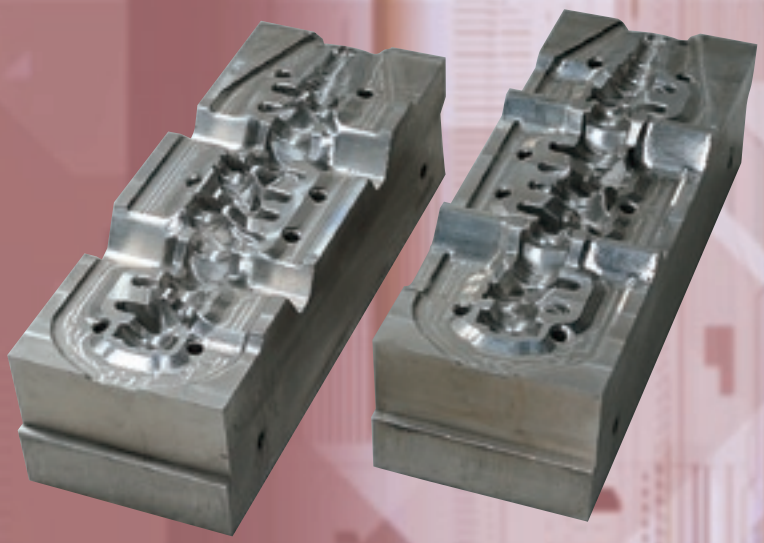
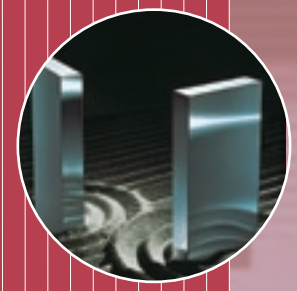
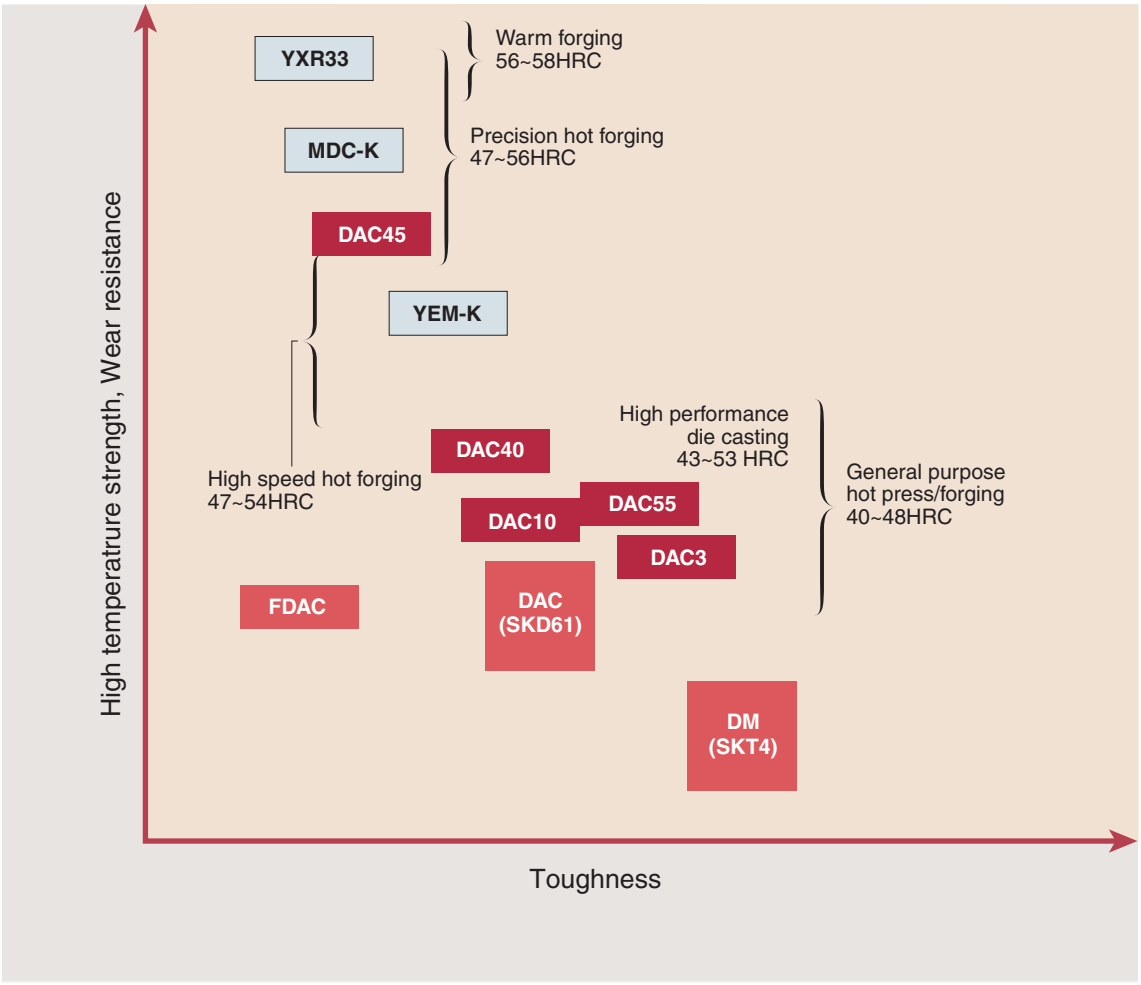
YSS
HOT WORKING TOOL STEELS





Characteristics of YSS Cold Work Tool Steels



Applications and YSS grade Features

Grade		Applications	Features
YSS	JIS equivalent		
DAC	SKD61	Hot forging dies, Extrusion dise, Die casting dies.	General-purpose hot-working tool steel used in a wide range of applications.
DAC3	–	Hot forging dies, Extrusion dise.	A hot-working tool steel which has improved hardenability and greater toughness than DAC, and helps avoid cracking in hot-working press dies, high-hardened Al extrusion dies.
DAC10	–	Die casting dies, Extrusion dies.	Steel for precision die casting and hot-working press die which has excellent heat crack resistance and wear resistance.
DAC40	–	Extrusion dies.	Al extrusion die steel and hot-working press die steel which has better high-temperature strength and softening resistance than DAC.
DAC55	–	Die casting dies.	Tool steel for large or squeeze die casting moulds with excellent heat crack resistance.
YEM-K	–	Hot forging dies.	Hot-working tool steel with the improved high-temperature strength and toughness of JIS-SKD7 steel.
MDC-K	–	Hot forging dies.	Very high-strength hot working tool steel with the improved toughness of JIS-SKD8.
DAC45	–	Die casting dies, Hot forging dies.	Has great high-temperature strength and outstanding crack resistance, and is suited for hot-working press dies requiring wear resistance and high Si-Al die-cast molds requiring erosion resistance.
YXR3	–	Hot forging dies.	High-toughness matrix high speed steel.
YXR33	–	Hot forging dies, Anti-meltdown insert pin.	High-toughness matrix high speed steel for hot-working tools, and excellent wear resistance and crack resistance. Can withstand high-temperature loads such as in warm-and hot-working precision forging dies.
DM	SKT4	Hammer dies.	Tool steel for hammer dies.
FDAC	–	Dies for small lot, Simple dies Holding lock.	Free-cutting hot-working tool steel.

Chemical compositions of YSS hot-working tool steels

YSS	Grade	Chemical composition										
	JIS equivalent	C	Si	Mn	P	S	Ni	Cr	W	Mo	V	Co
DAC	SKD61	0.39	1.0	0.40	≤ 0.030	≤ 0.010	–	5.15	–	1.40	0.80	–
DAC3	(Original steel)	High toughness die steel										
DAC10	(Original steel)	High-strength die steel										
DAC40	(Original steel)	High-strength Al extrusion die steel										
DAC55	(Original steel)	High-strength and toughness die steel										
YEM-K	(Original steel)	High-strength die steel										
MDC-K	(Original steel)	High-strength die steel										
DAC45	(Original steel)	High-strength die steel										
YXR3	(Original steel)	Matrix high speed steel										
YXR33	(Original steel)	Matrix high speed steel										
DM	SKT4	0.55	0.25	0.85	0.030	≤ 0.010	1.65	1.20	–	0.35	0.15	–
FDAC	SKD61 Free cutting	0.39	1.00	0.65	0.030	0.130	–	5.15	–	1.40	0.55	–

*Harmful impurities such as S, Cu and Ni are restricted to below JIS levels using Hitachi Metals' own high-quality raw materials.

Heat Treatment

Standard heat treatment conditions for YSS hot-working tool steels

Grade	Annealing		Quenching	Tempering	
	Temperature	Hardness (HBW)	Temperature	Temperature	Hardness (HRC)
DAC	820-870 Slow cooling	≤ 229	1000-1050 Oil cooling(Air cooling)	550-650 Air cooling	≤ 53
DAC3	820-870 Slow cooling	≤ 229	1000-1050 Oil cooling(Air cooling)	550-650 Air cooling	≤ 53
DAC10	820-870 Slow cooling	≤ 229	1010-1030 Oil cooling(Air cooling)	550-650 Air cooling	≤ 53
DAC40	820-870 Slow cooling	≤ 229	1000-1050 Oil cooling	550-680 Air cooling	≤ 53
DAC55	820-870 Slow cooling	≤ 229	1010-1030 Oil cooling(Air cooling)	550-650 Air cooling	≤ 53
YEM-K	820-870 Slow cooling	≤ 229	1000-1050 Oil cooling(Air cooling)	550-650 Air cooling	≤ 53
MDC-K	820-870 Slow cooling	≤ 241	1050-1140 Oil cooling	600-700 Air cooling	≤ 55
DAC45	820-870 Slow cooling	≤ 241	1060-1080 Oil cooling	580-650 Air cooling	≤ 55
YXR3	800-880 Slow cooling	≤ 241	(1)1150-1170,(2)1130-1150 Oil cooling	560-590 Air cooling	≥ 57
YXR33	800-880 Slow cooling	≤ 241	1080-1160 Oil cooling	550-600 Air cooling	≥ 56
DM	750-800 Slow cooling	≤ 241	830-880 Oil cooling	400-650 Air cooling	≤ 50
FDAC	–	–	Delivery in prehardened condition		38-42

(1) Simple shape tools
(2) The others, especially needs toughness

Quenching and tempering time of YSS die steels

1.Holding time at hardening temperature

(1) Preheating time

First stage: 500~550°C hardening temperature holding time x 2
Second stage: 750~800°C hardening temperature holding time x 1
But preheating can be omittted when the electrical furnaces process is used or when workpieces are 50mm or under in thickness or a simple shape.

(2) Holding time at hardening temperature

Furnace	Thickness(mm)	≤ 15	25	50	75	100	125	150	200	300
Electrical furnace, Salt bath	Holding time(min)	15	25	40	50	60	65	70	80	100

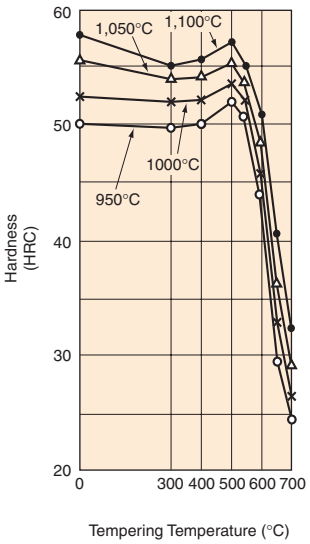
Caution: The salt bath needs preheating. Set the Soaking time same as the holding time.

2.Holding time at tempering temperature

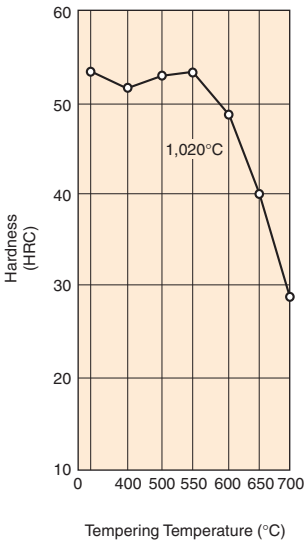
Thickness (mm)	≤ 25	26-35	36-64	65-84	85-124	125-174	175-249	250-349	350-499
Holding time (h)	1	1.5	2	3	4	5	6	7	8

YSS Quenched and tempered hardness curve

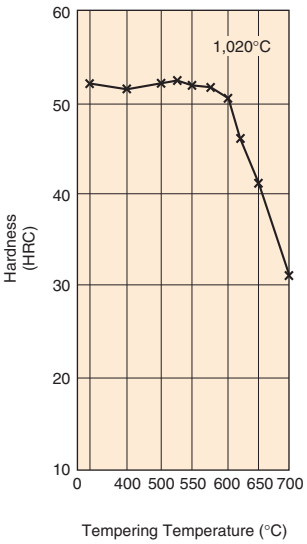
DAC



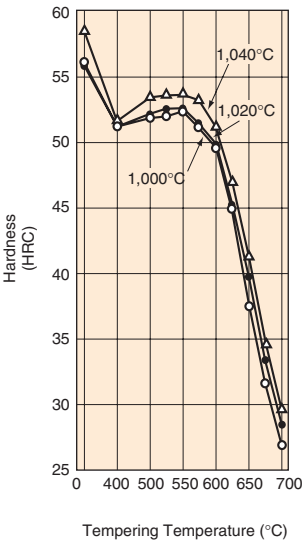
DAC3



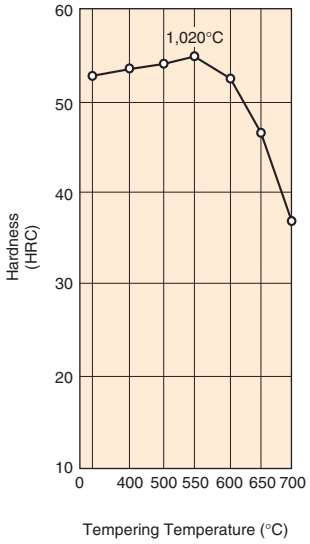
DAC10



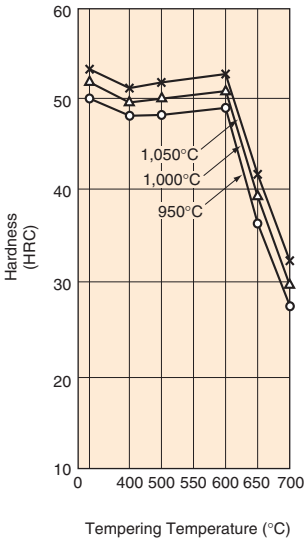
DAC55



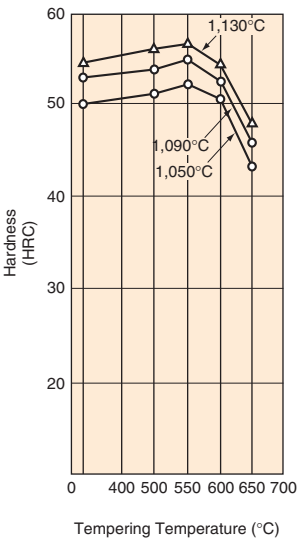
DAC40



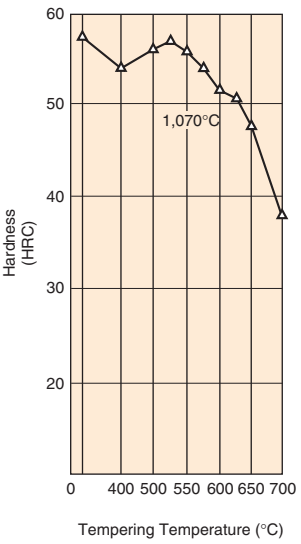
YEM-K



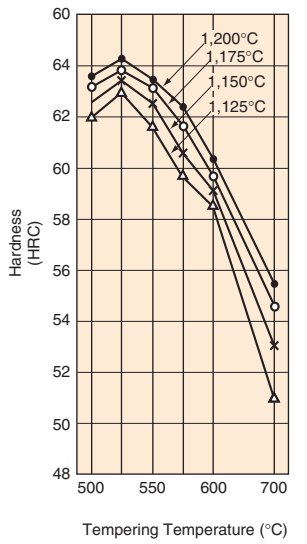
MDC-K



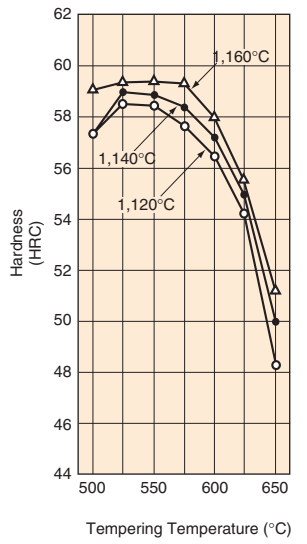
DAC45



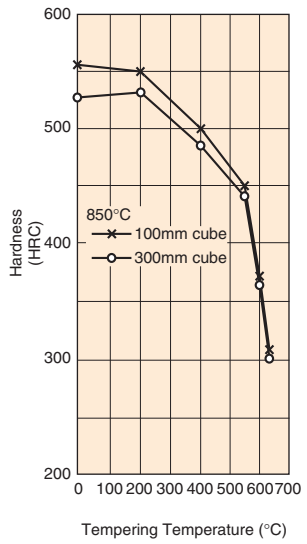
YXR3



YXR33

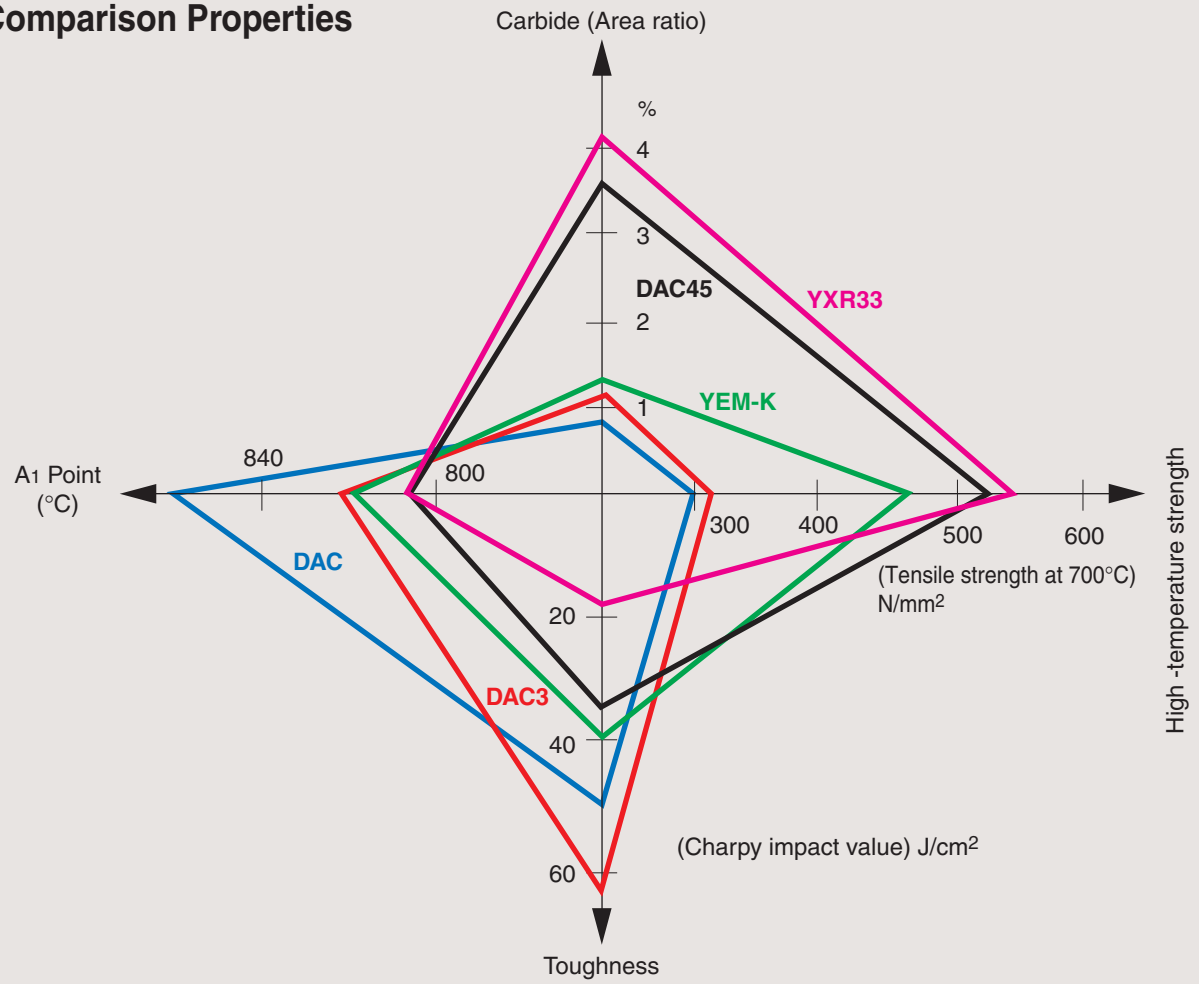


DM

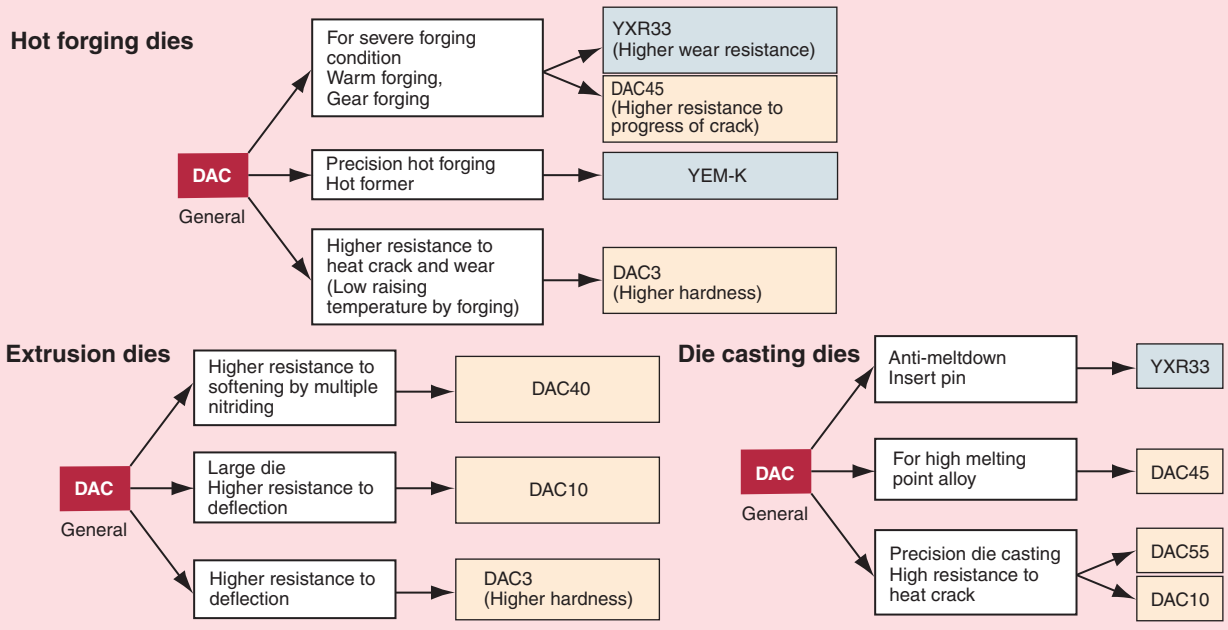


Properties

Comparison Properties

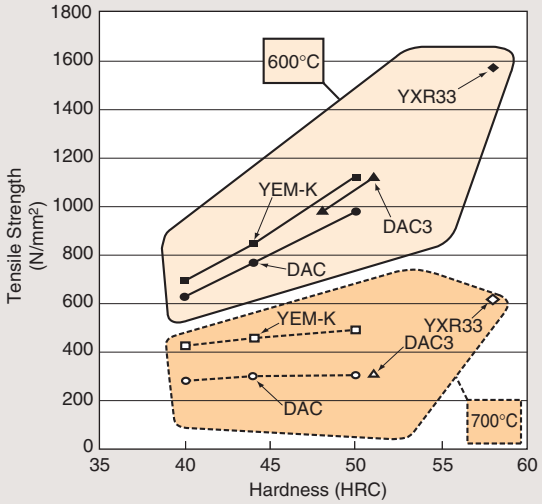


Guide for selecting die materials (example)

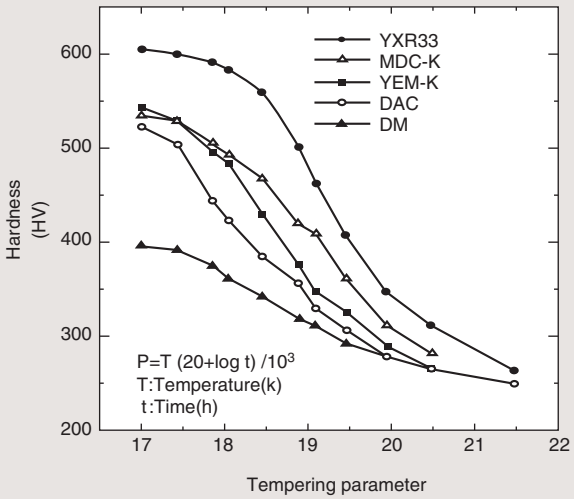


Properties

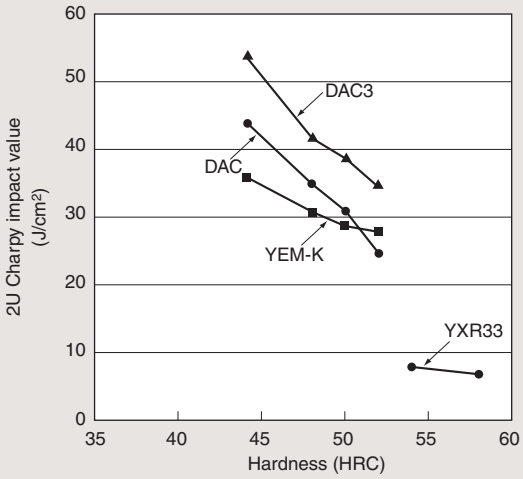
Tensile strength at elevated temperature



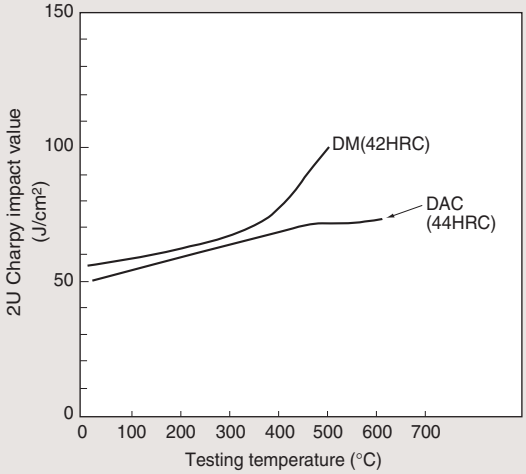
Tempering parameter



Charpy impact value at room temperature

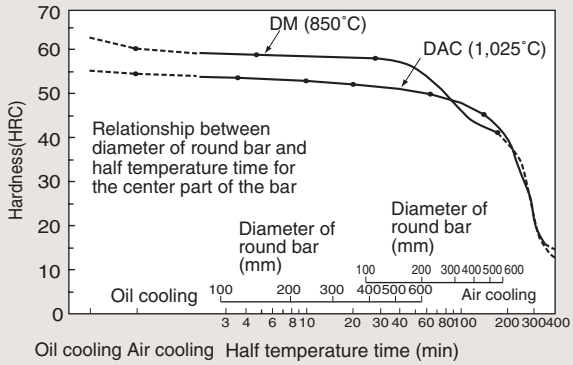


Charpy impact value at elevated temperature



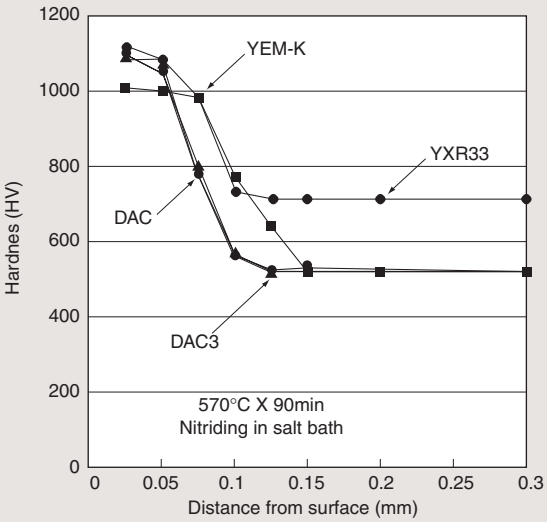
Hardenability

Half temperature time=Time required for cooling from quenching temperature to (Quenching temperature+Room temperature) /2



Relationship between half temperature time and quench hardness of hot working steels

Nitriding property



Properties

1.Coefficient of thermal expansion

[X10^{-6}/°C]

Grade	200°C	400°C	600°C	700°C
YXR33	11.6	12.1	13.0	13.2
DAC45	10.5	12.4	13.3	13.6
DAC10	11.1	12.3	13.8	13.2
DAC	12.5	13.2	13.8	14.0
DM	12.1	13.1	13.5	13.8

2. Thermal conductivity

[W/(m·k)]

Grade	20°C	200°C	400°C	600°C	700°C
YXR33	27.2	28.1	29.3	29.7	29.7
DAC45	26.4	27.6	28.9	28.1	27.6
DAC10	32.2	31.4	30.6	29.3	28.5
DAC	30.6	30.1	29.3	29.5	28.5
DM	36.0	39.4	37.7	36.0	35.2

1.Modulus of elasticity

[GPa]

Grade	20°C	200°C	400°C	600°C
DAC	206	196	178	132
DM	211	204	190	141

Hitachi Metals, Ltd. http://www.hitachi-metals.co.jp/

Head Office	SEAVANS North Building, 1-2-1, Shibaura, Minato-ku, Tokyo 105-8614, Japan Specialty Steel Company	Tel. +81-3-5765-4410 Fax. +81-3-5765-8317

Hitachi Metals America, Ltd.

Head Office	2 Manhattanville Road, Suite 301, Purchase, NY 10577, U.S.A.	Tel. +1-914-694-9200 Fax. +1-914-694-9279
Other Office	Chicago, Detroit, Charlotte, San Jose	

Hitachi Metals Europe GmbH

Head Office	Immermannstrasse 14-16,40210 Duesseldorf, Germany	Tel. +49-211-16009-0 Fax. +49-211-16009-29

Hitachi Metals Singapore Pte. Ltd.

	12 Gul Avenue, Singapore 629656	Tel. +65-6861-7711 Fax. +65-6861-1519

Hitachi Metals (Shanghai) Ltd.

	11F, Tian An Center, No.338 NanJing Road (West), Shanghai, 200003, China	Tel. +86-21-6358-6368 Fax. +86-21-6358-6327

Hitachi Metals(Dong Guan)Specialty Steel Co.,Ltd.

Guangzhou Liaison Office	Cha Shan Town, Dong Guan City, 522380 China	Tel. +86-769-640-6726 Fax. +86-769-640-6716
Dalian Branch	3-2, Koushin Mould Industrial Park Ⅲ B-1-1-1F. T. Z. Dalian, China	Tel. +86-411-8718-1011/1022 Fax. +86-411-8718-1033
Tianjin Branch	No.13 Workshop, Wenxin Industrial Park, Jingxiang Road, Xiaodian Town, Beichen Economic Development Zone, Tianjin, China	Tel. +86-22-8699-3101/3102 Fax. +86-22-8699-3103

Hitachi Metals, Ltd.

Beijing Liaison Office	Room No.1418, Beijing Fortune Building,5 Dong San Huan Bei-Lu, Chaoyang District, Beijing, 100004 China	Tel. +86-10-6590-8775 Fax. +86-10-6590-8776
Guangzhou Liaison Office	R3303, Metro plaza,183 Tianhebei Road Tianhe District, Guangzhou city, Guangdong, 510075 China	Tel. +86-20-8755-3649 Fax. +81-20-8755-3650

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Our address and contact indicated in this catalog are those as of November 2007.
If you cannot put a call through, please contact our Corporate Communication Group. in Tokyo below.
Tel:+81-3-5765-4076
Fax:+81-3-5765-8312
E-mail : hmcc@hitachi-metals.co.jp

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