

Contents

Page

Foreword	xi	
14.1	Types and nomenclature	1
14.1.1	Introduction	1
14.1.1.1	Purpose	1
14.1.1.2	Scope	1
14.1.2	Definition of rotodynamic pump	2
14.1.3	Types of rotodynamic pumps	2
14.1.3.1	Overhung impeller type (OH)	2
14.1.3.1.1	Flexibly coupled (OH0, OH1, OH2, OH3, and OH6)	4
14.1.3.1.2	Rigidly coupled/short coupled (OH4 and OH13)	4
14.1.3.1.2.1	Rigidly coupled	4
14.1.3.1.2.2	Short-coupled	4
14.1.3.1.3	Close-coupled (OH5, OH6, OH7, and OH8)	4
14.1.3.1.3.1	High-speed integral, gear-driven pumps (OH6)	4
14.1.3.2	Impeller between-bearing type (BB)	5
14.1.3.2.1	One and two stage with axially split casing (BB1)	5
14.1.3.2.2	One and two stage with radially split casing (BB2)	5
14.1.3.2.3	Multistage with axially split casing and volute (BB3)	6
14.1.3.2.4	Multistage with radially split casing held in place with tie bolts (BB4)	6
14.1.3.2.5	Multistage with radially split casing external casing and internal pumping elements (BB5)	6
14.1.3.3	Impeller vertically suspended type (VS)	6
14.1.3.3.1	Single casing	8
14.1.3.3.1.1	Submersible (VS0)	8
14.1.3.3.1.2	Discharge through column (VS1, VS2, and VS3)	8
14.1.3.3.1.3	Separate Discharge (VS4 and VS5)	8
14.1.3.3.2	Double casing (VS6, VS7, and VS8)	8
14.1.3.4	Regenerative turbine type (RT)	8
14.1.3.5	Circulator pumps (CP)	9

14.1.3.5.1.1	Close-coupled circulator pumps (CP1 and CP2)	10
14.1.3.5.1.2	Flexibly coupled circulator pumps (CP3)	10
14.1.3.6	Hydraulic power recovery turbine	10
14.1.3.7	Pumps of other configurations	10
14.1.3.7.1	Casing/Impeller Types.	12
14.1.3.7.1.1	Diffuser, vaned (a)	12
14.1.3.7.1.3	Volute (b)	12
14.1.3.7.1.4	Axial (c)	12
14.1.3.7.1.5	Pitot Tube (d)	12
14.1.3.7.2	Vertical	12
14.1.3.7.2.1	In-line (std)	12
14.1.3.7.2.2	End Suction (g)	12
14.1.3.7.3	Self-priming (h)	12
14.1.3.7.4	Sealless (i)	13
14.1.3.7.4.1	Magnetic Drive	13
14.1.3.7.4.3	Canned motor	13
14.1.3.7.5	Multistage (j)	13
14.1.3.7.6	Rotodynamic pump types – overhung impeller.	14
14.1.3.7.7	Rotodynamic pump types – vertically suspended.	15
14.1.3.7.8	Rotodynamic pump types – between bearing.	15
14.1.3.7.9	Rotodynamic pump types – regenerative turbine	15
14.1.3.7.10	Rotodynamic pump types – circulator pump.	16
14.1.4	Impeller Designs	16
14.1.4.1	Specific speed (n_s), type number (K), and suction specific speed (S)	18
14.1.4.1.1	Specific Speed	18
14.1.4.1.2	Type Number	18
14.1.4.1.3	Suction Specific Speed.	19
14.1.4.2	Radial flow	20
14.1.4.3	Francis vane (modified radial flow)	20
14.1.4.4	Mixed flow.	20
14.1.4.5	Axial flow	21

14.1.4.6	Vortex (recessed impeller) type	21
14.1.5	Discharge casing design	21
14.1.5.1	Volute	22
14.1.5.2	Concentric (circular) casing	22
14.1.5.2.1	Modified concentric casing	22
14.1.5.3	Vaned diffuser/collector	22
14.1.5.3.1	Bowl and stage casing	22
14.1.6	Construction drawings	22
14.1.7	General information	62
14.1.7.1	Size of a rotodynamic pump	62
14.1.7.2	Definition of duplicate performance pump	63
14.1.7.3	Definition of dimensionally interchangeable pump	63
14.1.7.4	Definition of identical pump (performance and dimensional)	63
14.1.7.5	Definitions for major pump sub-assemblies	63
14.1.7.5.1	Overhung pumps	63
14.1.7.5.1.1	Liquid end (or wet end assembly)	63
14.1.7.5.1.2	Power end (or frame assembly)	64
14.1.7.5.1.3	Back pull-out assembly	64
14.1.7.5.1.4	Bare rotor	65
14.1.7.5.1.5	Rotating assembly	65
14.1.7.6	Bowl assembly	65
14.1.7.7	Position of casing	65
14.1.7.8	Rotation of shaft	66
14.1.7.8.1	Gear driven	67
14.1.7.8.2	Double-extended shaft	67
14.1.7.9	Special case ASME/ANSI B73.1, C-frame adapter	67
14.1.7.10	Drivers for vertically suspended pumps	68
14.1.7.10.1	Vertical solid shaft driver	68
14.1.7.10.2	Vertical hollow shaft driver	68
14.1.7.11	Open/enclosed line shaft	68
14.1.7.12	Vertically suspended pump length	69

14.1.7.12.1	Total pump length	69
14.1.7.12.2	Pump setting	69
14.1.8	Pump nomenclature	70
14.1.8.1	Definitions - part names	70
14.1.8.2	Overhung and between-bearing pump dimensions	80
14.2	Definitions, terminology, and symbols	86
14.2.1	Volume rate of flow (Q)	89
14.2.1.1	BEP rate of flow (Q_{opt})	89
14.2.1.2	Minimum continuous stable flow ($Q_{min\ all\ stable}$)	90
14.2.1.3	Minimum continuous thermal flow ($Q_{min\ thermal}$)	90
14.2.1.4	Maximum allowable flow ($Q_{max\ all}$)	90
14.2.2	Speed (n)	90
14.2.2.1	Maximum allowable continuous speed ($n_{max\ all}$)	90
14.2.2.2	Minimum allowable continuous speed ($n_{min\ all}$)	90
14.2.2.3	Rated speed (n_r)	90
14.2.3	Head (h) [H]	90
14.2.3.1	Gauge head (h_g) [H_{Mx}]	90
14.2.3.2	Velocity head (h_v)	90
14.2.3.3	Elevation head (Z) [H_{stat}]	91
14.2.3.4	NPSH datum plane	91
14.2.3.5	Total suction head (h_s), open suction	91
14.2.3.6	Total suction head (h_s), closed suction	91
14.2.3.7	Total discharge head (h_d)	92
14.2.3.8	Total head (H) [H_{tx}]	92
14.2.3.9	Bowl assembly total head (H_{ba})	92
14.2.3.10	Atmospheric head (h_{atm})	92
14.2.3.11	Friction head (h_f or h_j)	92
14.2.4	Condition points	93
14.2.4.1	Rated condition point (Q_r) or (H_r)	93
14.2.4.2	Specified condition point	93
14.2.4.3	Normal condition point (Q_N) or (H_N)	93

14.2.4.4	Best efficiency point (BEP)	93
14.2.4.5	Shutoff (SO)	93
14.2.4.6	Operating regions	93
14.2.4.6.1	Preferred operating region (POR)	93
14.2.4.6.2	Allowable operating region (AOR)	93
14.2.5	Suction conditions	94
14.2.5.1	Submerged suction	94
14.2.5.2	Flooded suction	94
14.2.5.3	Static suction lift (l_s)	94
14.2.5.4	Net positive suction head (NPSH)	94
14.2.5.5	Net positive suction head available (NPSHA)	94
14.2.5.6	Net positive suction head required (NPSHR)	94
14.2.5.7	Net positive suction head resulting in 3% loss of total head (NPSH3)	94
14.2.5.8	Maximum suction pressure ($p_{s\ max}$, [$p_{1\ max\ op}$ or $p_{1\ max\ all}$]	95
14.2.6	Power	95
14.2.6.1	Electric motor input power (P_{mot}) [P_1]	95
14.2.6.2	Pump input power (P_p) [P]	95
14.2.6.3	Bowl assembly input power (P_{ba})	95
14.2.6.4	Pump output power (P_w) [P_u]	95
14.2.6.5	Overall efficiency (η_{OA})	95
14.2.6.6	Pump efficiency (η_p)	96
14.2.6.7	Bowl assembly efficiency (η_{ba})	96
14.2.6.8	Pump pressures	96
14.2.6.8.1	Working pressure (pd) [$p_{2\ max\ op}$]	96
14.2.6.8.2	Maximum allowable working pressure (MAWP)	96
14.2.6.8.3	Field-test pressure	96
14.2.6.8.4	Rated discharge pressure	96
14.2.6.9	Impeller balancing	96
14.2.6.9.1	Single-plane balancing (formerly called static balancing)	96
14.2.6.9.2	Two-plane balancing (formerly called dynamic balancing)	96

Appendix A	97
Appendix B	98
Appendix C	105
Appendix D	107

Figures

14.1.3 — Rotodynamic pump types	2
14.1.3.7 — Typical vertical pump impeller types with rings (casing and/or impeller).....	17
14.1.4.1 — General impeller types	20
14.1.4.2 — Double suction radial flow impeller	20
14.1.4.4 — Mixed-flow impeller	21
14.1.4.5 — Axial-flow impeller	21
14.1.4.6 — Vortex (recessed impeller) type	21
14.1.6a — Overhung impeller – flexibly coupled – frame mounted – single stage	23
14.1.6b — Overhung impeller – flexibly coupled – frame mounted – single-stage – lined pump	24
14.1.6c — Overhung impeller – flexibly coupled – horizontal – axial flow – single-stage	25
14.1.6d — Pitot tube pump	26
14.1.6e — Overhung impeller – flexibly coupled – foot mounted – single-stage – stock pump	27
14.1.6f — Overhung impeller – flexibly coupled – foot mounted – single-stage	28
14.1.6g — Overhung impeller – flexibly coupled – foot mounted – single-stage – ASME B73.1	29
14.1.6h — Overhung impeller – flexibly coupled – foot mounted – self-priming – single-stage	30
14.1.6i — Overhung impeller – flexibly coupled – centerline mounted – single-stage – API 610	31
14.1.6j — Overhung impeller – flexibly coupled – vertical – in-line – integral bearing frame – single-stage	32
14.1.6k — Overhung impeller – flexibly coupled – vertical – end suction – single-stage	33
14.1.6l — Overhung impeller – rigidly coupled – vertical – in-line – single-stage	34
14.1.6m — Overhung impeller – close-coupled – vertical – in-line – single-stage (showing seal and packing) ..	35
14.1.6n — Overhung impeller – close-coupled – vertical – end suction – single-stage – vertically mounted ..	36
14.1.6o — Overhung impeller – close-coupled – high-speed integral gear – single-stage	37
14.1.6p — Overhung impeller – close-coupled – horizontal – single -stage – end suction	38
14.1.6q — Overhung impeller – close-coupled – submersible – diffuser – single-stage – end suction	39
14.1.6r — Overhung impeller – close-coupled – submersible – volute – single-stage – end suction	40
14.1.6s — Between bearings – single-stage – axially split pump	41
14.1.6t — Between bearings – single-stage – radially split pump	42
14.1.6u — Between bearings – multistage – axially split pump	43
14.1.6v — Between bearings – multistage – radially split – single casing pump	44

14.1.6w — Between bearings – multistage – radially split – double casing pump	45
14.1.6x — Regenerative turbine – overhung side channel	46
14.1.6y — Regenerative turbine – overhung peripheral	47
14.1.6z — Regenerative turbine – between bearings - peripheral	48
14.1.6aa — Close-coupled sealless with canned motor	49
14.1.6bb — Close-coupled horizontal in-line.	49
14.1.6cc — Flexibly coupled horizontal in-line.	50
14.1.6dd — Vertically suspended – single casing – submersible pump	51
14.1.6ee — Vertically suspended – single casing – discharge through column – deep-well (set) pumps.	52
14.1.6ff — Vertically suspended – single casing – discharge through column – short-set pump	53
14.1.6gg — Vertically suspended – single casing – discharge through column – short-set - mixed flow pump	54
14.1.6hh — Vertically suspended – single casing – discharge through column – volute pump	55
14.1.6ii — Vertically suspended – single casing – discharge through column – axial flow pump	56
14.1.6jj — Vertically suspended – single casing – separate discharge – line shaft pump.	57
14.1.6kk — Vertically suspended – single casing – separate discharge – cantilever pump	58
14.1.6ll — Vertically suspended – double casing – diffuser pump.	59
14.1.6mm — Vertically suspended – double casing – volute/diffuser multistage pump	60
14.1.6nn — Vertically suspended – double casing – volute multistage pump	61
14.1.6oo — Vertically suspended – in-line casing diffuser	62
14.1.7.5.1.1 — Liquid end (or wet end) assembly.	63
14.1.7.5.1.2 — Power end (or frame assembly)	64
14.1.7.5.1.3 — Back pull-out assembly.	65
14.1.7.7 — Position of casing and shaft rotation.	66
14.1.7.8a — Horizontal pump – shaft rotation (CW rotation).	66
14.1.7.8b — Vertical pump – shaft rotation (CW rotation)	67
14.1.7.9 — Pump with C-frame motor adapter, short coupled	68
14.1.7.12 — Vertically suspended pump dimensions	69
14.1.8.2a — Overhung impeller – flexibly coupled – single-stage – frame mounted.	80
14.1.8.2b — Overhung impeller – flexibly coupled – single-stage – frame mounted – pump on base plate	81
14.1.8.2c — Overhung impeller – flexibly coupled – single-stage – centerline mounted	81
14.1.8.2d — Overhung impeller – flexibly coupled – single-stage – centerline mounted – pump on baseplate	82
14.1.8.2e — Overhung impeller – flexibly coupled – single-stage – centerline mounted (top suction)	82
14.1.8.2f — Overhung impeller – flexibly coupled – single-stage – centerline mounted – pump on baseplate (top suction)	83
14.1.8.2g — Impeller between bearings – flexibly coupled – single-stage – axial (horizontal) split case – pump on baseplate.	83

14.1.8.2h — Impeller between bearings – flexibly coupled – single-stage – axial (horizontal) split case	84
14.1.8.2i — Overhung impeller – close-coupled – single-stage – end suction	84
14.1.8.2j — Overhung impeller – flexibly coupled – vertical – end suction – single-stage – separate driver support.	85
14.1.8.2k — Overhung impeller – flexibly coupled – vertical – end suction – single-stage – integral driver support	85
14.1.8.2l — Overhung impeller – close-coupled – single-stage – vertical end suction	86
14.2.3.4 — Datum elevation for various pump designs at eye of first-stage impeller	91
14.2.4.6.2 — Performance curve for rotodynamic pumps	93
B.1 — Dimensions for types JM and JP, alternating current, face-mounting, close-coupled pump motors having rolling element contact bearings. (This figure relates to Tables B.1 and B.2.).	100
B.4 — Standard dimensions for HI – NEMA type HP and HPH vertical, solid-shaft motors	103
B.5 — Standard dimensions for HI – NEMA vertical hollow-shaft motors	104

Tables

14.1.1 – Rotodynamic pump type designations cross reference.	1
14.1.3.1 – Rotodynamic pump types – overhung	3
14.1.3.2 – Rotodynamic pump types - between-bearing	5
14.1.3.3 – Rotodynamic pump types - vertically suspended	7
14.1.3.4 – Rotodynamic pump types – regenerative turbine type	9
14.1.3.5 – Rotodynamic pump types – circulator pumps.	9
14.1.3.7 – Rotodynamic pump sub-classifications	11
14.1.8.1a – Rotodynamic pump nomenclature - alphabetical listing	70
14.1.8.1b – Rotodynamic pump nomenclature - numerical listing.	78
14.2a – Principal symbols	86
14.2b – Subscripts.	88
B.3 – provides open drip-proof frame selections.	98
B.1 – Dimensions for type JM, alternating current, face-mounting, close-coupled pump motors (US customary units)	99
B.2 – Dimensions for type JP, alternating current, face-mounting, close-coupled pump motors (US customary units)	100
B.2 – Dimensions for type JP, alternating current, face-mounting, close-coupled pump motors (US customary units)	101
B.3 – Open drip-proof frame selections.	101
B.4 – Standard dimensions for HI – NEMA type HP and HPH vertical solid-shaft motors (US customary units)	102
B.5 – Dimensions for vertical hollow-shaft driver couplings (US customary units)	103