**Maximum permissible torques in lb.ft.** [1)]
based on pitting and bending strength of teeth with good grease lubrication (i.e. use of automatic lubricator described on page 69 or manual lubrication at least once a day), linear speed v = 60 inches per second, with rigid support of the pinion on one side and 1.0 safety factor.

[1)] for keyway connection of pinion, the maximum keyway torque must be checked, see page 65.

**Module 1**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | | Plastic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical | Straight |
| Rack Order code | | 25 10 ... / 36 00 ... 35 10 ... / 36 90 ...[2)] | | 35 11 ...[2)] | | 27 10 ... | | | | | 26 10 ... |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Plastic |
| Pinion Order code | | 21 10 ... 06 10 ... | 21 10 ...* | 21 10 ...* | | 21 10 ...* | | | | | 22 10 ... |
| No.of pinion teeth | Pitch Circle Diameter d Helical Straight | | | | | | | | | | |
| 15 | 15.0 | 0.33 | 1.33 | 1.99 | | 2.21 | | | | | 0.07 |
| 17 | 17.0 | 0.48 | 1.84 | 2.95 | | 4.57 | | | | | 0.11 |
| 18 | 18.0 | 0.66 | 2.07 | 3.39 | | 5.97 | | | | | 0.13 |
| 20 | 20.0 | 0.96 | 2.73 | 4.43 | | 9.59 | | | | | 0.15 |
| 22 | 22.0 | 1.40 | 3.91 | 6.12 | | 12.54 | | | | | 0.22 |
| 25 | 25.0 | 2.43 | 4.94 | 8.11 | | 16.23 | | | | | 0.37 |
| 28 | 28.0 | 3.69 | 5.61 | 10.33 | | 17.70 | | | | | 0.59 |
| 32 | 32.0 | 5.90 | 9.59 | 14.75 | | 20.65 | | | | | 0.96 |
| 36 | 36.0 | 8.11 | 11.06 | 18.44 | | 23.60 | | | | | 1.25 |
| 40 | 40.0 | 11.80 | 16.23 | 23.60 | | 28.03 | | | | | 1.84 |

[2)] For round 35 series rack, only 80 % of torque is transmittable due to reduced face width

**Module 1.5**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | | Plastic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical | Straight |
| Rack Order code | | 25 15 ... / 36 01 ... 35 15 ... / 36 91 ...[2)] | | 35 16 ...[2)] | | 27 15 ... | | | | | 26 15 ... |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Plastic |
| Pinion Order code | | 21 15 ... 06 15 ... | 21 15 ...* | 21 15 ...* | | 21 15 ...* | | | | | 22 15 ... |
| No.of pinion teeth | Pitch Circle Diameter d Helical Straight | | | | | | | | | | |
| 15 | 22.5 | 0.81 | 1.70 | 2.36 | | 5.82 | | | | | 0.22 |
| 17 | 25.5 | 1.18 | 2.36 | 3.32 | | 11.80 | | | | | 0.29 |
| 18 | 27.0 | 1.62 | 3.32 | 4.79 | | 15.48 | | | | | 0.37 |
| 20 | 30.0 | 2.36 | 4.79 | 6.71 | | 23.6 | | | | | 0.44 |
| 22 | 33.0 | 3.69 | 7.38 | 11.06 | | 33.9 | | | | | 0.66 |
| 25 | 37.5 | 7.38 | 14.75 | 22.1 | | 44.2 | | | | | 0.96 |
| 28 | 42.0 | 9.59 | 18.44 | 28.7 | | 47.9 | | | | | 1.70 |
| 32 | 48.0 | 14.75 | 28.0 | 39.1 | | 55.3 | | | | | 2.95 |
| 36 | 54.0 | 20.7 | 33.2 | 46.5 | | 59.7 | | | | | 3.69 |
| 40 | 60.0 | 29.5 | 50.2 | 70.0 | | 79.6 | | | | | 5.16 |

[2)] For round 35 series rack, only 80 % of torque is transmittable due to reduced face width

* Standard 21 series pinions, but induction hardened.

**Maximum permissible torques in lb.ft.** [1)]
based on pitting and bending strength of teeth with good grease lubrication (i.e. use of automatic lubricator described on page 69 or manual lubrication at least once a day), linear speed v = 60 inches per second, with rigid support of the pinion on one side and 1.0 safety factor.

[1)] for keyway connection of pinion, the maximum keyway torque must be checked, see page 65; for maximum torque of compression coupling connection, see page 28.

**Module 2**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | | Plastic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical | Straight |
| Rack Order code | | 25 20 ... / 36 02 ... 35 20 ... / 36 92 ...[2)] | | 33 20 ... 35 21...[2)] | 38 20 ... | 27 20... / 34 20 ... 34 21 ... | | 39 20 ... 39 21 ... | 28 20 ... 28 21 ... | 29 20 ... 29 21 ... | 26 20... |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Plastic |
| Pinion Order code | | 21 20 ... 06 20 ... | 21 20 ...* 24 2. 2.. 20 28/88 ... | 21 20 ...* 24 2. 2.. 20 28/88 ... | 24 2. 5.. 20 29 ... 20 89 ... | 21 20 ...* | 24 2. 2.. 20 28 ... 20 88 ... | 24 2. 5.. 20 29 ... 20 89 ... | 24 2. 2.. 20 28 ... 20 88 ... | 24 2. 5.. 20 29 ... 20 89 ... | 22 20 ... |
| No.of pinion teeth | Pitch Circle Diameter d Helical Straight | | | | | | | | | | |
| 15 | 30.0 | 3.32 | 10.32 | 16.21 | | 22.1 | 66.3 | | | | 0.44 |
| 17 | 34.0 | 5.75 | 14.75 | 21.4 | | 31.0 | 84.8 | | | | 0.66 |
| 18 | 36.0 | 7.38 | 16.95 | 24.3 | | 36.9 | 88.4 | | 99 | | 0.81 |
| 20 | 42.44 40.0 | 10.33 | 20.6 | 31.7 | 33.9 | 55.3 | 102 | 106 | 118 | 134 | 0.88 |
| 22 | 44.0 | 14.01 | 24.3 | 38.3 | 43.5 | 66.3 | 107 | 114 | 131 | | 1.33 |
| 25 | 53.05 50.0 | 19.90 | 35.4 | 50.1 | 53.8 | 94.3 | 125 | 133 | 148 | 168 | 2.21 |
| 28 | 59.41 56.0 | 24.3 | 47.2 | 60.4 | 64.9 | 103 | 136 | 145 | 166 | 184 | 3.69 |
| 30 | 63.66 60.0 | 32.4 | 54.5 | 73.8 | 77.4 | 112 | 146 | 157 | 176 | 199 | |
| 32 | 67.90 64.0 | 40.5 | 61.2 | 85.5 | 88.4 | 120 | 155 | 168 | 184 | 214 | |
| 36 | 76.39 72.0 | 55.3 | 87.7 | 103 | 111 | 128 | 170 | 184 | 210 | 236 | |
| 40 | 80.0 | 72.2 | 99.5 | 138 | 144 | 147 | 184 | 212 | 236 | 269 | |

[2)] For round 35 series rack, only 80 % of torque is transmittable due to reduced face width

**Module 2.5**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | | Plastic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical | Straight |
| Rack Order code | | 25 25 ... 35 25 ...[2)] | | | | 27 25 ... | | | | | 26 25 ... |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Plastic |
| Pinion Order code | | 21 25 ... | 21 25 ...* | | | 21 25 ...* | | | | | 22 25 ... |
| No.of pinion teeth | Pitch Circle Diameter d Helical Straight | | | | | | | | | | |
| 15 | 37.5 | 6.34 | 11.42 | | | 44.2 | | | | | 0.88 |
| 17 | 42.5 | 10.32 | 18.43 | | | 61.9 | | | | | 1.33 |
| 18 | 45.0 | 13.27 | 23.6 | | | 73.8 | | | | | 1.62 |
| 20 | 50.0 | 18.43 | 33.2 | | | 111 | | | | | 1.77 |
| 22 | 55.0 | 25.8 | 44.2 | | | 133 | | | | | 2.65 |
| 25 | 62.5 | 39.1 | 70.0 | | | 189 | | | | | 4.42 |
| 28 | 70.0 | 44.2 | 84.8 | | | 206 | | | | | 7.38 |
| 32 | 80.0 | 73.8 | 98.0 | | | 240 | | | | | |
| 36 | 90.0 | 99.5 | 158 | | | 258 | | | | | |
| 40 | 100.0 | 129 | 181 | | | 295 | | | | | |

[2)] For round 35 series rack, only 80 % of torque is transmittable due to reduced face width

* Standard 21 series pinions, but induction hardened.

**Maximum permissible torques in lb.ft.** [1)]
based on pitting and bending strength of teeth with good grease lubrication (i.e. use of automatic lubricator described on page 69 or manual lubrication at least once a day), linear speed v = 60 inches per second, with rigid support of the pinion on one side and 1.0 safety factor.

[1)] for keyway connection of pinion, the maximum keyway torque must be checked, see page 65; for maximum torque of compression coupling connection, see page 28.

**Module 3**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | | Plastic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical | Straight |
| Rack Order code | | 25 30... / 36 04.. / 37 08<br>35 30... / 36 94 ... / 37 98[2)] | | 33 30 ...<br>35 31...[2)] | 38 30 ... | 27 30 ... / 34 30 ...<br>34 31 ... | | 39 30 ...<br>39 31 ... | 28 30 ...<br>28 31 ... | 29 30 ...<br>29 31 ... | 26 30 ... |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Plastic |
| Pinion Order code | | 21 30 ...<br>06 30 ... | 21 30 ...*<br>24 3. 2..<br>20 28/88 ... | 21 30 ...*<br>24 3. 2..<br>20 28/88 ... | 24 3. 5..<br>20 29 ...<br>20 89 ... | 21 30...* | 24 3. 2..<br>20 28 ...<br>20 88 ... | 24 3. 5..<br>20 29 ...<br>20 89 ... | 24 3. 2..<br>20 28 ...<br>20 88 ... | 24 3. 5..<br>20 29 ...<br>20 89 ... | 22 30 ... |
| No.of pinion teeth | Pitch Circle Diameter d<br>Helical Straight | | | | | | | | | | |
| 15 | 45.0 | 9.59 | 30.2 | 46.4 | | 64 | | | | | 1.33 |
| 17 | 51.0 | 15.48 | 51.6 | 73.8 | | 109 | | | | | 1.92 |
| 18 | 54.0 | 25.8 | 59.7 | 89.2 | | 129 | 273 | | 295 | | 3.32 |
| 20 | 63.66 60.0 | 33.9 | 67.8 | 102 | 107 | 158 | 287 | 302 | 310 | 372 | 4.57 |
| 22 | 70.03 66.0 | 48.6 | 84.8 | 125 | 134 | 225 | 302 | 317 | 346 | 391 | 8.11 |
| 25 | 79.57 75.0 | 71.5 | 124 | 173 | 181 | 324 | 346 | 361 | 391 | 446 | 11.06 |
| 28 | 84.0 | 95.8 | 151 | 210 | 217 | 357 | 380 | 409 | 442 | | |
| 32 | 96.0 | 144 | 214 | 295 | 306 | 376 | 398 | 415 | 457 | | |
| 36 | 108.0 | 200 | 271 | 377 | 387 | 473 | 494 | 516 | 568 | | |
| 40 | 120.0 | 251 | 332 | 457 | 472 | 575 | 590 | 604 | 649 | | |

[2)] For round 35 series rack, only 80 % of torque is transmittable due to reduced face width

**Module 4**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | | Plastic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical | Straight |
| Rack Order code | | 25 40 ...<br>35 40 ... [2)] | | 33 40 ...<br>35 41...[2)] | 38 40 ... | 27 40 ... / 34 40 ...<br>34 41 ... | | 39 40 ...<br>39 41 ... | 28 40 ...<br>28 41 ... | 29 40 ...<br>29 41 ... | |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Plastic |
| Pinion Order code | | 21 40 ...<br>06 40 ... | 21 40 ...*<br>24 4. 2..<br>20 28/88 ... | 21 40...*<br>24 4. 2..<br>20 28/88 ... | 24 4. 5..<br>20 29 ...<br>20 89 ... | 21 40...* | 24 4. 2..<br>20 28 ...<br>20 88 ... | 24 4. 5..<br>20 29 ...<br>20 89 ... | 24 4. 2..<br>20 28 ...<br>20 88 ... | 24 4. 5..<br>20 29 ...<br>20 89 ... | |
| No.of pinion teeth | Pitch Circle Diameter d<br>Helical Straight | | | | | | | | | | |
| 15 | 63.66 40 | 29.5 | 95.8 | 140 | 151 | 162 | 479 | 494 | | 568 | |
| 17 | 68 | 44.2 | 129 | 184 | 193 | 269 | 590 | 605 | 612 | | |
| 18 | 84.88 72 | 62.6 | 147 | 214 | 225 | 332 | 642 | 664 | | | |
| 20 | 93.37 80 | 84.8 | 184 | 262 | 273 | 472 | 701 | 719 | 789 | 900 | |
| 22 | 106.10 88 | 122 | 221 | 317 | 328 | 656 | 774 | 811 | 885 | 988 | |
| 25 | 100 | 177 | 306 | 424 | 435 | 789 | 848 | 885 | 981 | 1129 | |
| 28 | 112 | 258 | 372 | 531 | 542 | 900 | 959 | 996 | 1106 | 1269 | |
| 32 | 128 | 361 | 516 | 709 | 726 | 1033 | 1099 | 1143 | 1254 | 1453 | |
| 36 | 144 | 501 | 663 | 884 | 944 | 1143 | 1210 | 1254 | | | |
| 40 | 160 | 627 | 811 | 1143 | 1217 | 1261 | 1401 | 1453 | 1475 | | |

[2)] For round 35 series rack, only 80 % of torque is transmittable due to reduced face width

* Standard 21 series pinions, but induction hardened.

**Maximum permissible torques in lb.ft.** [1)]
based on pitting and bending strength of teeth with good grease lubrication (i.e. use of automatic lubricator described on page 69 or manual lubrication at least once a day), linear speed v = 60 inches per second, with rigid support of the pinion on one side and 1.0 safety factor.

[1)] for keyway connection of pinion, the maximum keyway torque must be checked, see page 65; for maximum torque of compression coupling connection, see page 28.

**Module 5**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical |
| Rack Order code | | 25 50 ... 35 50 ... [2)] | | 33 50 ... 35 51...[2)] | 38 50 ... 38 51 ... | 27 50 ... / 34 50 ... 34 51 ... | | 39 50 ... 39 51 ... | 28 50 ... 28 51 ... | 29 50 ... 29 51 ... |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened |
| Pinion Order code | | 21 50 ... | 21 50 ...* | 21 50 ...* | 24 5. 5.. | 21 50...* | 24 5. ... 20 28 ... 20 88 ... | 24 5. ... 20 29 ... 20 89 ... | 24 5. ... 20 28 ... 20 88 ... | 24 5. ... 20 29 ... 20 89 ... |
| No.of pinion teeth | Pitch Circle Diameter d Helical Straight | | | | | | | | | |
| 12 | 63.66 60 | 36.9 | 111 | 140 | 221 | 207 | | 664 | | 774 |
| 13 | 65 | 44.3 | 133 | 170 | | 243 | | | | |
| 15 | 79.57 75 | 66.4 | 192 | 236 | | 332 | 701 | 848 | 811 | 959 |
| 17 | 85 | 88.5 | 258 | 302 | | 538 | | | | |
| 18 | 95.49 90 | 118 | 295 | 339 | 479 | 668 | | 1070 | | 1217 |
| 19 | 95 | 140 | 332 | 384 | | 789 | | | | |
| 20 | 100 | 170 | 369 | 435 | | 848 | | | | |
| 21 | 105 | 207 | 413 | 472 | | 1011 | 1070 | | 1254 | |
| 22 | 110 | 243 | 450 | 524 | | 1143 | | | | |
| 24 | 127.32 120 | 317 | 546 | 620 | 885 | 1180 | 1239 | 1453 | | 1623 |
| 25 | 125 | 361 | 590 | 679 | | 1224 | 1291 | | 1475 | |
| 30 | 150 | 590 | 885 | 996 | | 1475 | | | | |

[2)] For round 35 series rack, only 80 % of torque is transmittable due to reduced face width

**Module 6**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical |
| Rack Order code | | 25 60... | | | | 27 60... / 34 60 ... 34 61 ... | | 39 60 ... 39 61 ... | 28 60 ... 28 61 ... | 29 60 ... 29 61 ... |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened |
| Pinion Order code | | 21 60... | 21 60...* . | | | 21 60...* | 24 6. ... 20 28 ... 20 88 ... | 24 6. ... 20 29 ... 20 89 ... | 24 6. ... 20 28 ... 20 88 ... | 24 6. ... 20 29 ... 20 89 ... |
| No.of pinion teeth | Pitch Circle Diameter d Helical Straight | | | | | | | | | |
| 13 | 82.76 78 | | | | | | 1070 | 1217 | 1254 | 1438 |
| 15 | 90 | 125 | 347 | | | 586 | | | | |
| 19 | 114 | 266 | 483 | | | 1365 | | | | |
| 20 | 127.32 120 | 317 | 597 | | | 1623 | | 2065 | | 2360 |
| 21 | 126 | 376 | 715 | | | 1807 | 2065 | | 2213 | |
| 25 | 159.15 150 | 642 | 1033 | | | 2176 | 2287 | 2618 | 2655 | 3024 |

* Standard 21 series pinions, but induction hardened.

**Maximum permissible torques in lb.ft.** [1)]
based on pitting and bending strength of teeth with good grease lubrication (i.e. use of automatic lubricator described on page 69 or manual lubrication at least once a day), linear speed v = 60 inches per second, with rigid support of the pinion on one side and 1.0 safety factor.

[1)] for keyway connection of pinion, the maximum keyway torque must be checked, see below; for maximum torque of compression coupling connection, see page 28.

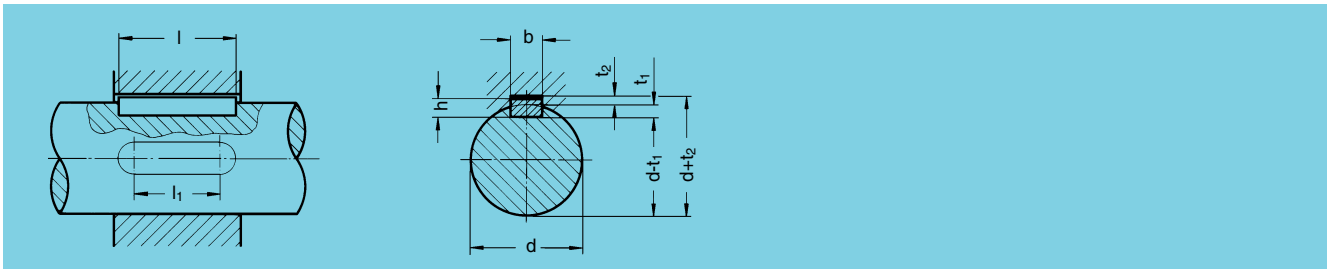
**Module 8**

| Rack Type | | Soft | | Quenched & Tempered | | Induction Hardened | | | Hardened & Ground | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rack Style | | Straight | | Straight | Helical | Straight | | Helical | Straight | Helical | |
| Rack Order code | | 25 80... | | | | 27 80... | | 39 80 ... 39 81 ... | | 29 80 ... 29 81 ... | |
| Pinion Style | | Soft | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | Hardened | |
| Pinion Order code | | 21 80... | 21 80...* | | | 21 80...* | | 24 8. ... | | 24 8. ... | |
| No.of pinion teeth | Pitch Circle Diameter d Helical Straight | | | | | | | | | | |
| 12 | 96 | 170 | 516 | | | 774 | | | | | |
| 15 | 120 | 310 | 848 | | | 1401 | | | | | |
| 18 | 152.79 | | | | | | | 4426 | | 5163 | |
| 20 | 160 | 774 | 1549 | | | 3319 | | | | | |
| 25 | 200 | 1549 | 2508 | | | 5532 | | | | | |

* Standard 21 series pinions, but induction hardened.

## Torque Rating of Keyway Connections

The values in the table are based on a maximum permissible compressive stress of 100 N/mm² (14.5 kpsi) and a bearing length of $l_1$.




| Key | Shaft diameter | Shaft Keyway | Keyway | Maximum Transmittable Torque $T_t$ in lb.ft., length of key $l_1$ in mm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| b x h | d | b x $t_1$ | b x $t_2$ | 10 | 16 | 20 | 28 | 40 | 50 | 70 | 100 | 140 |
| 3 x 3 | 8 ...10 | 3 x 1.8 | 3 x 1.4 | 3.7 | 6.6 | 8.9 | 11.1 | 16.2 | 19.2 | 28.0 | 39.8 | 55.3 |
| 4 x 4 | 10 ... 12 | 4 x 2.5 | 4 x 1.8 | 6.6 | 9.6 | 12.5 | 17.0 | 24.3 | 29.5 | 42.8 | 60.5 | 84.1 |
| 5 x 5 | 12 ...17 | 5 x 3.0 | 5 x 2.3 | 11.1 | 17.7 | 22.1 | 31.0 | 44.3 | 55.3 | 77.4 | 111 | 155 |
| 6 x 6 | 17 ... 22 | 6 x 3.5 | 6 x 2.8 | 18.4 | 29.5 | 36.9 | 51.6 | 73.8 | 92.2 | 129 | 184 | 258 |
| 8 x 7 | 22 ... 30 | 8 x 4.0 | 8 x 3.3 | 28.8 | 46.5 | 57.5 | 80.4 | 116 | 144 | 201 | 288 | 402 |
| 10 x 8 | 30 ... 38 | 10 x 5.0 | 10 x 3.3 | 36.9 | 60.5 | 75.2 | 105.5 | 150 | 188 | 263 | 376 | 526 |
| 12 x 8 | 38 ... 44 | 12 x 5.0 | 12 x 3.3 | 45.7 | 72.2 | 90.7 | 128 | 182 | 227 | 319 | 455 | 637 |
| 14 x 9 | 44 ... 50 | 14 x 5.5 | 14 x 3.8 | 60.5 | 97.4 | 121 | 170 | 243 | 304 | 424 | 607 | 850 |
| 16 x 10 | 50 ... 58 | 16 x 6.0 | 16 x 4.3 | 79.7 | 128 | 159 | 223 | 317 | 398 | 556 | 795 | 1112 |
| 18 x 11 | 58 ... 65 | 18 x 7.0 | 18 x 4.4 | 91.5 | 146 | 183 | 256 | 365 | 457 | 640 | 915 | 1280 |
| 20 x 12 | 65 ... 75 | 20 x 7.5 | 20 x 4.9 | 117 | 186 | 232 | 325 | 465 | 581 | 815 | 1165 | 1626 |
| 22 x 14 | 75 ... 85 | 22 x 9.0 | 22 x 5.4 | | | | 413 | 590 | 738 | 1033 | 1475 | 2065 |

The values given in the ratings table are based on uniform, smooth servo-operation and reliable grease lubrication. Since, in practice, the applications are very diverse, it is essential to consider the given conditions by using the appropriate factors (see below).

**Formulas for determining the acceleration torque of rack & pinion drive:**

$$a = \frac{v}{t_b} \quad [in/s^2]$$

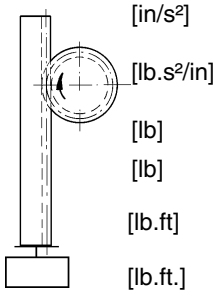
$$m = \frac{W}{g} \quad [lb.s^2/in]$$

$$F_T = m \cdot g + m \cdot a \quad \text{(for lifting axis)} \quad [lb]$$

$$F_T = m \cdot g \cdot \mu + m \cdot a \quad \text{(for driving axis)} \quad [lb]$$

$$T_{2req} = \frac{F_T \cdot (d/25.4)}{24} \quad [lb.ft]$$

$$T_{2perm} = \frac{T_{2table}}{K_A \cdot S_B \cdot f_N} \quad [lb.ft.]$$



**The drive should be selected such that $T_{2perm.} > T_{2req}$**

**Load Factor $K_A$**

| Drive | Type of load from the machines to be driven | | |
|---|---|---|---|
| | uniform | medium shocks | heavy shocks |
| uniform | 1.00 | 1.25 | 1.75 |
| light shocks | 1.25 | 1.50 | 2.00 |
| medium shocks | 1.50 | 1.75 | 2.25 |

**Safety Coefficient S**

The safety factor should be selected based on experience, typically $S_B$ = 1.1 to 1.4.

**Symbols**

| | | | |
|---|---|---|---|
| a | = | acceleration or deceleration rate | [in/s²] |
| d | = | pitch diameter of pinion | [mm] |
| $f_N$ | = | lifetime factor | |
| $F_T$ | = | tangential acceleration force | [lb.] |
| g | = | acceleration due to gravity | [386 in/s²] |
| $K_A$ | = | load factor | |
| m | = | mass being moved | [lb.s²/in] |
| $S_B$ | = | safety factor | |
| $t_b$ | = | acceleration time | [s] |
| $T_{2perm}$ | = | corrected acceleration torque | [lb.ft.] |
| $T_{2req}$ | = | acceleration torque | [lb.ft.] |
| $T_{2table}$ | = | rated output torque of reducer | [lb.ft.] |
| v | = | maximum linear speed | [in/s] |
| W | = | weight being moved | [lb] |
| η | = | gearbox efficiency at input speed | |
| μ | = | coefficient of friction of axis | |
| π | = | 3.1415 | |

**Life-time factor $f_n$**

Taking into consideration the linear speed at the rack, and the lubrication and support of the pinion.

| Bearing distance* | | 1 x tooth width | | | 2 x tooth width | | |
|---|---|---|---|---|---|---|---|
| Lubrication | | Contin. | Daily | Monthly | Contin. | Daily | Monthly |
| Linear speed of drive | | | | | | | |
| in/sec | ft/min | | | | | | |
| 20 | 100 | 0.85 | 0.95 | From | 1.05 | 1.15 | From |
| 40 | 200 | 0.95 | 1.10 | 3 | 1.15 | 1.301 | 3 |
| 59 | 295 | 1.00 | 1.20 | to | 1.20 | 1.45 | to |
| 79 | 395 | 1.05 | 1.30 | 10 | 1.25 | 1.60 | 10 |
| 118 | 590 | 1.10 | 1.50 | | 1.40 | 1.90 | |
| 197 | 985 | 1.25 | 1.90 | | 1.55 | 2.30 | |

* distance from center of pinion face width to center of adjacent bearing

The lifetime factors for daily and monthly lubrication cannot be determined by calculation and are only recommendations which underline the importance of good lubrication.

**Lubrication**

The ratings are based upon intermittent operating times with dwell times in-between, which is normal for servo systems, and continuous lubrication. A proven solution for continuous lubrication is our automatic lubricators and applicators, see page 69.

## Calculating Example

**Values Given**

○ Driving Axis ⊗ Lifting Axis

| | | | |
|---|---|---|---|
| Weight to be moved: | W | = | 660 lb |
| Linear speed: | v | = | 42.5 in/s |
| Acceleration time: | $t_b$ | = | 0.27 s |
| Acceleration due to gravity: | g | = | 386 in/s² |
| Coefficient of friction: | μ | = | |
| Pinion pitch diameter: | d | = | 67.90 mm |
| Load factor: | $K_A$ | = | 1.25 |
| Lifetime factor: | $f_N$ | = | 1.1 |
| Safety factor: | $S_B$ | = | 1.2 |

**Calculations**

$a = \frac{v}{t_b} = \frac{42.5}{0.27} = 157.4$ in/s²

$m = \frac{W}{g} = \frac{660}{386} = 1.71$ lb.s²/in

$F_T = m \cdot g + m \cdot a = 1.71 \cdot 386 + 1.71 \cdot 157.4 = 929.4$ lb

$F_T = m \cdot g \cdot \mu + m \cdot a$ (for driving axis only)

$T_{2req} = \frac{F_T \cdot (d/25.4)}{24} = \frac{929.4 \cdot (67.90/25.4)}{24} = 103.5$ lb.ft.

Assuming 29.20.100 and 24.23.532 pinion with $T_{2table} = 214$ lb.ft.

$T_{2perm} = \frac{T_{2table}}{K_A \cdot S_B \cdot f_N} = \frac{214}{1.25 \cdot 1.2 \cdot 1.1} = 129.7$ lb.ft.

**The drive should be selected such that $T_{2perm.} > T_{2req}$**

$T_{2perm} > T_{2req} = 129.7$ lb.ft. > 103.5 lb.ft.

Selection: Rack: 29.20.100 Page 54
Pinion: 24.23.532 Page 32

**Pinion Forces**

Tangential Force $F_T = 929.4$ lb. (from above)

Separating Force $F_r = F_T \cdot \tan 20° = 929.4 \cdot 0.364 = 338.3$ lb.

Axial Force $F_A = F_T \cdot \tan 19.528° = 929.4 \cdot 0.355 = 329.6$ lb.
(Helical Only)

Radial Force $F_R = \sqrt{F_T^2 + F_r^2} = \sqrt{929.4^2 + 338.3^2} = 989$ lb.

## Your Calculations

**Values Given**

○ Driving Axis ○ Lifting Axis

| | | | |
|---|---|---|---|
| Weight to be moved: | W | = | _____ [lb] |
| Linear speed: | v | = | _____ [in/s] |
| Acceleration time: | $t_b$ | = | _____ [s] |
| Acceleration due to gravity: | g | = | 386 in/s² |
| Coefficient of friction: | μ | = | _____ |
| Pinion pitch diameter: | d | = | _____ [mm] |
| Load factor: | $K_A$ | = | _____ |
| Lifetime factor: | $f_N$ | = | _____ |
| Safety factor: | $S_B$ | = | _____ |

**Calculations**

$a = \frac{v}{t_b} =$ _____ [in/s²]

$m = \frac{W}{g} =$ _____ [lb.s²/in]

$F_T = m \cdot g + m \cdot a =$ _____ [lb]

$F_T = m \cdot g \cdot \mu + m \cdot a =$ _____ [lb]

$T_{2req} = \frac{F_T \cdot (d/25.4)}{24} =$ _____ [lb.ft.]

Permissible torque $T_{2table}$, see page 62

$T_{2perm} = \frac{T_{2table}}{K_A \cdot S_B \cdot f_N} =$ _____ = [lb.ft.]

$T_{2perm} > T_{2req} =$ _____ lb.ft. > _____ lb.ft. = fulfilled

**Pinion Forces**

$F_T =$

$F_r = F_T \cdot \tan 20° =$

$F_A = F_T \cdot \tan 19.528° =$
(Helical Only)

$F_R = \sqrt{F_T^2 + F_r^2} =$

When mounting a pinion directly onto a gearbox output shaft, the radial and axial forces should be taken into consideration when selecting the gearbox. The axial force is generated by helical gearing only and changes direction depending on the direction of travel of the rack & pinion.

**Actual size of modular gearing according to DIN 867**

**Module 1.0**

**Module 1.25**

**Module 1.5**

**Module 2.0**

**Module 2.5**

**Module 3.0**

**Module 4.0**

**Module 5.0**

**Module 6.0**

**Module 8.0**