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भारतीय मानक प्रारूप

मारेजिंग इस्पात का ताप उपचार — रीति संहिता

(पहला पुनरीक्षण)

Draft *Indian Standard*

HEAT TREATMENT OF MARAGING STEEL — CODE OF PRACTICE

(First Revision)

ICS 77.140.10

Metallography and Heat-Treatment Sectional Committee, MTD 22

Last date for receipt of comments is XX/XX/2023

FOREWORD

This Indian Standard (First Revision) is to be adopted by the Bureau of Indian Standards Standards on the recommendation of the Metallography and Heat-Treatment Sectional Committee and approval of the Metallurgical Engineering Division Council.

This standard was originally published in 1998. This revision has been brought out to bring the standard in the latest style and format of the Indian Standards.

Maraging steels are ultra high strength steels that differ from conventional steels in that they are not hardened by carbon. Instead, these steels are strengthened by precipitation of intermetallic compounds produced by age hardening a matrix of very low carbon. Fe-Ni martensite containing carbon, in fact, is an impurity in maraging steels and is kept at the lowest possible concentration.

Nominal composition of some of the common grades of maraging steel are given in Annex A for information.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2: 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Draft Indian Standard

HEAT TREATMENT OF MARAGING STEEL — CODE OF PRACTICE

(*First Revision*)

1 SCOPE

This standard describes the heat treating procedures, temperature schedules and other details relating to heat treatment of maraging steels. The procedures described, however, are meant only for guidance. The actual procedure of treatment should be agreed upon between manufacturer and purchaser.

2 TERMINOLOGY

2.1 Solution Treatment

Solution annealing is done by heating the material above Ac3 temperature. The temperatures employed are about 50°C above Ac_3. High temperatures (900-1100°C) produce grain boundary embrittlement due to formation of titanium carbide (TiC) films at austenitic grain boundaries. Prolonged annealing in this temperature range should be avoided for all the composition containing high content of titanium.

2.2 Age-Hardening Treatment

A precipitation hardening treatment normally done at 455-510°C for 3 to 12 hours depending upon the grade in order to achieve the desired strength of the alloy.

3 HEAT TREATMENT PROCESS

3.1 Solution Treatment

Solution annealing of maraging steels can be done between 820-980°C for minimum of 1 hour per 25 mm sectional thickness, but not less than 30 minutes and cooled in air or water to room temperature. When solution annealing is done at a temperature above 900°C for sectional sizes above 100 mm it is always preferable to cool in water to avoid grain boundary embrittlement. Control of atmosphere is necessary to minimize surface damage. Fuel oil or fuel gas with very low sulphur (sulphur of less than 1000 ppm in fuel gas and equivalent amount in case of oil) should be used. A neutral atmosphere is preferable. In case of electric heating dissociated ammonia can be used for bright annealing. Maraging steel is less susceptible to hydrogen embrittlement as compared to medium carbon low alloy steel of similar strength. Hence dry hydrogen or dissociated ammonia atmospheres are recommended. The cooling rate after annealing is of little consequence because it has no effect either on microstructure or properties. It is essential, however, that the steel be cooled to room temperature before it is age-hardened to avoid any untransformed (retained) austenite. Double solution annealing can also be adopted for hot worked materials to enhance its mechanical properties. If double solution treatment is adopted, the job has to be cooled to room temperature after first solution treatment.

For cold rolled products, the heating process should consist of first evacuating the furnace chamber and then heating up to 200°C holding 2-3 hours to drive out moisture etc, and then again heating up to 820-900°C at the rate of 100°C per hour, soaking 1 hour per 25 mm of sectional thickness but not less than 30 minutes and finally cooling in an atmosphere of argon to room temperature. Temperature tolerance for solution annealing is ± 20°C.

3.2 Age-Hardening

The age-hardening can be done either in normal atmosphere or in vacuum. The typical ageing treatment consists of treating at 480°C for grades 18Ni (200), 18Ni (250) and 18Ni (300) for 3-6 hours, and for grade 18Ni (350) for 6-12 hours. The 350 grade can also be aged for 3-6 hours at 495-510°C. For applications such as die casting tooling, ageing at temperatures of the order of 530°C is employed. In case of vacuum ageing, the vacuum level during ageing should be up to 10-3 torr and cooling is done either in vacuum or in argon atmosphere. Rate of cooling has little effect.

3.3 Distortions During Heat Treatment

Very small dimensional changes during hardening treatment allow maraging steel components to be machine finished in the solution annealed condition. The finished parts then can be hardened without the need for further machining. When greater dimensional accuracy is required an allowance for contraction should be made. For minimizing distortion in case of large components during ageing, the following heat cycle may be followed:

a) Charge the material below 200°C;
b) Soak for 3 hours at 200-250°C;
c) Heat at the rate of 50-60°C per hour to 480°- 510°C;
d) Soak for 3 hours, minimum; and
e) Air cool or cool in vacuum to room temperature.

3.4 Cleaning and Finishing

For removal of oxide films formed by heat treatment, grit blasting is the most efficient technique. Maraging steels also can be chemically cleaned by pickling in sulphuric acid or by duplex pickling, first in hydrochloric acid and then in nitric acid plus hydrofluoric acid. As with conventional steels, care must be taken to avoid overpickling.

4 TESTING AFTER HEAT TREATMENT

The following tests are generally conducted after heat treatment:

a) Tensile test in aged condition
b) Fracture toughness test in aged condition.
c) Hardness test in solution-treated condition and in aged condition.
d) Grain size test in solution-treated condition.

5 TYPICAL MECHANICAL PROPERTIES

Typical mechanical properties of heat treated standard 18Ni maraging steels are given in Table 1.

Table 1 Heat Treatment and Typical Mechanical Properties

Grade	Heat Treatment Condition	Tensile Strength *Min* MPa	Yield Strength *Min* MPa	Elongation on 50 mm Gauge Length Percent, *Min*	Reduction in Area percent, *Min*	Typical Hardness HRC	Fracture Toughness MPa/m
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
18Ni (200)	A	1500	1400	10	60	44-48	155-200
18Ni (250)	A	1800	1700	8	55	48-52	120 *Min*
18Ni (300)	A	2050	2000	7	40	51-55	80 *Min*
18Ni (350)	B	2450	2400	6	25	56-59	35-50
18Ni (Cast)	C	1750	1650	8	25	47-50	105 *Min*

NOTE
Treatment A : Solution treated for 1 h at 820°C and aged for 3 h at 480°C.
Treatment B : Solution treated for 1 h at 820°C and aged for 12 h at 480°C.
Treatment C : Annealed for 1 h at 1150°C, aged for 1 h at 595°C, again solution treated for 1 h at 820°C and finally aged for 3 h at 480°C.

ANNEX A

(*Foreword*)

CHEMICAL COMPOSITION OF COMMON GRADES OF MARAGING STEELS

A-l Different grades of maraging steel have been developed that provide specific levels of yield strength ranging from 1030 to 3450 MPa. Typical composition of certain common grade of maraging steels are given in Table 2 for information.

Table 2 Nominal Composition of Common Maraging Steels

Grade	Chemical Composition, Percent				
	Ni	Mo	Co	Ti	Al
(1)	(2)	(3)	(4)	(5)	(6)
18Ni(200)	18	3.3	8.5	0.2	0.1
18Ni(250)	18	5.0	8.5	0.4	0.1
18Ni(300)	18	5.0	9.0	0.7	0.1
18Ni(350)	18	4.2	12.5	1.6	0.1
18Ni(Cast)	17	4.6	10.0	0.3	0.1

NOTE 1 — Carbon content shall not be more than 0.03 percent.

NOTE 2 — Some manufacturers use a combination of 4.8 percent Mo and 1.4 percent Ti (nominal) for 350 grade.