

Special Steels for Precise Die and Mold

FM ALLOY[®] DURO[™]

For Cold Work

High Toughness Grades

DURO-F1

DURO-F3

DURO-F7

High Wear Resistance Grade

DURO-SP

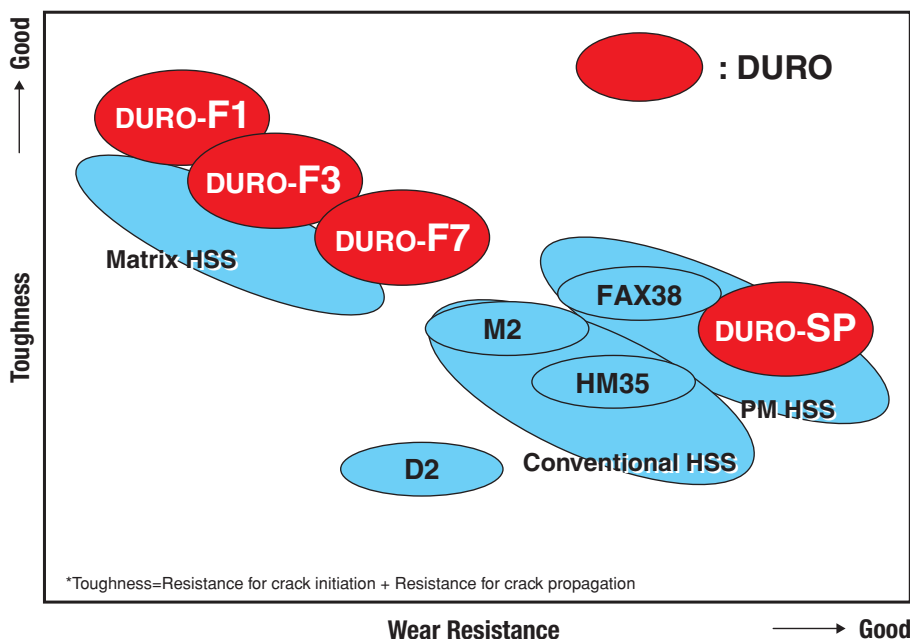


DURO-Created by NACHI's original technology Steels with superior balance of toughness and wear resistance for precise die and mold

- DURO series, special steels for precise die and mold, are high quality and high grade materials which are made by NACHI's original technology of steel manufacturing and refining.
- They have less non-metallic inclusion and segregation that can cause fractures. Also shows superior performance because of great control of carbide quantity and size.

Properties of DURO for Cold Work

- DURO for Cold Work has two type grades, High Toughness Grades are DURO-F1, F3, F7, High Wear Resistance Grade is DURO-SP.
- Each grade has a different balance of toughness and wear resistance, so whatever the application, there is a DURO grade available.



Typical Nachi Steel Grades

Classification		Grade	Application
High Speed Steels (HSS)	Conventional HSS	SKH9D	Die and Punch
		HSU2C	Plus Punch
	HM42		
	Powder Metallurgical HSS	FAX Series	Punch
Alloy Tool Steels	Die and Mold Steel for Cold Work	ICS22	Die for Eye Glasses
		MDS9	Mold for Rubber
		MCR1	Die and Punch
FM ALLOY	Steel for Precise Die and Mold (DURO Series)	DURO-F1, 3, 7, SP	Cold Work Die and Punch
		DURO-F1, N1	Hot Work Die and Punch
	Plastic Mold Steel with Corrosion Resistance and Mirror Finish	PROVA-400	Plastic Mold
	Corrosion and Wear Resistance Alloy Steel	NPR1	Injection Molding Machine Parts

FM ALLOY is

a brand name for NACHI's newest material products. Made from NACHI's own technology to be high performance alloys with fine microstructure control.

DURO is

named from the Latin word which means "hard" or "endure". A description for our tough materials to be used for die and mold.

Benefits of DURO

- DURO is made by a highly purified procedure, to have high toughness and fatigue strength because of very little non-metallic inclusions.
- Quantity and size of carbides in DURO microstructure are controlled to have a superior balance of toughness and wear resistance.

Classification	Grade	Hardness	Strong Points
High Toughness Matrix HSS	DURO-F1	HRC 54-60	High toughness die and mold steel Has the highest toughness in all die and mold materials that get HRC60.
	DURO-F3	HRC 57-62	Well balance steel Is a medium grade between F1 and F7, has good toughness and wear resistance.
	DURO-F7	HRC 59-65	High wear resistance steel Has high hardness of HRC65, and still shows high toughness.
High Wear Resistance HSS	DURO-SP	HRC 60-67	Super high wear resistance steel Has higher wear resistance than PM HSS, and still shows good toughness.

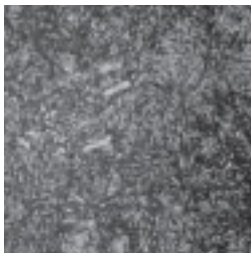
*DURO-F1 is also good for hot work, please reference NACHI catalog "DURO for Hot Work".

Microstructure

DURO-F1



DURO-F3



DURO-F7



DURO-SP



PM HSS



Conventional HSS



Die and Mold Steel for Cold Work



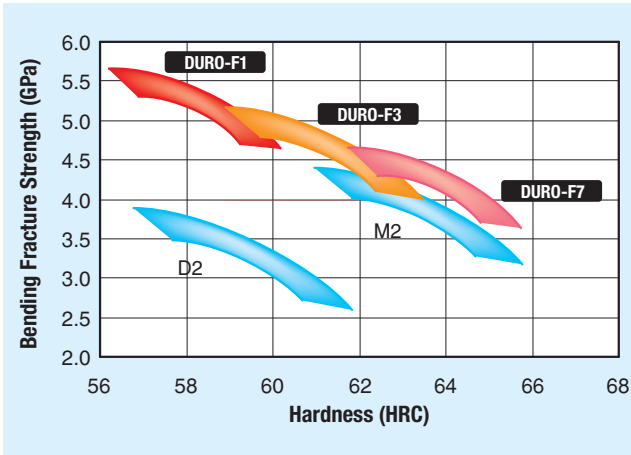
*Nital etching
× 500

DURO Series have the best balance for quantity and size of carbides in each grade and a uniform microstructure with minor segregation.

Features of DURO-F Series, High Toughness Steels

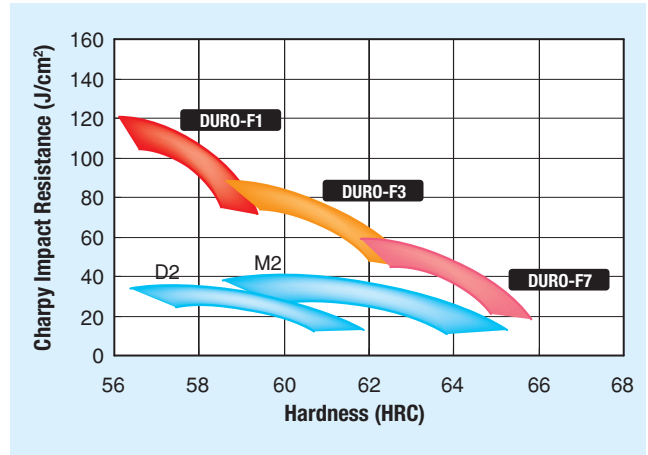
Mechanical Properties

High bending fracture strength



DURO-F Series show high bending fracture strength in hardness range HRC 56-65.

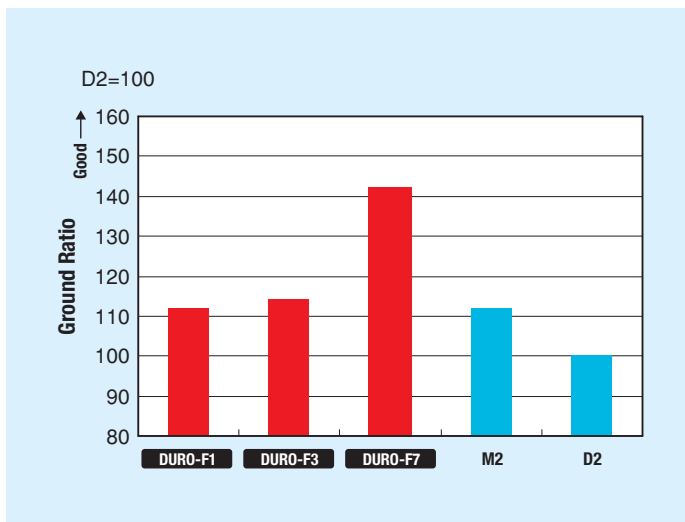
Superior Charpy impact resistance



DURO-F Series show superior charpy impact resistance in hardness range HRC 56-65.

Grindability of DURO-F Series

Better grindability than other material



Ground Ratio= (weight loss of a sample)/(weight loss of a wheel)

Surface Grinder Machine
 Wheel: WA60K
 Feed: 60m/min
 Depth: 0.05 mm
 RPM: 2000 min⁻¹

Grindability of DURO-F Series is better than M2 and D2.

Heat Treatment of DURO-F Series



Heat treatment condition

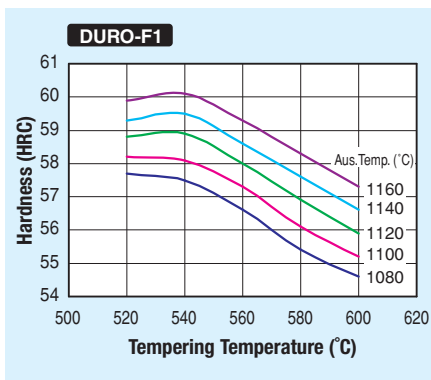
Grade	Requirement	Aus. [°C (°F)]	Temp. [°C (°F)]	Hardness (HRC)
DURO-F1	For toughness	1100 (2012)	580 × 2 (1076)	56.0
	Standard	1120 (2048)	560 × 2 (1040)	58.0
	For wear	1160 (2120)	560 × 2 (1040)	59.5
DURO-F3	For toughness	1100 (2012)	580 × 2 (1076)	59.0
	Standard	1140 (2084)	580 × 2 (1076)	60.0
	For wear	1160 (2120)	560 × 2 (1040)	61.5
DURO-F7	For toughness	1120 (2048)	600 × 2 (1112)	60.0
	Standard	1120 (2048)	580 × 2 (1076)	62.5
	For wear	1180 (2156)	560 × 2 (1040)	65.0

*Thickness of sample: 50 mm, vacuum furnace + pressure gas quenching (about 4 bar)

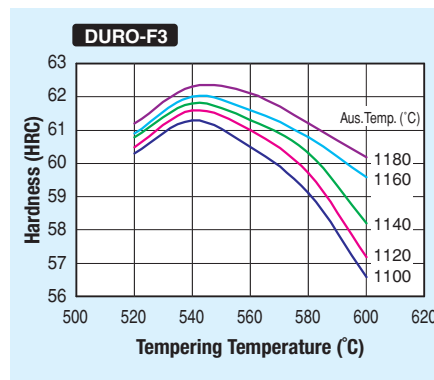
*Hardness may vary depending on material size and method, condition or facilities of heat treatment.



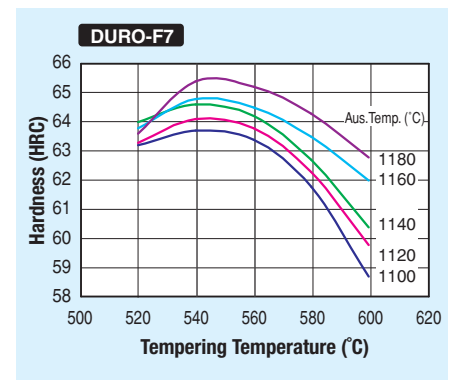
Hardness chart



DURO-F1 can be used in range HRC 54-60.
To get HRC 60 it is suggested to use a salt bath furnace.



DURO-F3 can be used in range HRC 57-62.
If hardness under HRC 57 is necessary, DURO-F1 is recommended.

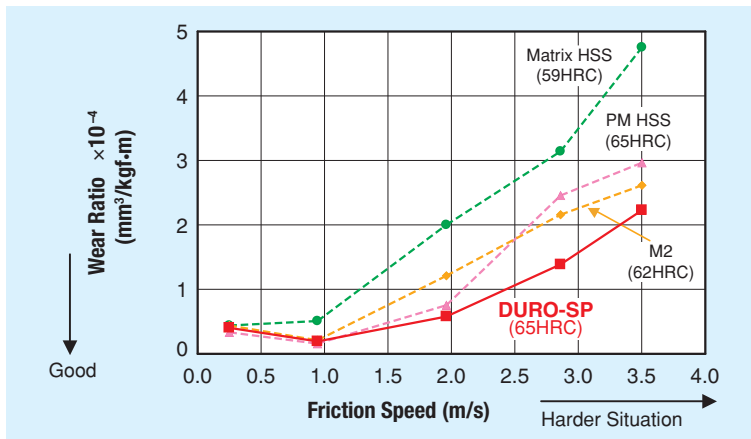


DURO-F7 can be used in range HRC59-65.

Features of DURO-SP, High Wear Resistance Steel

Mechanical Properties

Superior wear resistance

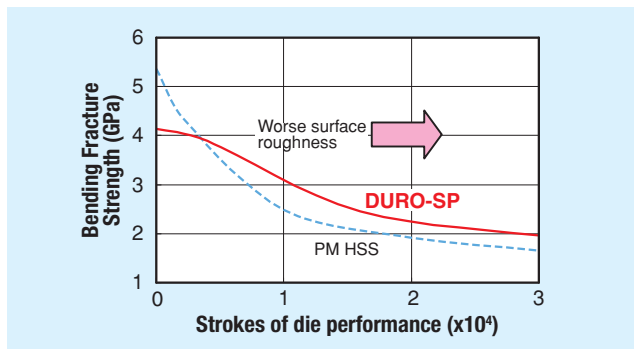


OGOSHI's test
 Rotor: SCM435
 Distance: 200 m
 Final load: 6.3 kg

DURO-SP shows superior wear resistance compared not only to matrix HSS but conventional HSS and even PM HSS.

Minimal loss of strength with rough surface

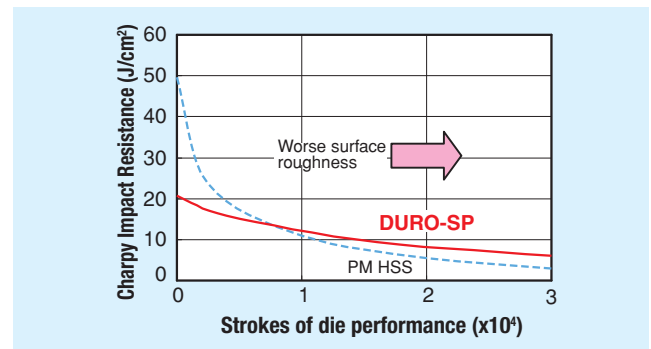
◆ Bending fracture strength



DURO-SP shows less surface roughness and strength decreases because of better wear resistance than PM HSS.

*Generally strength of materials decreases by notch effect as surface roughness of the materials become worse.

◆ Charpy impact resistance



DURO-SP shows less charpy impact resistance decrease than PM HSS.

*Generally strength of materials decreases by notch effect as surface roughness of the materials become worse.

Applications

Grade	Application	Life comparison
DURO-F1	Blanking punch	5 times longer than other matrix HSS
DURO-F3	Forming roll	2 times longer than other cold work die steel
DURO-F7	Forming rack	1.5 times longer than other matrix HSS
DURO-SP	Fine-blanking punch	4 times longer than other matrix HSS
	Flow forming mandrel	5 times longer than other matrix HSS
	Injection die	8 times longer than other matrix HSS

Heat treatment of DURO-SP

Heat treatment condition

Grade	Requirement	Aus. [°C (°F)]	Temp. [°C (°F)]	Hardness (HRC)
DURO-SP	For toughness	1120 (2048)	600 × 3 (1112)	61.0
	Standard	1160 (2120)	580 × 3 (1076)	64.0
	For hardness and wear resistance	1200 (2192)	560 × 3 (1040)	66.0

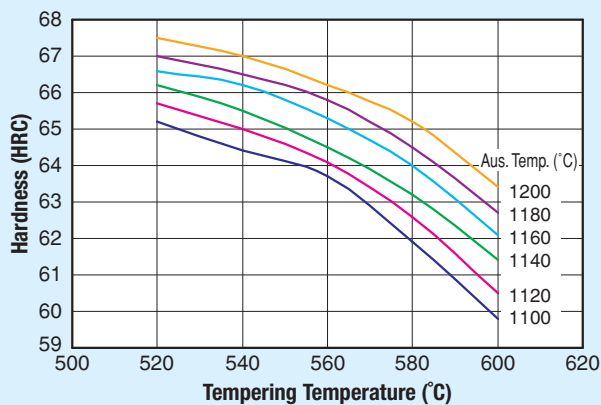
*Thickness of sample: 50 mm, vacuum furnace + pressure gas quenching (about 4 bar)

*Hardness may vary depending on material size and method, condition or facilities of heat treatment.

Hardness of DURO-SP

- The best heat treatment of DURO-SP differs depending on applications.
- For fine blanking around HRC 64 is a standard hardness.
- For flow forming mandrel HRC 60-62 is common and for some cold work forming punches over HRC 67 could be a good choice.

Hardness chart



DURO-SP can be used in range HRC 60-67.
HRC 62-64 is normally recommended.

Sample choices of steel grade for applications

Current Grade	Life Factor	Recommendation			
		DURO-F1	DURO-F3	DURO-F7	DURO-SP
PM HSS	Wear, Micro chipping				⊙
	Chipping, Fracture	⊙	○		
M2	Wear, Micro chipping				⊙
	Chipping, Fracture	⊙	⊙	○	
Matrix HSS	Wear, Micro chipping			○	○
	Chipping, Fracture	○	○		
D2	Wear, Micro chipping				⊙
	Chipping, Fracture	⊙	⊙	⊙	○
H13	Wear, Micro chipping	⊙			

⊙ : Best ○ : Good

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