Table 14.5: Bending and contact strength for selected gear materials. *Source:* Adapted from ANSI/AGMA 2101-D04 [2004] and MPIF Standard 35 [2009].

Material designation	Grade	Typical hardness[a]	Bending strength, S_t MPa	Contact strength, S_c MPa
Steel				
Through-hardened	1	—	See Fig. 14.23a	See Fig. 14.24
Through-hardened[b]	1	180–400 HB	0.533 HB + 88.3	2.41 HB + 237
	2	180–400 HB	0.703 HB + 11.3	2.22 HB + 200
	2	—	See Fig. 14.23a	See Fig. 14.24
Carburized and hardened	1	55–64 HRC	380	1240
	2	58–64 HRC	450[c]	1550
	3	58–64 HRC	515	1895
Nitrided and through-hardened[b]	1	83.5 HR15N	0.568 HB + 83.8	1035
	2	—	0.749 HB + 110	1125
Nitralloy 135M and Nitralloy N, nitrided[b]	1	87.5 HR15N	0.594 HB + 87.76	1170
	2	87.5 HR15N	0.784 HB + 114.81	1260
2.5% Chrome, nitrided[b]	1	87.5 HR15N	0.7255 HB + 63.89	1070
	2	87.5 HR15N	0.7255 HB + 153.63	1185
	3	87.5 HR15N	0.7255 HB + 201.81	1305
Cast Iron				
ASTM A48 gray cast iron, as-cast	Class 20	—	34.5	345–415
	Class 30	174 HB	59	450–520
	Class 40	201 HB	90	520–585
ASTM A536 ductile (nodular) iron	60-40-18	140 HB	150–230	530–635
	80-55-06	179 HB	150–230	530–635
	100-70-03	229 HB	185–275	635–770
	120-90-02	269 HB	215–305	710–870
Bronze				
$S_{ut} > 275$ GPa			39.5	205
$S_{ut} > 620$ GPa			165	450
Powder Metal				
FL-4405, $\rho = 7.30$ g/cm^3		80 HRB	340	1945
FLN2-4405, $\rho = 7.35$ g/cm^3		90 HRB	410	1240
FLC-4608, $\rho = 7.30$ g/cm^3		65 HRB	660	1450
FN-0205, $\rho = 7.10$ g/cm^3		69 HRB	210	1240

[a] Hardness refers to case hardness unless through-hardened.
[b] See Figs. 14.23 and 14.24.
[c] 485 MPa may be used if bainite and microcracks are limited to Grade 3 levels.

the quality of lubricant and the lubrication regime in which the gear operates, and gear life is more difficult to accurately predict. This will be discussed further in Section 14.12.

Figure 14.25 shows the stress cycle correction factors for bending and contact stress considerations.

Temperature Factor

While the AGMA prescribes the use of a temperature factor, the only recommendation is that the temperature factor, K_t, be taken as unity if the temperature does not exceed 120°C. For higher temperatures, K_t greater than one is needed to allow for the effect of temperature on oil film and material properties. No specific recommendations are given; experimental evaluation is therefore required.

Reliability Factor

The allowable stresses were based upon a statistical probability of 1% failure at 10^7 cycles, or 99% reliability. For other reliabilities, the data in Table 14.6 should be used to obtain K_r.

Hardness Ratio Factor

Calculation of contact stresses was discussed in Ch. 8, and further details of such calculations specific to gears are discussed in Section 14.12. A common result from such analyses is that the contact stresses are much larger than the yield stress of the gear material, indicating that plastic deformation takes place at the contact location. Gross plastic deformation

Table 14.6: Reliability factor, K_r. *Source:* From ANSI/AGMA 2101-D04 [2004].

Probability of survival, percent	Reliability factor[a] K_r
50	0.70[b]
90	0.85[b]
99	1.00
99.9	1.25
99.99	1.50

[a] Based on surface pitting. If tooth breaka[g] considered a greater hazard, a larger valu be required.
[b] At this value, plastic flow may occur r than pitting.

does not occur, because the plastic zone is bounded by very stiff elastic regions that restrict metal flow.

Furthermore, since the pinion has fewer teeth than the gear, it will be subjected to a larger number of contact stress loadings due to its geometry. There is some justification to using a harder pinion than gear, in order to obtain a uniform safety factor for contact stress and pitting resistance failures. However, a harder pinion results in higher stresses on the gear. Therefore, a correction factor C_H is defined by AGMA, and is applied to the gear only. The hardness-ratio factor is defined by

$$C_H = 1.0 + A' \left(g_r - 1.0\right), \tag{14.47}$$

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