

6062 217  
6062 707

# Guide to **EUROPEAN PUMPS & PUMPING**

**The practical reference book on  
pumps and pumping with  
comprehensive buyers guide to  
European manufacturers and  
suppliers**

**Edited by Brian Nesbitt**

**PD Pump Consultant**



Second Edition Published 2000

First Edition 1994

This publication is copyright under the Berne Convention and the International Copyright Convention. All rights reserved. Apart from any fair dealing for the purpose of private study, research, criticism, or review, as permitted under the Copyright Designs and Patents Act 1988, no part may be reproduced, stored in any retrieval system, transmitted in any form, by any means, electronic, electrical, chemical, mechanical, photocopying, recording, or otherwise, without the prior permission of the copyright owners. Unlicensed multiple copying of this publication is illegal. Inquiries should be addressed to: The Publishing Editor, Professional Engineering Publishing Limited, Northgate Avenue, Bury St Edmunds, Suffolk, IP32 6BW, UK.

© Roles and Associates Limited

ISBN 1 86058 286 9

A CIP catalogue for this book is available from the British Library

Whilst every care has been taken in the preparation of this publication, the publishers are not responsible for any statement made in this publication. Data, discussion, and conclusions developed by the Editor are for information only and are not intended for use without independent substantiating investigation on the part of potential users. Opinions expressed are those of the Editor and not necessarily those of the Institution of Mechanical Engineers or its publishers.

Printed and bound in Great Britain by Antony Rowe Limited, Chippenham, Wiltshire.



**Professional  
Engineering  
Publishing**

Professional Engineering Publishing,  
Bury St Edmunds and London UK

Published in  
association with

**ROLES  
&associates**

# Contents

<b>Chapter 1 — The properties of liquids</b>	<b>1</b>	2.5.4 Other instruments	66
<b>1.1 Explanation of Terms</b>	<b>2</b>	<b>2.5.5 Measurement standards</b>	67
1.1.1 Introduction	2		
1.1.2 Changes of state	2		
1.1.3 Viscosity	3	<b>Chapter 3 — Pump types</b>	69
1.1.4 Density and relative density	4	<b>3.1 Introduction</b>	71
1.1.5 Compressibility	4	<b>3.2 Rotodynamic pumps</b>	72
1.1.6 pH value	5	3.2.1 Rotodynamic pump theory	72
1.1.7 Hazards	6	3.2.2 Rotodynamic pump curves	78
<b>1.2 Water</b>	<b>9</b>	3.2.3 Rotodynamic pump classification	81
1.2.1 Demineralized water	9	3.2.4 Types of rotodynamic pump	83
1.2.2 Fresh water	9	<b>005 Standard water pumps</b>	83
1.2.3 Brackish water	12	<b>010 Double suction axially-split pumps</b>	84
1.2.4 Sea water	12	<b>015 Heating, water and sanitation pumps</b>	84
<b>1.3 Oils</b>	<b>14</b>	<b>020 Automatic water supply packages</b>	85
1.3.1 General	14	<b>025 Standard pumps to EN 733</b>	85
1.3.2 Viscosity	14	<b>030 Agricultural pumps without driver</b>	86
<b>1.4 Liquid-solid mixtures</b>	<b>16</b>	<b>035 Fixed irrigation pumps</b>	86
1.4.1 General	16	<b>040 Machine tool coolant pumps</b>	86
1.4.2 Sewage	18	<b>045 Marine pumps</b>	87
1.4.3 Sludge	19	<b>050 Electrically driven submersible pumps</b>	88
1.4.4 Pulps	19	<b>055 Vertical wet pit pumps</b>	88
<b>1.5 Liquid-gas mixtures</b>	<b>20</b>	<b>060 Vertical dry pit pumps</b>	89
<b>1.6 Table of liquid properties</b>	<b>20</b>	<b>065 Portable self-priming pumps and</b>	
1.6.1 General	20	<b>submersible pumps not electrically driven</b>	89
1.6.2 Liquid Table	22	<b>070 Deep well pumps with ejector</b>	90
1.6.3 Supplementary diagrams	30	<b>075 Submersible deep well pumps</b>	90
<b>Chapter 2 — Liquid flow</b>	<b>39</b>	<b>080 Wash water pump packages</b>	91
<b>2.1 Basic equations</b>	<b>40</b>	<b>085 Multi-stage segmental pumps &lt;300m</b>	92
2.1.1 Explanation of terms	40	<b>090 Multi-stage segmental pumps &gt;300m</b>	92
2.1.2 Continuity equation	40	<b>095 Standard pumps to ISO 2858, ISO 3069, ISO 3661</b>	92
2.1.3 Bernoulli's equation	40	<b>100 End suction pumps to ASME/ANSI B73.1</b>	93
2.1.4 Momentum equation	41	<b>105 Inline pumps to ASME/ANSI B73.2</b>	93
2.1.5 Energy equation	42	<b>110 End suction pumps to API 610/ISO/DIS 13709</b>	95
<b>2.2 Pipe flow losses</b>	<b>43</b>	<b>115 Double suction pumps to API 610/ISO/DIS 13709</b>	95
2.2.1 Reynolds Number	43	<b>120 Magnetic drive pumps</b>	95
2.2.2 Pressure losses in straight pipes	43	<b>125 Canned motor pumps</b>	96
2.2.3 Pressure losses in fittings	44	<b>130 Non-metallic pumps</b>	97
2.2.4 Hydraulic diameter	44	<b>135 Pulp pumps</b>	97
2.2.5 Total losses in a pipe system	45	<b>140 Pumps for solids &gt;10mm</b>	97
<b>2.3 Liquid-solid mixtures</b>	<b>46</b>	<b>145 Pumps for solids &lt;10mm</b>	98
2.3.1 General	46	<b>150 Hygienic quality pumps</b>	98
2.3.2 Homogeneous suspensions	46	<b>155 High speed single-stage pumps</b>	99
2.3.3 Heterogeneous suspensions	47	<b>160 High speed multi-pump packages</b>	99
2.3.4 Paper pulp	49	<b>165 Multi-stage axially-split pumps</b>	100
<b>2.4 Pressure loss diagrams</b>	<b>50</b>	<b>170 Multi-stage radially-split pumps</b>	100
2.4.1 General	50	<b>175 Vertical multi-stage pumps</b>	101
2.4.2 Water	53	<b>180 Non-clogging pumps with standard motor</b>	102
2.4.3 Oil	56	<b>185 Submersible non-clogging pumps</b>	102
2.4.4 Paper pulp	60	<b>190 Other non-clogging pumps</b>	103
<b>2.5 Flow measurement</b>	<b>62</b>	<b>195 Mixed flow pumps</b>	103
2.5.1 General	62	<b>200 Axial propeller pumps</b>	103
2.5.2 Instruments for pipe systems	63	<b>205 Power recovery turbines</b>	103
2.5.3 Instruments for open channels	65	<b>3.3 Special rotodynamic pumps</b>	104
		<b>215 Peripheral pumps</b>	104
		<b>217 Pitot tube pumps</b>	105
		<b>218 Disc pumps</b>	106

<b>3.4 Positive displacement pumps</b>	<b>106</b>	<b>4.1 System curves</b>	<b>150</b>
3.4.1 Rotary positive displacement pump theory	106	4.1.1 Pump nominal duty point	150
3.4.2 Reciprocating positive displacement pump theory	107	4.1.2 Single pipe system	150
3.4.3 Positive displacement pump curves	111	4.1.3 Variable system curves	151
3.4.4 Classification of positive displacement pumps	111	4.1.4 Branched pipe systems	152
3.4.5 Types of positive displacement pump	112	4.1.5 Viscous and non-Newtonian liquids	154
<b>220 External gear pumps</b>	<b>113</b>	<b>4.2 Valve pressure drop</b>	<b>154</b>
<b>225 Internal gear pumps</b>	<b>113</b>	4.2.1 General	154
<b>230 Screw pumps with two or more screws</b>	<b>114</b>	4.2.2 Isolating valves	154
<b>235 Progressing cavity pumps</b>	<b>115</b>	4.2.3 Non-return valves	154
<b>240 Lobe pumps and rotary piston pumps</b>	<b>116</b>	4.2.4 Control valves	154
<b>245 Rigid vane and flexible vane pumps</b>	<b>118</b>	<b>4.3 Multiple pump systems</b>	<b>156</b>
<b>250 Peristaltic hose pumps</b>	<b>119</b>	4.3.1 Series pump operation	156
<b>255 Rotary peristaltic pumps</b>	<b>119</b>	4.3.2 Parallel pump operation	157
<b>257 Rotary eccentric piston pumps</b>	<b>120</b>	4.3.3 Pressure boosting	158
<b>260 Piston pumps for hydraulic power applications</b>	<b>120</b>	4.3.4 Pressure maintenance	159
<b>265 Portable plunger pump packages for high pressure descaling/cleaning</b>	<b>120</b>	<b>4.4 Pump hydraulic specification data</b>	<b>160</b>
<b>270 Plunger pumps - horizontal and vertical</b>	<b>121</b>	4.4.1 Hydraulic tolerances	160
<b>275 Piston pumps</b>	<b>123</b>	4.4.2 Pump H and Q at maximum efficiency	160
<b>277 Syringe pumps</b>	<b>123</b>	4.4.3 Minimum pump flow	161
<b>280 Mechanical diaphragm pumps</b>	<b>124</b>	<b>4.5 Water hammer in pump installations</b>	<b>162</b>
<b>282 Air-driven diaphragm pumps</b>	<b>125</b>	4.5.1 Hydraulic gradient	162
<b>285 Metering pumps</b>	<b>125</b>	4.5.2 Causes of water hammer	163
<b>287 Direct-acting pumps</b>	<b>126</b>	4.5.3 Pump behaviour power loss	163
<b>289 Non-metallic positive displacement pumps</b>	<b>128</b>	4.5.4 Protection against water hammer	164
<b>3.5 Other pump types</b>	<b>128</b>	<b>4.6 Pressure pulsations in piping systems</b>	<b>167</b>
3.5.1 Fluid powered pumps	129	4.6.1 Rotodynamic pumps	167
<b>290 Jet pumps</b>	<b>129</b>	4.6.2 Positive displacement pumps	167
<b>295 Air lift pumps</b>	<b>130</b>	<b>4.7 Bibliography</b>	<b>167</b>
3.5.2 Novel rotary pumps	130	<b>Chapter 5 — Flow regulation</b>	<b>169</b>
<b>300 Barrel emptying pumps</b>	<b>131</b>	<b>5.1 Introduction</b>	<b>170</b>
<b>305 Archimedean screw pumps</b>	<b>131</b>	<b>5.2 Variable flow requirements</b>	<b>171</b>
3.5.3 Miscellaneous pumps	131	<b>5.3 Flow regulation</b>	<b>172</b>
<b>315 Miscellaneous types</b>	<b>132</b>	5.3.1 Methods	172
<b>3.6 Suction performance</b>	<b>133</b>	5.3.2 Control signals	172
3.6.1 Cavitation	133	<b>5.4 On-off control of constant speed pump</b>	<b>172</b>
3.6.2 Net Positive Suction Head and Net Positive Inlet Pressure	134	5.4.1 Principle and application	172
3.6.3 Permissible suction lift	135	5.4.2 Costs	173
3.6.4 Cavitation effects on pump operation	136	5.4.3 Problems when starting/loading	173
3.6.5 Self-priming	138	5.4.4 Problems when stopping/unloading	173
3.6.6 The effect of dissolved and entrained gases	139	5.4.5 Operational sequences	174
3.6.7 Examples	139	5.4.6 Storage volumes	175
<b>3.7 Standards</b>	<b>140</b>	5.4.7 Power consumption	176
3.7.1 General	140	5.4.8 Examples	177
3.7.2 Issuing authorities	140	<b>5.5 Pole-changing induction motors</b>	<b>177</b>
3.7.3 Pumps	142	5.5.1 Principle and application	177
3.7.4 Safety	142	5.5.2 Costs	178
3.7.5 Reliability and operational life	144	5.5.3 Problems when starting	178
3.7.6 Dimensions and performance	144	5.5.4 Problems when stopping	178
3.7.7 Vibration and noise	145	5.5.5 Storage volumes	178
3.7.8 Forces and moments on connections	145	5.5.6 Power consumption	178
3.7.9 Components	146	5.5.7 Examples	178
3.7.10 Performance testing	146	<b>5.6 Multi-speed gearboxes</b>	<b>178</b>
3.7.11 Hygiene	147	5.6.1 Principle and application	178
3.7.12 Electromagnetic pollution	147	5.6.2 Costs	179

5.6.7 Examples	179	6.8 Reference sources	217
<b>5.7 Throttling by control valve</b>	<b>179</b>	<b>6.9 Bibliography</b>	<b>218</b>
5.7.1 Principle and application	179		
5.7.2 Costs	180	<b>Chapter 7 — Process seals</b>	<b>221</b>
5.7.3 Sizing the control valve	180	<b>7.1 Introduction</b>	<b>222</b>
5.7.4 Power consumption	181	<b>7.2 Methods of sealing: Rotary shafts</b>	<b>222</b>
5.7.5 Examples	181	7.2.1 Non-contacting seals	222
<b>5.8 By-pass return</b>	<b>181</b>	7.2.2 Lip seals	222
5.8.1 Principle and application	181	7.2.3 Hover seals	222
5.8.2 Costs	182	7.2.4 Auxiliary pumps	222
5.8.3 Sizing by-pass	182	7.2.5 Soft packing	223
5.8.4 Overflow by-pass return	182	7.2.6 Mechanical seals	223
5.8.5 Power consumption	182	<b>7.3 Process liquid seals for rotary shafts</b>	<b>223</b>
5.8.6 Example	183	7.3.1 Soft packing	224
<b>5.9 Infinitely variable speed</b>	<b>183</b>	7.3.2 Mechanical seals	227
5.9.1 Principle and application	183	<b>7.4 Methods of sealing: Reciprocating rods</b>	<b>236</b>
5.9.2 Costs	187	7.4.1 Lip seals	236
5.9.3 Conversion of pump curves	187	7.4.2 Soft packing	237
to various speeds		<b>7.5 Soft packing process liquid seals</b>	<b>237</b>
5.9.4 Efficiencies of various methods	188	for reciprocating rods	237
5.9.5 Power consumption	189	<b>7.5.1 Operating principles</b>	<b>237</b>
5.9.6 Regulation system: schematics	190	7.5.2 Design variations	237
5.9.7 Schematics for various systems	191	<b>7.5.3 Packing material</b>	<b>237</b>
<b>5.10 Factors affecting choice of</b>	<b>192</b>	7.5.4 External systems	237
<b>flow regulation method</b>	<b>193</b>	7.5.5 Maintenance	237
5.10.1 Direct flow regulation	193	7.5.6 Trouble-shooting	237
5.10.2 Speed regulation	194	<b>7.6 Selection of process liquid sealing</b>	<b>238</b>
<b>Chapter 6 — Pump materials</b>	<b>197</b>	7.6.1 Process liquid	238
<b>6.1 Introduction</b>	<b>198</b>	7.6.2 Size, speed and pressure	238
<b>6.2 Typical materials</b>	<b>198</b>	7.6.3 Local environment	238
6.2.1 Grey cast iron	199	7.6.4 Cost	238
6.2.2 Spheroidal and nodular cast iron	200	7.6.5 Standardisation	239
6.2.3 Low alloy steel	200	<b>7.7 Bibliography</b>	<b>239</b>
6.2.4 Alloyed cast iron	201	<b>Chapter 8 — Shaft couplings</b>	<b>241</b>
6.2.5 11-13% Cr steel	202	<b>8.1 Introduction</b>	<b>242</b>
6.2.6 Stainless steel	203	<b>8.2 Types of coupling</b>	<b>242</b>
6.2.7 Super stainless steel	203	<b>8.3 Misalignment</b>	<b>243</b>
6.2.8 Copper alloys	204	<b>8.4 Forces and moments</b>	<b>244</b>
6.2.9 Aluminium alloys	204	<b>8.5 Service factors</b>	<b>244</b>
6.2.10 Nickel alloys	204	<b>8.6 Speed</b>	<b>245</b>
6.2.11 Other metallic materials	205	<b>8.7 Size and weight</b>	<b>245</b>
6.2.12 Non-metallic materials	209	<b>8.8 Environment</b>	<b>245</b>
6.2.13 Coatings	209	<b>8.9 Installation and disassembly</b>	<b>246</b>
<b>6.3 Material strength and integrity</b>	<b>211</b>	<b>8.10 Service life</b>	<b>246</b>
<b>6.4 Corrosion and erosion</b>	<b>211</b>	<b>8.11 Shaft alignment</b>	<b>248</b>
6.4.1 Liquid corrosion of metals	211	8.11.1 General	248
6.4.2 Corrosion rate	211	8.11.2 Methods of alignment	248
6.4.3 Types of corrosion	212	8.11.3 Determination of shim thickness	249
6.4.4 Corrosion testing	213	8.11.4 Graphical method of	
<b>6.5 Abrasion resistant materials</b>	<b>214</b>	determining shim thickness	250
6.5.1 Pump selection	214	8.11.5 Optical alignment	250
6.5.2 Hard metallic materials	214	<b>8.12 Choice of coupling</b>	<b>252</b>
6.5.3 Rubber cladding	214	8.12.1 Costs	252
<b>6.6 Materials resistant to cavitation damage</b>	<b>215</b>	8.12.2 Factors influencing choice	252
<b>6.7 Material selection</b>	<b>215</b>	<b>8.13 Guards</b>	<b>252</b>
6.7.1 Basic information	215	<b>8.14 Literature</b>	<b>253</b>
6.7.2 Material combinations	216		
6.7.3 Corrosion resistance	216		
6.7.4 Liquid effect on unknown materials	217		

<b>Chapter 9 — Electric motors for pumps</b>	<b>255</b>			
9.1 General electrical technology, basic principles	256	11.1.13 Painting	285	
9.1.1 Electrical units	256	11.1.14 Purchased equipment	285	
9.1.2 Electrical systems	256	11.1.15 Functional testing	285	
9.1.3 Power; active, apparent and reactive	257	11.1.16 Witnessing	286	
9.1.4 Phase compensation	257	11.1.17 Clarification of specifications	286	
9.1.5 Speed	257	11.1.18 Certification	286	
9.1.6 Torque	258	11.1.19 Documentation	287	
9.1.7 Voltage	258			
9.1.8 Starting	259	<b>11.2 Mass-produced standard pumps</b>	<b>287</b>	
9.1.9 Efficiency	259	<b>11.3 Pumps built to purchaser's specification</b>	<b>287</b>	
9.2 Regulations and standards	259	<b>11.4 Guidelines for documentation</b>	<b>289</b>	
9.2.1 Controlling authorities	259	11.4.1 Rotodynamic pumps	289	
9.2.2 Physical protection	261	11.4.2 Positive displacement pumps	290	
9.2.4 Mounting arrangements	262			
9.2.5 Terminal markings and direction of rotation	263	<b>11.5 Bibliography</b>	<b>291</b>	
9.2.7 Temperature classification	263			
9.2.8 Potentially explosive atmospheres	264			
9.2.9 Certification	264			
9.3 Motor types	264	<b>Chapter 12 — Installation and maintenance</b>	<b>293</b>	
9.3.1 Constant speed AC motors	264	<b>12.1 Installation</b>	<b>294</b>	
9.3.2 Variable speed AC motors	265	<b>12.2 Foundations</b>	<b>295</b>	
9.3.3 Variable speed DC motors	266	<b>12.3 Tanks and sumps</b>	<b>295</b>	
9.4 Motor starters	267	12.3.1 General	295	
9.4.1 Direct-on-line	268	12.3.2 Submersible pumps	296	
9.4.2 Star-Delta	268			
9.4.3 Soft starts	268	<b>12.4 Pipe systems for pumps</b>	<b>297</b>	
9.4.4 Resistance	269	12.5 Care and maintenance	300	
9.5 Noise	269	12.5.1 General considerations	300	
9.6 Maintenance	269	12.5.2 Preventative maintenance	302	
9.7 Example	269	12.5.3 Trouble-shooting guide	304	
Special Note: Engines	270			
Special Note: Turbines	270	<b>12.5.4 Stocking spare parts</b>	<b>305</b>	
Special Note: Power recovery turbines	270			
<b>Chapter 10 — Ancillary equipment</b>	<b>271</b>	<b>Chapter 13 — Pump economics</b>	<b>307</b>	
10.1 Baseplates, skids, trailers and lifting frames	272	<b>13.1 Economic optimisation</b>	<b>308</b>	
10.2 Belt drives	273	13.1.1 Introduction	308	
10.3 Gearboxes	273	13.1.2 New and existing plant	309	
10.4 Relief valves	274	<b>13.2 Economic assessment criteria</b>	<b>309</b>	
10.5 Accumulators	275	13.2.1 Investment calculation - new plant	309	
10.6 Pulsation dampers	276	13.2.2 Investment calculation - existing plant	310	
10.7 Instrumentation	278	13.2.3 Estimated profits and service life	310	
		13.2.4 Energy costs	311	
<b>Chapter 11 — Quality assurance and testing</b>	<b>281</b>	<b>13.3 Important system characteristics</b>	<b>312</b>	
11.1 Introduction	282	13.3.1 Pumping efficiency	312	
11.1.1 Physical properties	282	13.3.2 Demand variations	314	
11.1.2 Heat treatment	283	13.3.3 Availability	314	
11.1.3 Chemical composition	283	13.3.4 Hydraulic power	315	
11.1.4 Corrosion resistance	283			
11.1.5 Non destructive testing	283	<b>13.4 Partial optimisation</b>	<b>316</b>	
11.1.6 Repairs	283	13.4.1 Economic pipe diameter	316	
11.1.7 Welding	283	13.4.2 Component efficiency	317	
11.1.8 Inspection	284	13.4.3 Existing plant	317	
11.1.9 Assembly	284			
11.1.10 Packaging	284	<b>Chapter 14 — Pump selection</b>	<b>319</b>	
11.1.11 Pressure testing	284	<b>14.1 General operating conditions</b>	<b>320</b>	
11.1.12 Running tests	284	<b>14.2 Selection of pump according to pump designation</b>	<b>321</b>	
		Direct selection table	321	
		<b>14.3 Selection of pump according to duty and capabilities</b>	<b>323</b>	
		Rapid selection table	324	
		<b>14.4 Selection of pump according to hydraulic performance</b>	<b>326</b>	
		14.4.1 Pumps for low viscosity liquids	326	
		14.4.2 Pumps for viscous liquids	328	

14.4.3 Pumps for highly viscous liquids	328	<b>Chapter 16 — Pump classification guide and guide to manufacturers and suppliers</b>	<b>359</b>
<b>14.5 Pumps for liquid-solid mixtures</b>	<b>328</b>	<b>16.1 Introduction</b>	<b>360</b>
14.5.1 Pumping non-abrasive solids	329	<b>16.2 Pump classification guide</b>	<b>360</b>
14.5.2 Pumping abrasive solids	329	<b>16.3 Pump manufacturers and suppliers guide</b>	<b>364</b>
14.5.3 "Gentle pumping"	329	<b>16.4 Manufacturers and suppliers of ancillary products</b>	<b>384</b>
14.5.4 Pumping waste water, sewage	330	<b>16.5 Names and addresses of European manufacturers and suppliers</b>	<b>386</b>
<b>14.6 Check lists for pump purchase specification</b>	<b>331</b>	<b>16.6 Trade Names</b>	<b>405</b>
<b>14.7 Purchasing</b>	<b>334</b>	<b>Chapter 17 — Units and conversions</b>	<b>407</b>
<b>Chapter 15 — Case studies</b>	<b>335</b>	<b>17.1 SI, The International System of Units</b>	<b>408</b>
<b>15.1 Pumping fresh water to a high reservoir</b>	<b>336</b>	<b>17.2 Conversion Factors for SI units</b>	<b>409</b>
<b>15.2 A small sewage pumping station</b>	<b>337</b>	<b>17.2.1 Plane angle</b>	<b>409</b>
<b>15.3 A fresh water booster station</b>	<b>339</b>	<b>17.2.2 Length</b>	<b>409</b>
<b>15.4 Circulation pump for domestic central heating</b>	<b>340</b>	<b>17.2.3 Area</b>	<b>409</b>
<b>15.5 Adjustable jet pump</b>	<b>340</b>	<b>17.2.4 Volume</b>	<b>410</b>
<b>15.6 Modernisation of water supply for industrial use</b>	<b>341</b>	<b>17.2.5 Time</b>	<b>410</b>
<b>15.7 Contractors' use of electric powered submersible sump pumps</b>	<b>342</b>	<b>17.2.6 Linear velocity</b>	<b>410</b>
<b>15.8 Engine driven self-priming pumps</b>	<b>343</b>	<b>17.2.7 Linear acceleration</b>	<b>410</b>
<b>15.9 Land reclamation pump</b>	<b>344</b>	<b>17.2.8 Angular velocity</b>	<b>410</b>
<b>15.10 Cargo pumps for tankers</b>	<b>345</b>	<b>17.2.9 Angular acceleration</b>	<b>410</b>
15.10.1 Large tankers for crude oil	345	<b>17.2.10 Mass</b>	<b>410</b>
15.10.2 Smaller tankers for finished products	346	<b>17.2.11 Density</b>	<b>410</b>
15.10.3 Tankers for LNG	346	<b>17.2.12 Force</b>	<b>411</b>
<b>15.11 Liquid detergent manufacture-pump installation</b>	<b>346</b>	<b>17.2.13 Torque</b>	<b>411</b>
<b>15.12 Positive displacement pumps-variable discharge conditions</b>	<b>347</b>	<b>17.2.14 Pressure, stress</b>	<b>411</b>
<b>15.13 Positive displacement pumps-load-unload control</b>	<b>347</b>	<b>17.2.15 Dynamic viscosity</b>	<b>411</b>
<b>15.14 Energy recovery turbines</b>	<b>349</b>	<b>17.2.16 Kinematic viscosity</b>	<b>411</b>
<b>15.15 Economic aspects of energy utilisation</b>	<b>350</b>	<b>17.2.17 Energy</b>	<b>412</b>
<b>15.16 Choosing non-return valves</b>	<b>353</b>	<b>17.2.18 Power</b>	<b>412</b>
<b>15.17 Common errors which create pump operating problems</b>	<b>355</b>	<b>17.2.19 Flow</b>	<b>412</b>
15.17.1 Planning	355	<b>17.2.20 Temperature</b>	<b>412</b>
15.17.2 Liquid properties	356	<b>17.3 Other conversion factors</b>	<b>413</b>
15.17.3 Equipment positioning	356	<b>17.3.1 Hardness</b>	<b>413</b>
15.17.4 Pipework design	357	<b>17.3.2 Material toughness</b>	<b>414</b>
		<b>17.4 Normal quantities and units used within pump technology</b>	<b>414</b>
		<b>Chapter 18 — Useful pump terms translated</b>	<b>415</b>
		<b>Chapter 19 — Reference index</b>	<b>418</b>
		<b>Index to Advertisers</b>	<b>426</b>