

**Special Steels for Precise Die and Mold**

**FM ALLOY<sup>®</sup> DURO<sup>™</sup>**

**For Hot Work**

High Toughness Grade

**DURO-N1**

High Strength Grade

**DURO-F1**

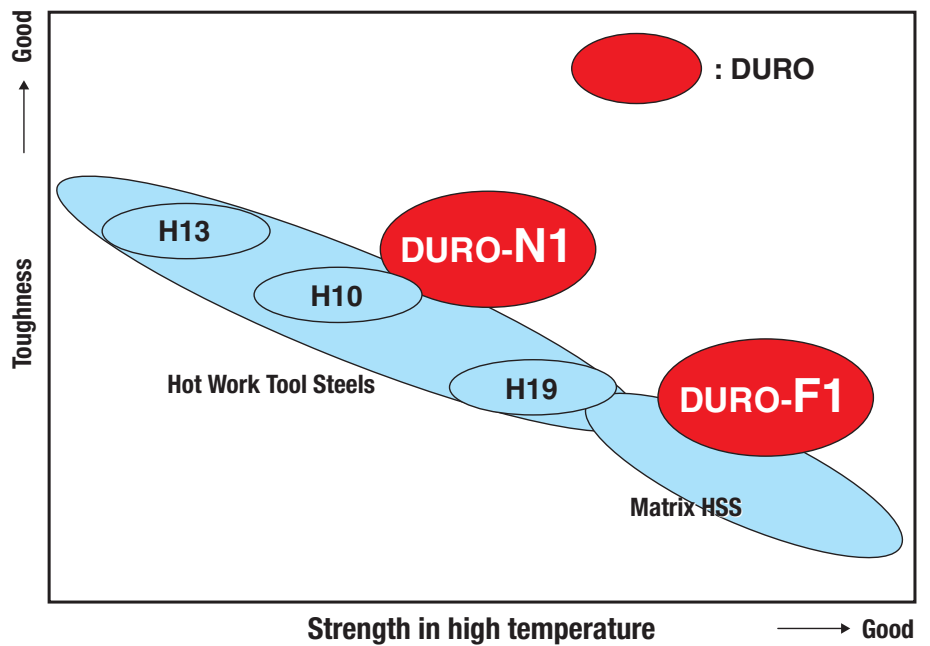


# DURO-Created by NACHI's original technology Steels with high toughness and strength for precise die and mold

- 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 may cause fractures, and shows superior performance because of the best control for carbide quantity and size.

## Properties of DURO for Hot Work

- DURO for Hot Work has two type grades, High Toughness Grade is DURO-N1, High Strength Grade is DURO-F1.
- Each grade has a different balance of toughness and wear resistance, so whatever the applications, 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 Hot Working Die and Mold Steel	<b>DURO-N1</b>	HRC 50-54	<b>Super high toughness die and mold steel</b> Has excellent high toughness with strength in high temperature.
High Strength Matrix HSS	<b>DURO-F1</b>	HRC 54-60	<b>High toughness die and mold steel</b> Shows superior high hardness and toughness compared with usual hot work tool steels.

\*DURO-F1 is also good for cold work, please reference NACHI catalog "DURO for Cold Work."

## Microstructure

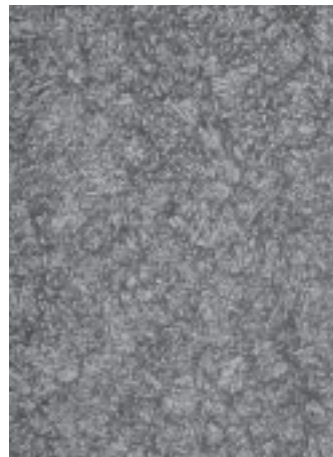
**DURO-N1**



**DURO-F1**



**H13**



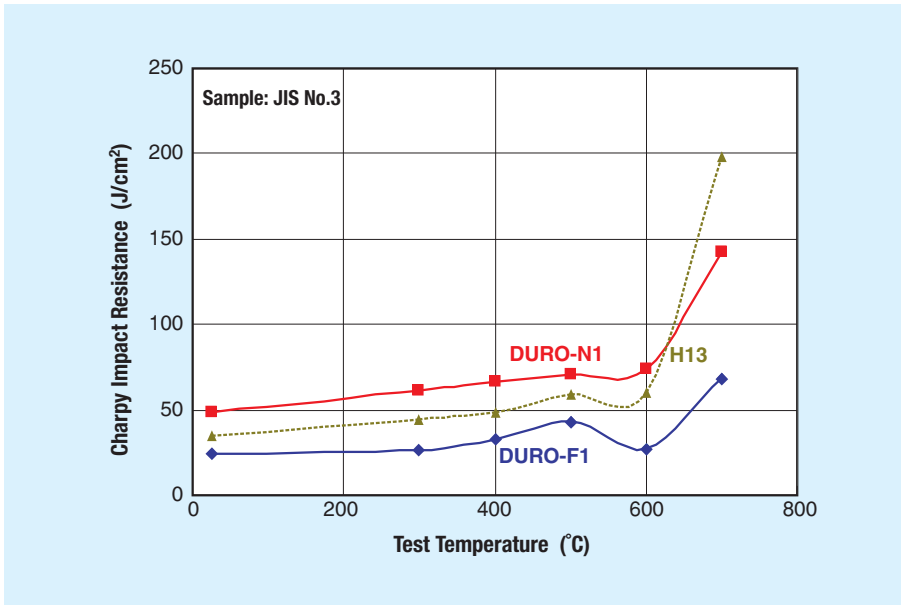
DURO series have the best balance for quantity and size of carbides in each grade, and a uniform microstructure with minor segregation.

\*Nital etching × 500

# Features of DURO Series for Hot Work

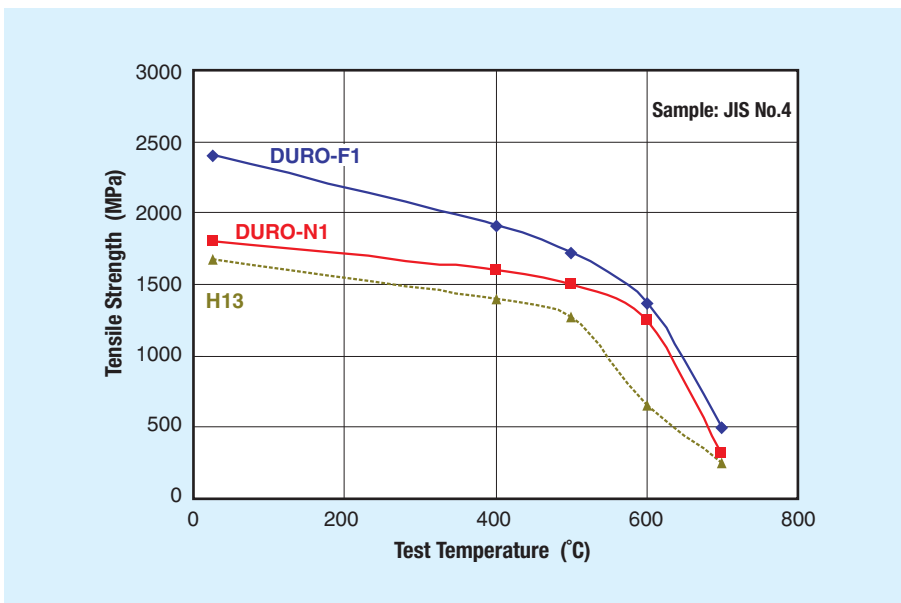
## Mechanical Properties

### Superior impact resistance in high temperature



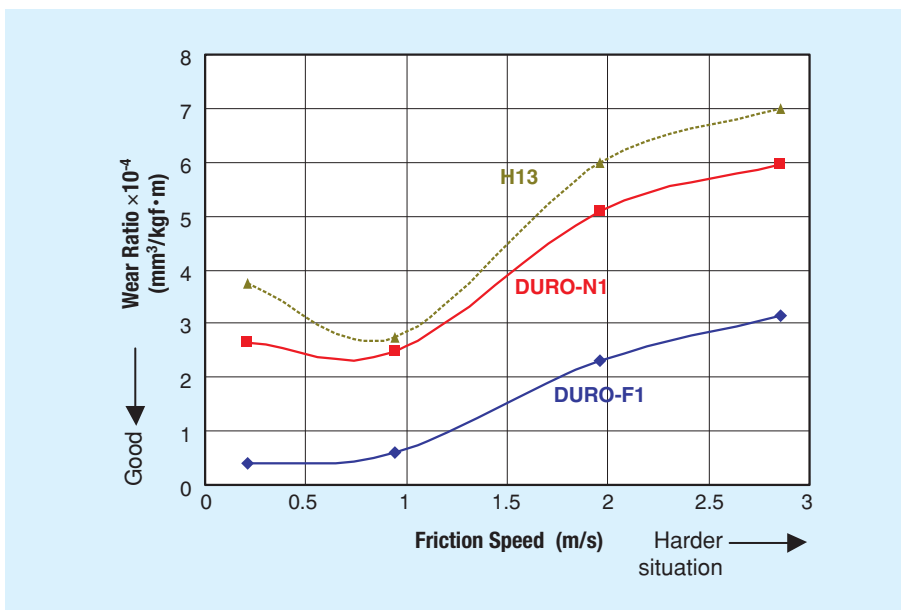
DURO-N1 shows higher impact resistance than H13 in temperature R.T. to 600 °C (Warm working zone).

### Excellent tensile strength in high temperature



DURO-N1 and F1 have higher tensile strength than H13 in temperature R.T. to 700 °C.

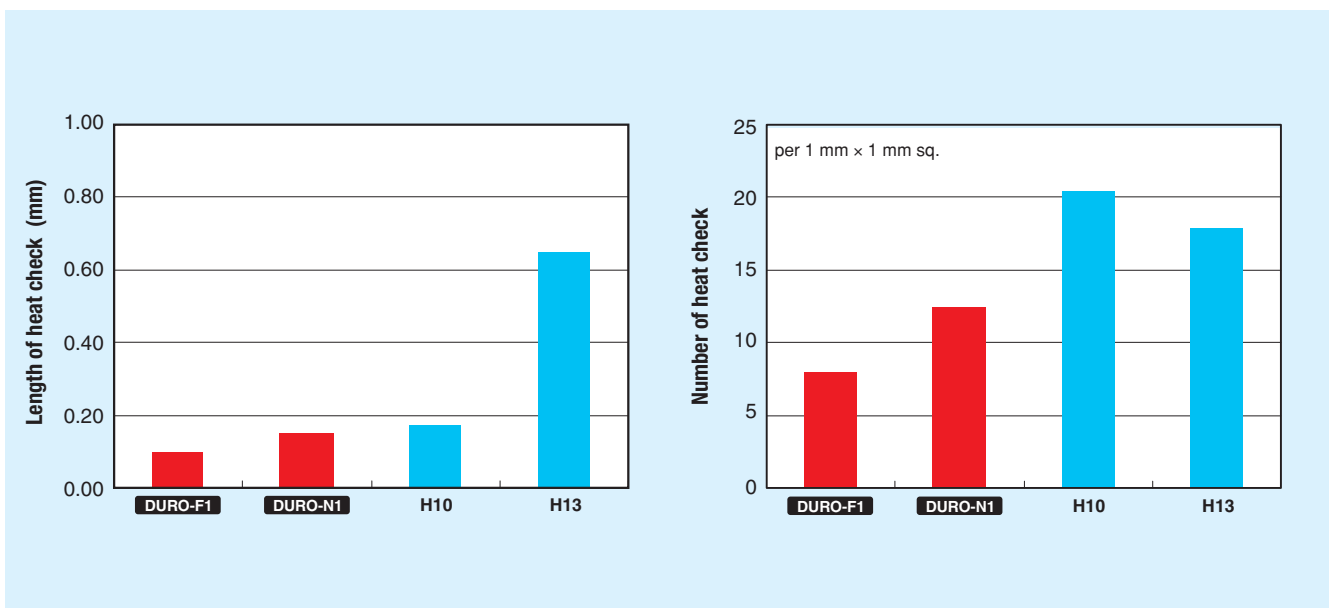
## Superior wear resistance



**OGOSHI's test**  
 Rotor: SCM435  
 Distance: 200 m  
 Final load: 6.3 kg  
 No lubricant

DURO-N1, F1 show higher wear resistance than H13.

## Great heat check resistance



DURO-N1, F1 have high strength in high temperature and show great heat check resistance.

### Heat check test

- Heating 700 °C (1292 °F) → Water cooling 4sec ← Air cooling 2sec
- Cycle: 1000

# Features of DURO Series for Hot Work

## Heat treatment of DURO for Hot Work

### Heat treatment condition

Grade	Requirement	Aus. [°C (°F)]	Temp. [°C (°F)]	Hardness (HRC)
<b>DURO-N1</b>	For toughness	1030 (1886)	620 × 2 (1148)	50.5
	Standard	1050 (1922)	600 × 2 (1112)	52.0
	For strength in high temperature	1070 (1958)	580 × 2 (1076)	53.5
<b>DURO-F1</b>	For toughness	1080 (1976)	600 × 2 (1112)	54.5
	Standard	1100 (2012)	580 × 2 (1076)	56.0
	For strength in high temperature	1140 (2084)	580 × 2 (1076)	57.5

\*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.

### Heating time

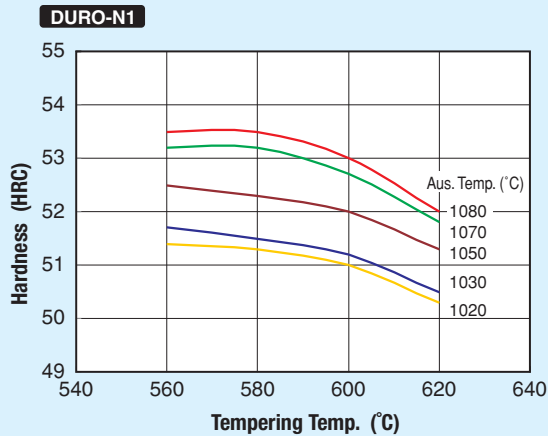
Grade	Holding time	Diameter or thickness of work (mm)						
		< 15	25	50	75	100	150	200
<b>DURO-N1</b>	Aus. (min)	15	25	40	50	60	70	80
	Temp. (hr)	1	1.5	2	3	4	5	6
<b>DURO-F1</b>	Aus. (min)	1.5	4	6	7	9	12	18
	Temp. (hr)	1	1	2	3	4	5	6

\*Heating time of DURO-N1 should be decided same as normal hot work tool steels, and DURO-F1 as Matrix HSS.

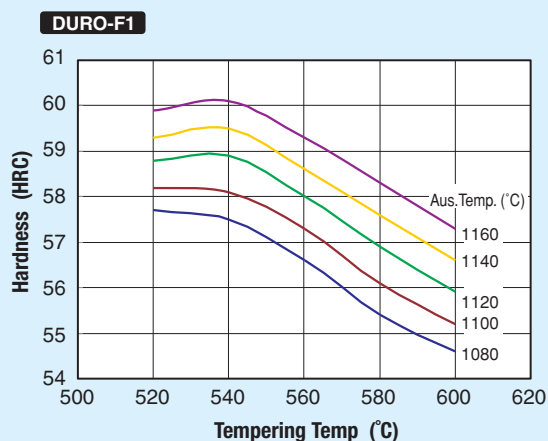
### Applications

Grade	Application	Life comparison
<b>DURO-N1</b>	Die for hub forming	<b>1.7 times longer</b> than H10
	Die for forging	<b>2 times longer</b> than H19
	Forging punch	<b>2.2 times longer</b> than H13
	Knock out punch	<b>2.2 times longer</b> than H13
<b>DURO-F1</b>	Forging punch	<b>4 times longer</b> than H10
	Ring punch for forging	<b>2.4 times longer</b> than H10

## Quenched and tempered hardness chart



DURO-N1 can be used in range HRC 50-54. For special applications it can also be used at HRC55 or HRC48.



DURO-F1 can be used in range HRC 54-60. To get HRC60 it is suggested to use a salt bath furnace.

### Sample choices of steel grade for applications

Current Grade	Life Factor	Recommendation	
		DURO-N1	DURO-F1
H13 type	Heat deformation, Heat check	◎	○
	Fracture	○	
H10 type	Heat deformation, Heat check	○	◎
	Fracture	○	
H19 type	Heat deformation, Heat check		◎
	Fracture	◎	
Matrix HSS	Heat deformation, Heat check		○
	Fracture	◎	○
M2	Heat deformation, Heat check		
	Fracture	○	◎

◎ : Best ○ : Good



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