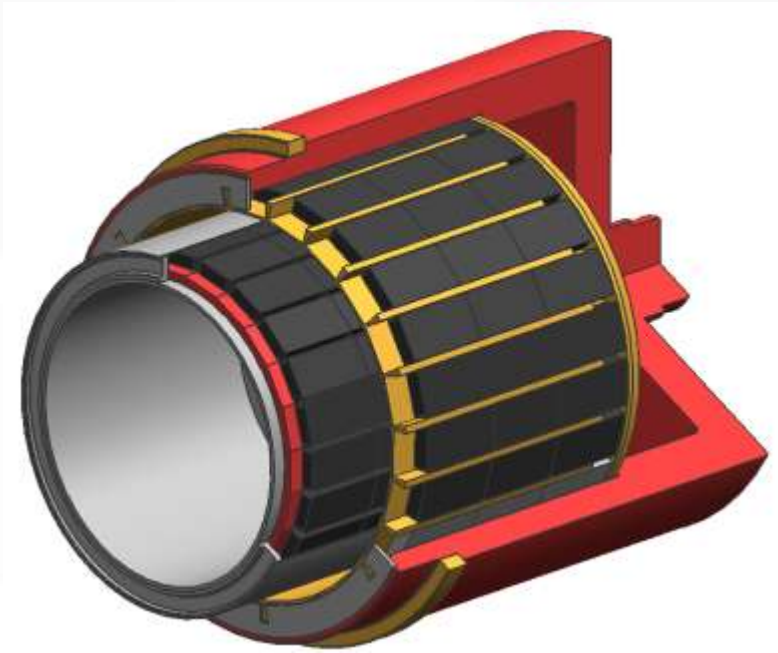
(Pages 55 to 56)

9.1.3 Magnetic Couplings

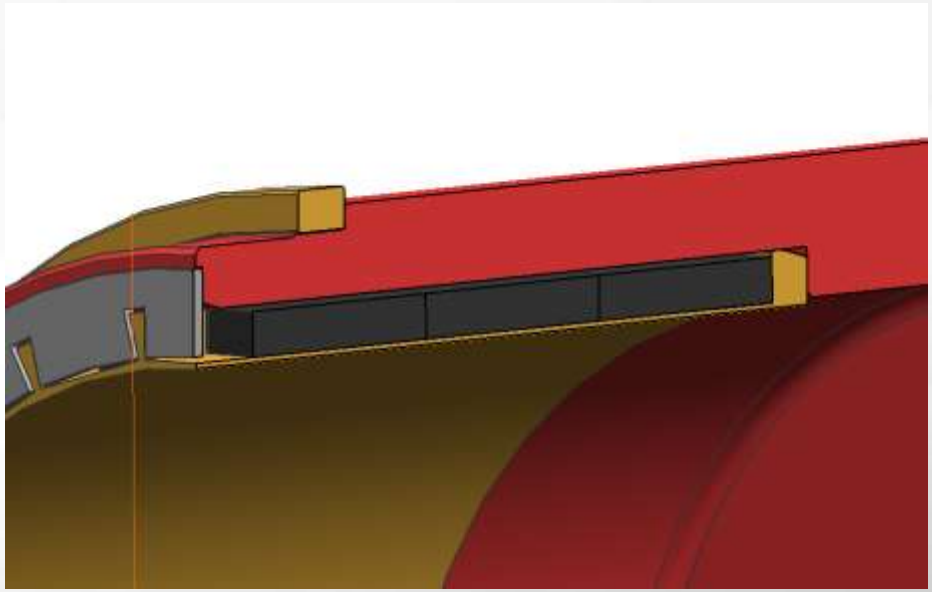
- Synchronous or Torque ring design (asynchronous)
- Magnets mechanically retained and or bonded
- OMR should not be able to contact Shell – Non-sparking bump ring needed
- (•) Inside of OMR – the magnets themselves shall be protected to prevent damage
  - This was mandatory in 1st Edition, now has to be specified
  - HMD do this as standard with metal sheathing
  - Exposed magnets can be damaged and can cause premature failure of pressure boundary

API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

Non-sparking Bump ring



Sheathed outer magnets



API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

(Pages 55 to 56)

9.1.3 Magnetic Couplings - Continued

- Couplings sized to avoid decoupling on start
- Rated torque of coupling to cover rated conditions plus a 5% increase in head
- (•) 120% past BEP
- Rated torque service factors are given in table 12.
- Typically HMD use:
  - DOL start 1.8 – 2.0
  - Soft Start or VFD operation 1.2
  - Considerably higher factor of safety
- (•) Torque/Speed curve can be supplied per Figure 9.

API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

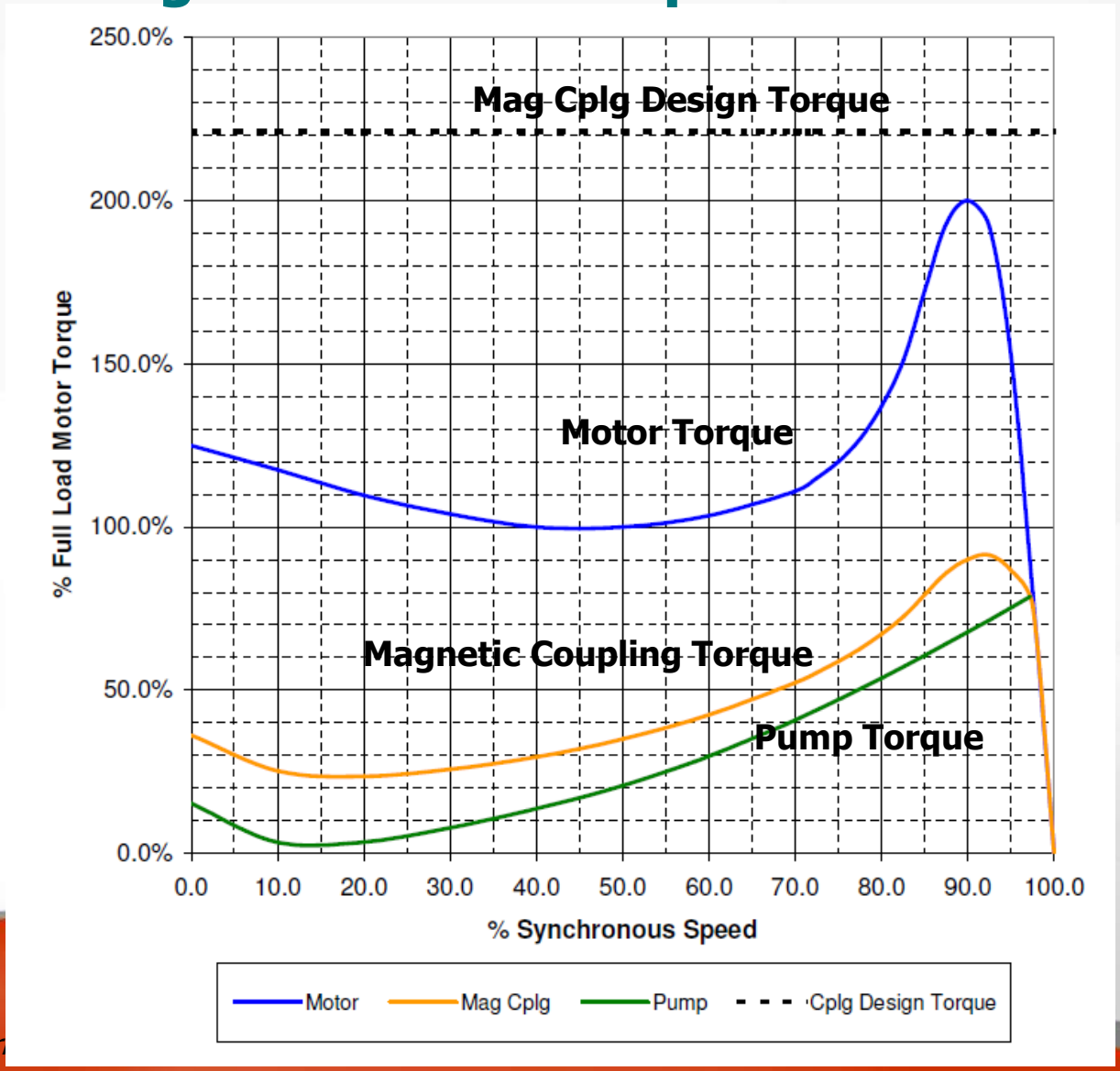


Figure 9. – Speed Torque Curve

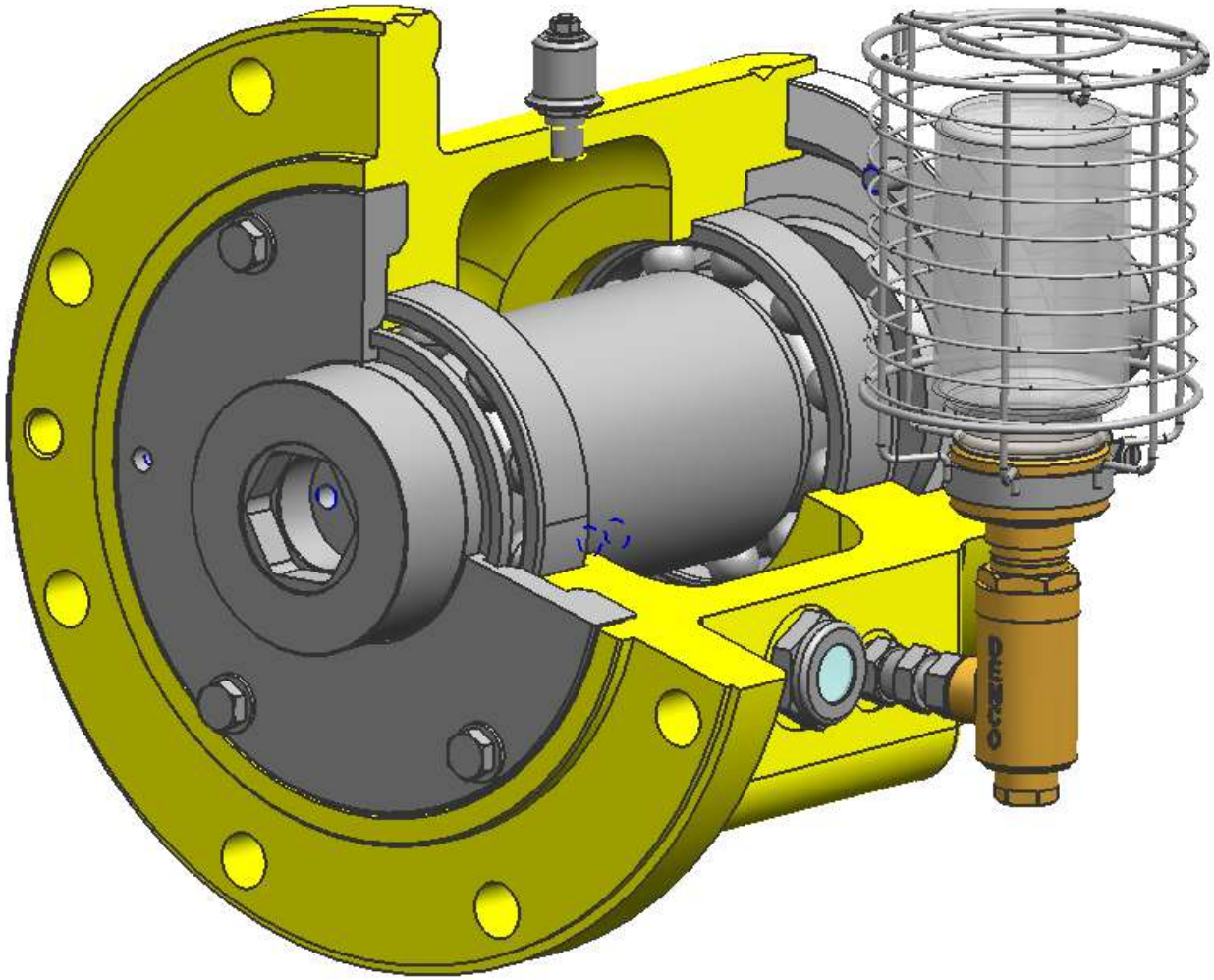
API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

(Pages 56 to 60)

9.1.4 Rolling-element Bearings, Bearing Housings and Lubrication

- Factor *ndm* for individual bearings < 500,000
- L10 > 25,000h
- Radial clearances shall be in accordance manufacturers standard practice
- (•) Bearing housings to feature:
  - Plugged fill and drain openings
  - Constant level sight feed oilers (with wire cages)
  - Bulls eye level
  - Replaceable Labyrinth or magnetic seals
- No lip seals

API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps



API 685 Bearing Housing

API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

(Pages 60 to 63)

9.1.5 Accessories

- Flexible Couplings
  - Min 125mm between shafts of pump and motor
    - Allowing back pull-out of pump without disturbing motor
  - All metal flexible element type
- Coupling Guards
  - Rigid enough to withstand 900N load
  - (•) Spark Resistant Material (HMD standard is brass)

API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

(Pages 63 to 65)

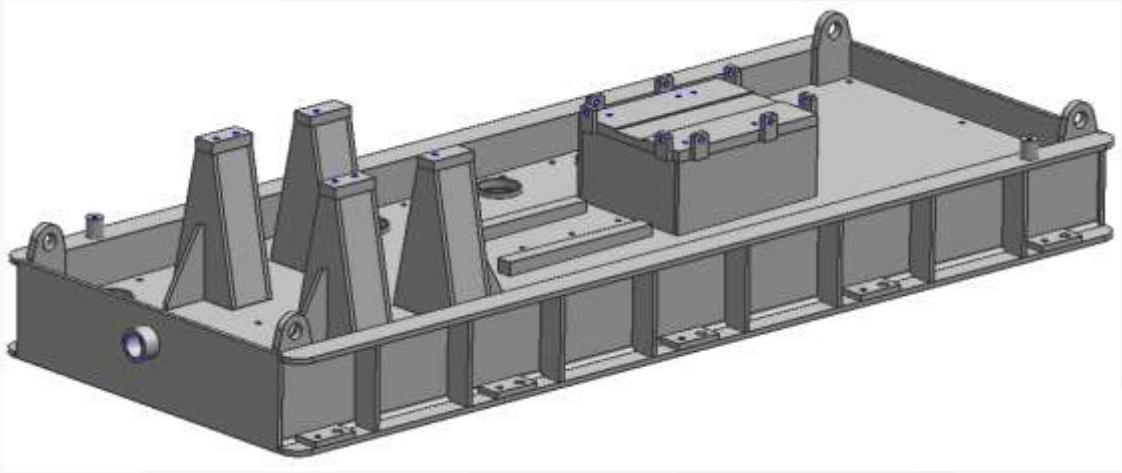
9.1.5 Accessories

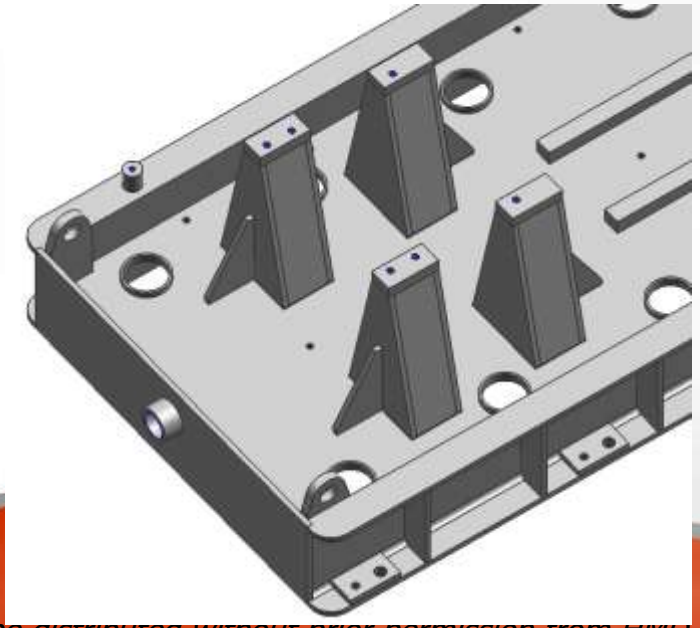
- Baseplates
  - Single-piece drain rim or drain pan baseplate
  - Extending under pump and motor
  - Allow use of 3mm shim packing under drivers
  - Continuous seal welds to be used
  - Grout locking features on underside of baseplate
  - 50mm radii on outside corner in contact with grout
  - Lifting lugs
  - Jacking screws
  - Feature vertical levelling screws

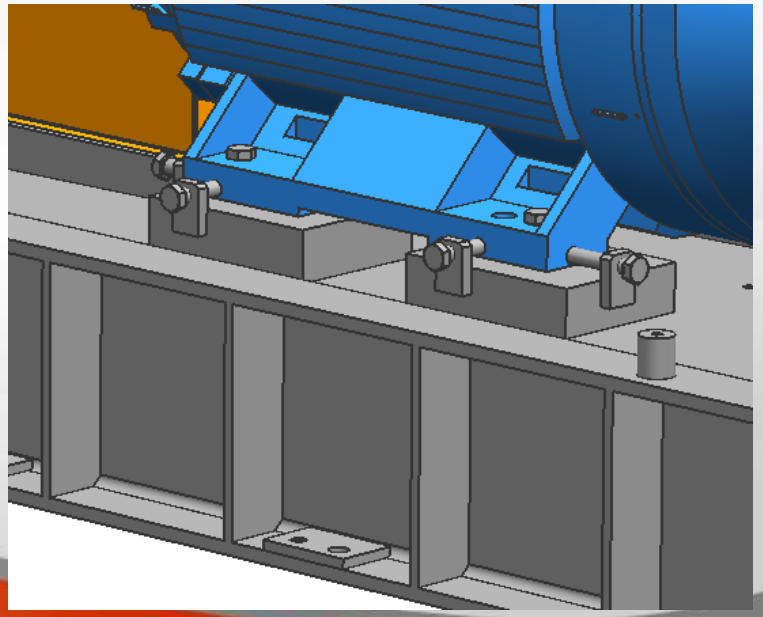
API 685 – 9. Specific Pump Sections
9.1 Magnetic Drive Pumps

API 685 Baseplate Design

- Drain Pan
- 50 mm radii on corners
- Grout Holes and Vents
- Lifting Lugs
- Jacking Screws







API 685 – 10. Vendors Data

(Pages 68 to 73)

10.2 Proposals

- Minimum information forwarded - Drawings
  - General Arrangement drawing
    - Direction of rotation
    - Size and location of major connections
    - Overall weights
    - Lifting points
  - Cross Sectional Drawing
  - Schematics of auxiliary systems
- See Annex O for example VDDR (Vendor Drawing and Data Requirements)

API 685 – 10. Vendors Data

(Pages 68 to 73)

10.2 Proposals

- Minimum information forwarded – Technical Data
  - Purchasers Datasheets
  - Predicted noise data
  - VDDR – including schedule of transmittal
  - Schedule for delivery
  - List of major wearing parts (if applicable)
  - List recommended spare parts
  - Utility requirements
  - Details of optional or additional tests
  - Specific Speed and Suction Specific Speed
  - Performance curve

API 685 – Annexes

(Pages 74 to 79)

Annex A – Application Information (informative)

- Provides a good basis as to what is needed to be understood when applying a seal less pump.
- Covers Circulation plan selection, although vendors usually take care of this
- Provides other general guidance on:
  - Pump performance selection
  - Magnet Component Temperatures
  - Installation, Operation, and Maintenance (Some good guidance points)

API 685 – Annexes

(Pages 80 to 83)

Annex B – Hazard-Based Specification of Control/Containment Guidelines (informative)

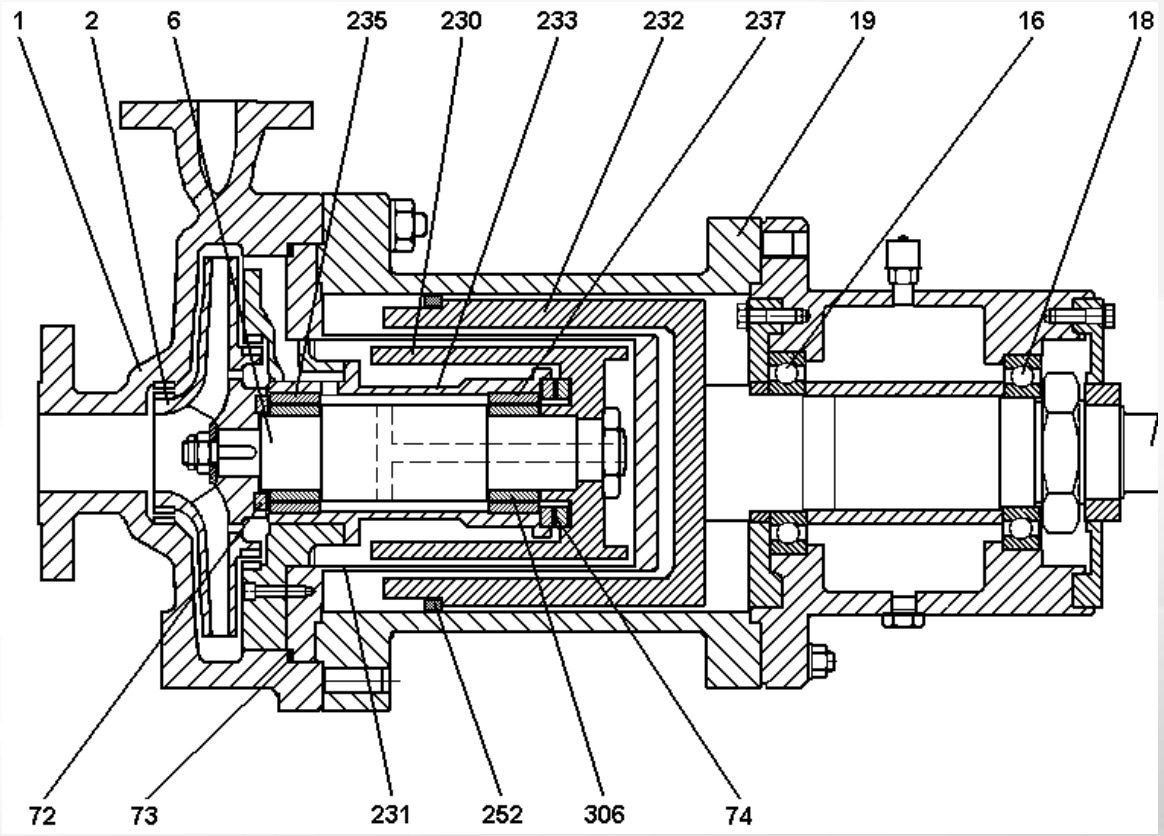
- A selection procedure that can be used to select the appropriate level of secondary control or containment.
- Covers instrumentation of such systems

API 685 – Annexes

(Pages 84 to 87)

Annex C – Sealless Centrifugal Pump Nomenclature (informative)

1	Casing	74	Collar, thrust outboard
2	Impeller	230	Magnetic assembly, inner
6	Shaft, pump	231	Shell, containment
12	Shaft, drive	232	Magnet assembly, outer
16	Bearing, inboard	233	Housing, bearing
18	Bearing, outboard	235	Bushing, bearing inboard
19	Frame (magnet coupling housing)	237	Bushing, bearing outboard
72	Collar, thrust inboard	252	Ring, rub
73	Gasket	306	Sleeve, journal



API 685 – Annexes

(Pages 88 to 91)

Annex D – Circulation and Cooling Water Piping Schematics (normative)

- Provide details of internal bearing feed systems
- Usually decided by the vendor
- Closest system to HMD Discharge to discharge method is:
  - Plan 1-S
  - Plan 11-S (without orifice)
- Note, no cooling water is required with HMD pumps

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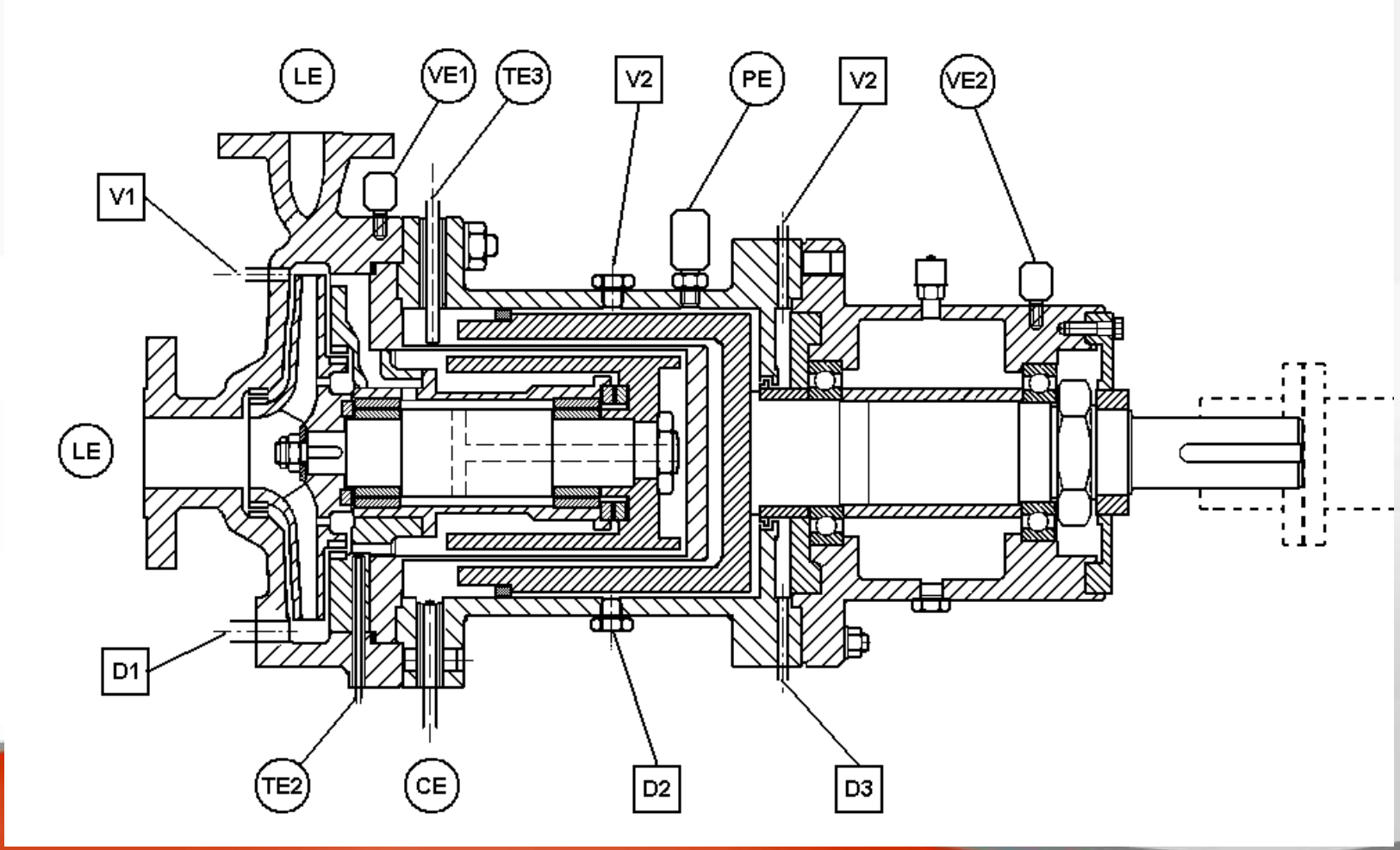
(Pages 92 to 94)

Annex E – Instrumentation and Protective System (informative)



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Annex E – Instrumentation and Protective System (informative)

(Pages 92 to 94)

Tag	Description	Location	Function
DI	Primary Casing Drain	Low point of primary casing	Remove all fluids from primary casing for decommissioning.
D2	Secondary Casing Drain	Low point of secondary containment casing	Remove all fluids from secondary casing for decommissioning.
D3	Secondary Control drain	Low point of area just outside of secondary control barrier	Controlled leakage path for liquids from the secondary control casing.
JE	Power Sensor	Motor Wiring	Indication or alarm/shutdown on high or low power due to dry running, excess load, or single phasing.
LE1	Level Sensor	Pump suction or discharge piping	Permissive/shutdown on absence of liquid level to avoid dry-run.
LE2	Liquid Sensor	Low point of secondary containment area	Shutdown on detection of liquid indicating a failure of the primary containment.
PE	Pressure Sensor	Secondary pressure casing	Shutdown on rising pressure due to containment shell leakage.
TEI	Thermal cutout device	Motor stator windings	Alarm shutdown on excessive temperature in windings due to loss of circulating fluid or over load.
TE2	Temperature sensor with thermowell	Circulation flow path	Indication or alarm/shutdown on increasing temperature due to loss of circulation or magnetic drive decoupling.
TE3	Temperature sensor directly applied	On containment shell/can	Indication or alarm/shutdown on increasing temperature due to loss of circulation or magnetic drive decoupling.
V1	Primary Casing Vent	High point of primary casing	Venting of vapors from primary casing.
V2	Secondary Casing Vent	High point of secondary casing	Venting of vapors from secondary casing.
VE	Vibration sensor	On pump (near) bearing housing	Indication or alarm/shutdown on excessive vibration.
ZE	Shaft position sensor	On pump housing or embedded in stator	Indication or alarm/shutdown on excessive change in shaft position. May be either radial or axial and indicates the wear on the product lubricated bearings.

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(Pages 95 to 124)

Annex F – Criteria for Piping Design (normative)

Annex G - Material Class Selection Guidance (normative)

Annex H - Material and Material Specifications for Pump parts (normative)

- Includes international standard for materials

Annex I – Magnet Material for Magnetic Couplings (informative)

- Provides typical magnet properties and limits

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(Pages 125 to 143)

Annex J – Determination of Residual Unbalance (normative)

Annex K – Pressure temperature profiles in the Recirculation Circuit (normative)

- Gives key information relating to heat balance graphs

Annex L – Lateral Analysis (normative)

Annex M – Standard Baseplates (normative)

Annex N – Inspectors Checklist (informative)

API 685 – Annexes

(Pages 144 to 170)

Annex 0 – Vendor Drawing and Data Requirements

Annex P – Test Data Summary (informative)

Annex Q – Specific Speed and Suction-Specific Speed (informative)

Annex R – Typical Datasheets (informative)

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Questions