

Galling of Stainless Steels and the Stress It Takes

Galling is the first problem a stainless tool steel user meets, and it is measured. The tables below give the threshold galling stress of each stainless family on the button on block test, the material ranking for adhesive wear, the volume loss of the common alloys and the effect of temperature.

Reference only. This is a reference summary of published practice and it is not a specification of ours. The values are reproduced from the source tables, and the mechanism that ends a particular die depends on the workpiece, the press, the lubrication and the way the die was fitted. Final selection is confirmed on the job.

The threshold galling stress, grade by grade

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Grade	Condition	Hardness	MPa	ksi
Austenitic				
S20161	Annealed	95 HRB	104 (a)	15 (a)
S21800	Annealed	92 HRB	104 (a)	15 (a)
S28200	Annealed	96 HRB	166	24
S28200	Cold drawn	35 HRC	62	9
S20910	Annealed	97 HRB	35	5
S20900	Annealed	96 HRB	48	7
S24100	Annealed	23 HRC	97	14
S30430	Annealed	74 HRB	35	5
Type 304	Annealed	86 HRB	55	8
Type 304	Cold drawn	27 HRC	17	2.5
Type 316	Annealed	82 HRB	48	7
Type 316	Cold drawn	27 HRC	35	5
Type 303	Annealed	85 HRB	138	20
Type 201	Annealed	95 HRB	104	15
N08020	Annealed	87 HRB	14	2
Martensitic				
S42010	Tempered at 204 °C (400 °F)	50 HRC	104 (a)	15 (a)
S42010	Tempered at 260 °C (500 °F)	47 HRC	62	9
Type 410	Annealed	87 HRB	7	1
Type 410	Tempered at 260 °C (500 °F)	43 HRC	21	3
Type 416	Annealed	95 HRB	21	3
Type 416	Tempered at 316 °C (600 °F)	37 HRC	62	9
Type 416	Tempered at 538 °C (1000 °F)	32 HRC	42	6
Type 420	Tempered at 204 °C (400 °F)	51 HRC	25	18
Type 420	Tempered at 260 °C (500 °F)	49 HRC	55	8
Type 440C	Tempered at 260 °C (500 °F)	55 HRC	125	18
Precipitation hardenable				
S45500	Aged at 510 °C (950 °F)	48 HRC	90	13
S45500	Aged at 566 °C (1050 °F)	43 HRC	59	8.5
S45500	Aged at 621 °C (1150 °F)	36 HRC	28	4
S45000	Annealed	29 HRC	69	10
S45000	Aged at 480 °C (895 °F)	43 HRC	55	8
S45000	Aged at 566 °C (1050 °F)	38 HRC	17	2.5
S45000	Aged at 621 °C (1150 °F)	33 HRC	14	2
S17400	Aged at 480 °C (895 °F)	45 HRC	69	10
S17400	Aged at 621 °C (1150 °F)	34 HRC	35	5
S13800	Aged at 538 °C (1000 °F)	46 HRC	21	3
S66286	Aged at 718 °C (1325 °F)	30 HRC	14	2
Ferritic and duplex				
S18200	Cold drawn	98 HRB	35	5
Type 430F	Annealed	92 HRB	14	2
Type 430	Cold drawn	98 HRB	10	1.5
Type 329	Annealed	25 HRC	7	1

Threshold galling stress of self-mated stainless steels on the button on block test, ASTM G98, unlubricated ground finish, reproduced from ASM Handbook, Volume 18. Entries marked (a) did not gall within the range of the test. The values are printed as they stand in the source.

What the ranking says

One design assumption that does not survive the data

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Material	Hardness	At 105 rev/min	At 415 rev/min
D2 tool steel	61 HRC	0.46	0.34
AISI 4337	52 HRC	0.73	0.48
Stellite 6B	48 HRC	1.00	1.27
Hadfield Mn steel	95 HRB	1.25	0.41
Al (10.5%) bronze	87 HRB	2.21	1.52
Type 6061-T6 aluminium	59 HRB	17.06	21.15
AISI 4130	47 HRC	9.44	6.80
Astralloy V	46 HRC	213.58	8.22
Type 440C	57 HRC	3.81	0.54
S21800	95 HRB	2.79	1.58
Type 201	90 HRB	4.95	4.68

Relative ranking of adhesive wear resistance of wrought materials, reproduced from ASM Handbook, Volume 18. Weight loss is in milligrams per thousand cycles on the crossed cylinder test, ASTM G83, at 71 N. D2 tool steel at 61 HRC is the best entry in the table, ahead of the cobalt base hardfacing alloy in the third row.

Temperature moves the answer

What to do about a stainless tool that seizes

Measure	Why it works
Pick the grade from the measured list	Grade choice moves the threshold galling stress by a factor of twenty or more, so it is the first decision and not the last.
Make the couple dissimilar	A stainless part running against a different material family removes the worst of the self-mated galling case altogether.
Do not rely on cold working	Cold drawing an austenitic grade raises its hardness and lowers its galling resistance at the same time, which is the opposite of what the hardness figure suggests.
Keep the surface ground and dry of debris	The published threshold values are measured on an unlubricated ground finish, so a torn or hand filed surface sits below them.
Lubricate where the application allows	A film of any kind separates the asperities that would otherwise cold weld, and adhesive wear is the mechanism that film interrupts.
Watch the service temperature	The austenitic grades hold or improve their adhesive wear resistance as the joint runs hotter, while the hardening alloys lose it.

Measures against galling in stainless steel tooling and mating parts, from ASM Handbook, Volume 18. The published test methods behind the table are the button on block screening test and, for threaded connections, a make and break test on the actual connection.

Grades and stock

Aobo Steel, tool steel supplier

Aobo Steel supplies tool steel to distributors and mold, tool and die shops, including D2, D3, DC53, A2, O1, H13, H11, H10, H21, S7, M2, M42, L6, P20 and 420 and 440C stainless. Forged or hot rolled, annealed or pre-hardened, cut to your sizes, with test certificates.

Source, ASM Handbook, Volume 18, Friction, Lubrication, and Wear Technology, ASM International, 1992.

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