



AFBMA designation, 463 Babbitt, 411 Alternate structural formulas, 369 Back cone Angle of contact angle, 273 open belt, 12 radius, 273 cross belt, 12 Backlash in gears, 156 gears, 167 Ball bearings, 457, 461 Angular gears, 274 Band and block brakes, 743 ANSI number of chain, 114 Band brakes, 738 Applications of Barlow's equation, 783 gear boxes, 346 Base circle, 163 pressure vessels, 772 Basic dynamic load capacity, 469 worm gears, 302 Bearing Arc designation, 462 contact factor, 39 lubrication, 486 of approach, 167 materials, 411 of recess, 167 modulus, 436 Arm / spider, 351 pressure, 123, 435 Attitude angle, 418–419 Belt Axial pitch of angle of contact, 12 helical gears, 243 compound, 6 worm gears, 302 construction, 7 Axial width of folded layer, 8 land on piston, 523 raw edge, 8 piston ring, 523 tensions ratio, 15 top land of piston, 523 Belt materials, 7



814 Index	
Belt joints	cone, 701
Bolted, 12	multiplate, 699
Hinged comb, 11	single plate, 683
Laced, 10	Coefficient of friction, 684
Birnie's equation, 782	Collar bearing, 442
Block shoe brakes, 726	Combined rotation and translation in brakes,
Boiler code, 798	722
Brakes, 719	Comparison of silent chains with roller chains,
Breaking loads of chains, 117	132
Buckingham equation for wear, 208	Compound
Built up pulley, 49	belt drive, 6
	epicyclic gear trains, 359
Cage of roller bearings, 459	gear train, 347
Cam profile with	Compression rings, 525
flat follower, 620, 624	Condition for maximum power with belts, 21
roller follower, 623	Cone
Cam shaft, 619	center, 272
Cams, 619	clutch, 701
Cap bolts for connecting rod, 548	distance, 275
Capstan equation, 15	Connecting rod, 539
Center distance between	axial force due to gas pressure, 541
gear box shafts, 380	axial force due to inertia, 541
pulleys, 23, 32	bending force due to inertia, 542
Centrifugal clutch design, 705	big end, 548
Centrifugal tension, 19	Connecting rod design, 544
Chain drive, 104	cross section, 545
advantages/disadvantages, 106	large end, 548
classification, 106	small end, 544
designation, 114, 135	Constant acceleration cam, 620
design, 124	Constant mesh gear box, 385
driving links, 133	Construction of
Change in vessel size with pressure, 785	centrifugal clutch, 704
Chordal action in sprockets, 111	gear boxes, 346
Circular pitch, 156, 242	flywheel, 642
Class of pressure vessels, 774	pistons, 520
Classification of	rolling bearings, 459
bearings, 407	sheave, 85
gear boxes, 362	silent chains, 133 V belts, 2–4
rolling bearings, 460	
Clavarino's equation, 781	wire ropes, 75
Clearance ratio in bearings, 435	Contact ratio of mating gears, 169 Conveyor chains, 107
Clutches, 681	Core of rope, 75
electro-magnetic, 683	Correction factor for pitch length, 39
centrifugal, 704	Correction factor for pitch length, 39



Corrosion allowance in pressure vessels, 774	Desirable qualities of piston, 518
Crankshaft materials, 561	Diameter quotient, 304
Crankshaft design for	Differential band brakes, 741
TDC position, 562	Disc brakes with
maximum torque position, 565	arctual pads, 755
Creep of belt, 23	circular pads, 757
Critical pressure in bearings, 420	Double block shoe brakes, 734
Cross belt, 13	Double helical gears, 245
Crossed helical gears, 243	Drawing cam profile, 622
Crosshead pistons, 520	Drive designation of worms, 310
Crown on pulleys, 45	Drive proportions, 308
Crown gears, 274	Drum and sheave arrangement, 84
Cyclic loads, 479	Dynamic
Cycloid profile, 159	equivalent load, 253, 283, 471
Cylinder air cooled, 502	load, 199
Cylinder design, 506	strength, 319, 338
Cylinder head, 509	•
Cylindrical roller bearing, 460	Eccentricity ratio, 418
Cylindrical worm, 305	Effect of pressure on size of pressure vessel,
	777
Dedendum, 156	Effective load for helical gears, 251
Deep groove bearing, 460, 470	Efficiency of worm drive, 322
Definition and function of	Elliptical bearing, 409
brakes, 719	End covers, 787
clutches, 681	End cover fixing, 795
pistons, 518	bolted, 796
Deflector pistons, 520	integral, 796
Deformation factor, 202	riveted, 796
Design of	Endurance strength of worms, 318
arms of flywheel, 656	Energy absorbed by brakes, 721
cone clutch, 702	Energy in
side crank, 575	combined rotation and translation, 722
shaft, 562, 642	pure rotation, 721
single plate clutch, 690	pure translation, 722
Design power and corrected power, 119	Energy loss due to friction, 426
Design procedure for	Epi-cycloid curve, 160
block shoe brakes, 737	Epicyclic gear trains solutions, 351
chain drive, 124	formula method 1, 355
cone clutch, 702	formula method 2, 356
rolling bearings, 481	translation method, 353
wire rope drive, 87	Equivalent number of teeth of
Design for gear drive with center distance	helical gears, 247
given, 215	bevel gears, 276
not given, 219	Errors in gears, 203



Externally contracting brakes, 754	valves, 602
Eye splice for ropes, 80	Formulative number of teeth
	bevel gears, 276
Face	helical gears, 247
advance for spiral gears, 291	Four lobe bearing, 410
angle of bevel gears, 273	Friction clutch, 683
contact ratio for spiral gears, 291	Friction in worm drives, 322
width of bevel gears, 273	Friction materials, 684
width and overlap of helical gears, 245	Frictional forces between
Factor of safety, 87, 117, 135, 254	gudgeon pin and crank pin, 544
Factors affecting gear design, 212	piston rings and cylinder, 543
Failure of rolling element bearings, 488	Function of a gear box, 345
Fast and loose pulley, 51	8
Fiber rope drive, 69	Gas force, 521, 528
Fiber rope materials, 69	Gear box housing, 387
Finite bearings, 418	Gear design considerations, 193
Fixed block shoe brakes, 726	Gear design for wear strength, 205
Flange size of cylinder, 508	Gear drives
Flank, 141, 155	advantages /disadvantages, 153
Flat belts	versus other drives, 152
joints, 10	Gear materials, 192
pulleys, 44	Gear profiles
specifications, 9	cycloid, 159
Flat follower, 620	involute, 160
Fleet angle, 86	Gear ratios, 311–312, 347
Fluctuation in energy and speed, 643	Gear tooth proportions, 158, 245
Fluid couplings, 390	Gear tooth strength, 193
Flywheels, 641	Gear trains, 346, 351
bending stresses in constrained arms, 650	Grooved pulleys, 51
solid, 651	Gudgeon pin, 526
with arms, 655	design, 527
with web, 654	fixing, 527
Flywheels for	fully floating, 527
engines, 661	Guide links in chains, 133
punches, 666	Gun metal, 412
Followers, 620	Hand of helix, 242
Foot step bearing, 441	Hand of spiral, 292
Force analysis on worms, 314	Heat dissipated from bearings, 431
Forces on	Heat generated
chain, 117	and temperature rise, 428
connecting rod, 541	during clutching, 694
crank shaft, 562	Heat transfer coefficient, 326
gear tooth, 248	Helical gears design, 241, 249
tooth of bevel gear, 279	Helix angle, 242
tooth of pinion, 277	Herringbone gears, 244



Hertz stresses on tooth surface, 205	open belt, 23
Hoisting chains, 107	worm, 304, 309
Hydraulic clutch, 682	Length to diameter ratio of sleeve bearing,
Hydrodynamic bearings, 406	434
Hydrodynamic thrust bearing, 443	Lewis equation, 195
Hydrostatic bearing, 408, 441	Lewis equation for helical gears, 250
Hydrostatic test pressure, 773	Lewis form factor, 197
Hypo-cycloid curve, 160	Life and reliability factors, 210
Hypoid gears, 362	Life of belts, 33
	Life of rolling bearings with varying loads,
I head engine, 593–594	477
Independent wire rope center, 75	Lift
Inertia force in connecting rod, 540, 542	diagrams, 622
Initial tension in belts, 17	of valves, 600
Inner race, 459	Lining wear, 724
Interference, 171	Load capacity, 241, 244
Interference in internal gears, 224	Load distribution factor, 212
Internal combustion engine, 500	Load factor, 481
Internal gear design, 223, 225	Loads on gear tooth, 193
Internally expanding shoe analysis, 746–747	Long bearing, 417
Involute gear tooth systems, 162	Longitudinal stresses in pressure vessels, 775
Involute profile, 160	Lubrication factor for chains, 120
Involute versus cycloid profile, 161	Lubrication hydrodynamic, 415
ISO designation of bearings, 462	, ,
ISO number of chains, 144	Main dimensions of radial ball bearings, 464
	Mass and energy stored in flywheel, 651
Keys, 140	Materials and allowable stresses for pressure
Kinematic diagram, 367	vessels, 773
Kinematic viscosity, 414	Materials for
	brake lining, 720
L head engine, 594	worm, 306–307
Lame's equation, 779	Maximum
Largest gear with a specified pinion, 179	addendum radius, 172
Law of gearing, 164	allowable error in gears, 203
Lay of wire ropes, 72	chain speed, 123
alternate right and left, 73	error between meshing gears, 284
lang, 72	number of teeth on gear, 179
ordinary, 73	pressure in sleeve bearings, 421, 433
regular, 72	speed of silent chain, 136
Lead, 303, 311	tension, 20
Lead angle, 303, 311-312	torque transmitting capacity of clutch, 690
Length of	Mean effective pressure, 503
belt and center distance, 32	Mechanical efficiency of engine, 504
crossed belt, 24	Minimum film thickness, 435



Minimum number of teeth to avoid	Parts of roller chain, 108
interference, 173	Path of contact, 165
Minimum	Phosphorous bronze, 301, 318, 321
oil film thickness, 435	Piston, 518
oil thickness to clearance ratio, 435	barrel, 524
pulley diameter, 31	bosses, 524
teeth for a gear wheel, 174	design, 521
teeth for a pinion, 173	head, 521
teeth for a pinion with rack, 175	materials, 519
Miter gears, 274	rings, 525
Module, 156, 158, 216	Pitch
Mounting factor in gears, 213	angle, 272
Mounting of rolling bearings, 487	angle and gear ratio, 274
Multi belt grooved pulley, 52	circle diameter, 109
Multi-plate clutch, 699	cone, 272
Multiple-strand chains, 108	line, 272
-	line velocity, 348
Needle bearings, 460–461	Pivoted block brakes, 733
Non circular gears, 227	Planetary gear, 352
Normal	Plastics, 9, 412
module, 247	Plate thickness for pressure vessels, 784, 799
pitch, 242	Ports, 594
pressure angle, 242	Positive drive clutch, 683
Number of speeds and stages in a gear box,	Power capacity of chains, 118, 136
369	Power losses in gear box, 388
Number of start, 303	Power rating of V belts, 32
Offset bearing 410	Power transmission chains, 107
Offset bearing, 410	Pressure angle, 304
Offset link, 108 Oil	14.5° composite, 162
	14.5° full depth, 162
flow through bearings, 423	20° full depth, 162
ring grooves, 521	20° stub, 162
rings, 526	of worm, 304
On on half 12	Pressure vessels, 772
Open belt, 12	circumferential stresses, 774
Opening in pressure vessels, 798	longitudinal sreesses, 775
Optimum structural formula, 372	Properties of
Orthogonally displaced bearing, 410	bearing material, 411
Oscillating loads, 483	belt materials, 9
Outer race, 459	brake lining materials, 721
Overload factor, 212	friction materials, 684
Parallel helical gears, 243	involute teeth, 161
Parameters affecting interference, 172	lubricants, 412
Partial bearing, 409	Proportions of bevel gear, 276



PTFE, 412	Self aligning thrust bearing, 460
Pulleys	Self- energizing brakes, 729
armed, 46	Self locking brakes, 729
solid, 44	Semi global face, 306
webbed, 46	Semi-floating gudgeon pin, 527
Push rod design, 616–617	Serpentine belt, 7
Ç	Service factor, 120, 251
Quarter twist belt, 6	Sheave, 85
	alignment, 87
Rack, 152	for fiber ropes, 70
Radial clearance in sleeve bearings, 434	groove hardness, 86
Rated life of a bearing, 472	groove size, 86
Ray diagram, 373	Shoe actuation, 749
Reliability factor for gears, 210	Shoe and brake factor, 750
Reliability of bearings, 474	Short bearings, 418
Reynolds equation, 417	Silent chains allowable pressures, 132
Rim velocity, 648	Simple band brakes, 738
Ring	Simple gear train, 347
axial width, 523	Simple harmonic motion, 604
depth of grooves, 523	Single belt grooved pulley, 52
Rocker arm, 611	
Rocker shaft, 615	Size factor for gears, 214
Roller bearing dimensions, 464	Size of
Roller chains, 108	bearings, 463
Roller follower, 621	cylinder and power, 503
Rolling bearings, 457, 461	valve stem, 601
advantages, 458	valves, 599
angle of contact, 469, 490	Skirt of piston, 524
dimensions, 464	Slide bearings, 457
disadvantages, 458	Slide velocity between gear teeth, 179
Rolling elements, 459	Sliding mesh gear box, 384
Root angle, 273	Slip of belt, 22
Rope drives design, 70	Small / long shoe brake, 730
Ropes, 68	Solid flywheel, 651
Rotation factor, 213, 471	Solid pulley, 45
	Sommerfeld number, 416, 418
SAE designation of oils, 414	Specifying a chain, 134
Selection of	Speed ratio of epicyclic gear trains, 353
lubricant, 486	Speed ratios in geometric progression, 365
parameters for design of bearings, 433	2 2
type of gear box, 364	Spelter socket, 80
wire rope, 81	Spherical roller bearings, 461
wire rope center, 81	Spiral
Self aligning bearing, 460	angle, 292
	bevel gears, 291



820 Index

wrapped belt, 9 Temperature factor, 214 ropes, 77 Temperature rise in bearings, 435 Tensile strength of wire rope, 88 Split bearing, 409 Tensile stresses due to centrifugal force, 649 Split flywheel, 659 Terminology Spring force on valve, 603 gear drives, 155 Sprocket, 139 helical gears, 242 body styles, 140 worm and worm wheel, 302 mounting, 140 Thick cylinders, 778 proportions, 141 Thickness of valve, 600 Spur gears, 191 Thimbles for ropes, 80 Squeeze film, 444 Thin spherical vessels, 784 Squeeze film journal bearings, 444 Thread angle, 303 Standard Three lobe bearing, 410 modules, 158 Throat angle, 86 pitch diameters of pulleys, 37 Throat diameter, 303 width of belts, 30 widths of silent chains, 134 Thrust bearings, 441 Time for clutch engagement, 692 wire diameter, 88 Tolerance on adjacent pitch, 203 Static equivalent load, 468 Static load capacity, 465 Tooth correction factor for chains, 119 Tooth length, 242 Stepped flat pulley, 50 Tooth profiles, 159 Stepped grooved pulley, 51, 53 Straight face of worm, 305 Tooth thickness, 156 Toothed pulley, 53 Straight hobbed face, 305 Top land of piston, 521 Strand center, 81 Tori-spherical end cover, 793 Strand factor, 118 Torque converters, 392 Stranded ropes, 77 Torque ratios of epicyclic gears, 361 Strands, 76 Torque transmitting capacity, 686 Strap thickness of connecting rod, 549 Transmission ratio of a stage, 371 Strength in bending for worm, 317 Trunk pistons, 519 Strength in wear of worm, 321 Two lobe bearing, 409 Strength of bevel gear tooth, 280 Two stage gear box with fixed ratio, 384 Strength of worm gear tooth, 317 Types of Stresses belts, 2 due to internal pressure, 774 bevel gears, 273 in cylinder, 505 brakes, 720 in flywheel, 649 clutches, 682 in wire rope, 82 crank shafts, 561 Structural diagram, 368 Structural formula, 368 cylinders, 501 flat belt drive, 5 Studs/bolts for cylinder, 508 gear drives, 153 Surface finish factor for gears, 213 helical gears, 243 Swaged terminations, 80 pistons, 519 Synchromesh gear box, 386 pitches, 157 Taper roller bearing, 461



Index 821

pulleys, 43 wire ropes, 77 worm gears, 305 worms, 305 Uniform pressure in clutch, 686 Uniform wear in clutch, 687 Unit load, 420 Units of viscosity, 414 Use of oil cooler, 326 Use of silent chains, 132 V belts drive design, 16, 36 Values of elastic coefficient, 207 Values of static load constant, 466 Values of modulus of elasticity, 83, 202 Valve, 593, 596 arrangements, 599 gear mechanism, 593 materials, 598 range of sizes, 599 spring, 607 temperatures, 598 timings, 601 seats, 595, 599 Variation of bearing pressure, 685 Velocity factor, 199 Velocity ratio, 164 Viscosity, 413 Viscosity index, 415

Wall thickness of cylinder, 506 Water cooled cylinder, 502 Wear strength of bevel gears, 284 Wear strength of helical gears, 254 Webbed pulley, 46 Wedge sockets for ropes, 80 Weight of chains, 116 Whole depth, 156 Width of belt, 30 Width of belt and width of pulley, 45 Wire rope clamps/clips, 80 Wire rope, 74 advantages, 74 classification, 78 designation, 78 materials, 74 terminations, 79 Wire strand core, 75 Wires, 75 Working depth of gear teeth, 156 Worm and worm wheel, 300 advantages/disadvantages, 301 design of drive, 328 hour glass worm, 305 proportions, 308 Worm and worm wheel design, 328 approx. center distance given, 328 center distance not given, 333 Worm gear proportions, 309

Zero film, 408