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(S. K. NEOGI)
CONTROLLER.

RAKSHA MANTRALAYA
MINISTRY OF DEFENCE
GOVERNMENT OF INDIA

DEPARTMENTAL SPECIFICATION

SPECIFICATION FOR

HOMOGENEOUS MACHINABLE STEEL ARMOUR PLATES OF NOMINAL THICKNESS 8 MM TO 300 MM

CQA (M) - 51 / 2004
Superseded by CQA(M)-51/1983 edition

ISSUED BY

CONTROLLERATE OF QUALITY ASSURANCE (METALS)
MINISTRY OF DEFENCE (DGQA)
GOVERNMENT OF INDIA
P.O. ICHAPUR-NAWABGANJ
DIST. 24 PARGANAS (NORTH), WEST BENGAL
PIN - 743 144

RECORD OF AMENDMENTS

Amendment no.	Sub-heading to which amendment pertains	Authority	Incorporated by 'Name and Rank' in block capitals	Initials

CONTENTS

0.0 FOREWORD

0.1 This specification has been prepared and sealed by Controllerate of Quality Assurance (Metals), Ichapur. Considerable assistance has been derived from GOST-B-21968-76 in connection with fracture test parameters and ballistic test requirements while formulating the specification.

0.2 This specification is approved by the Controller, Controllerate of Quality Assurance (Metals), Ministry of Defence, and is mandatory for use in Defence Services. The information Contained in this specification is not to be communicated either directly or indirectly to press or any person not authorized to receive it.

0.3 This specification should be used to guide design, manufacture, quality control, quality assurance and procurement of Armour plates of nominal thickness 8 mm to 300 mm.

0.4 Enquiries regarding this specification in relation to any contractual conditions should be addressed to the Controller, Controllerate of Quality Assurance (Metals), Ministry of Defence, Government of India, P.O. Ichapur-Nawabganj, Dist. 24- Parganas (North), West Bengal, Pin - 743 144.

0.5 Copies of the specification can be obtained from the Controller, Controllerate of Quality Assurance (Metals), Ichapur- Nawabganj, Dist. 24- Parganas (North), West Bengal, Pin - 743 144.

1.0 SCOPE

1.1 This specification states material and performance requirements for steel Armour Plates of nominal thickness 8 mm to 300 mm to be used in soft annealed or hardened and tempered condition for manufacture of armour components and proof of Projectiles.

2.0 RELATED SPECIFICATION

2.1 Reference is made in this specification to :-

IS - 228	Method for Chemical analysis of metals
IS -1499	Method for Charpy Impact test (U-notch) for metals (steel)
IS - 1500	Method for Brinell hardness test for steel
IS -1608	Method of Tensile testing of steel products
IS - 4163	Method for determination of Inclusion content
ASTM Desig:A435-74	Method for Ultrasonic examination
GOST-B-21968-76	Shell proof armour steel plates

2.2 Reference in this specification to an Indian standard (undated) means in any tender or contract, the edition current at the date of such tender or contract.

SECTION- ONE

3.0 MANUFACTURE

3.1 The steel is to be manufactured through Electric Arc Furnace and vacuum degassing route, followed by annealing of ingots, if not hot transferred.

3.2 Calcium silicide treatment shall be given in steel during ingot Casting.

3.3 Ingots are to be cast wide end up or wide end down with hot top in standard moulds unless other methods are approved by the Quality Assurance Authority. The method for casting to be used, is to be declared by the steel maker.

3.4 Suitable measures are to be taken by the steel maker to avoid segregation, banding and to keep the steel as free as possible from inclusions.

4.0 DISCARD

4.1 10% top and 5% bottom discards are to be given to ensure cleanliness and freedom from harmful defects.

5.0 REMOVAL OF SURFACE DEFECTS

5.1 All harmful surface defects should be removed from the slab/plate prior to rolling to final size. However, removal of surface defects by grinding is allowed after soft annealing and shot blasting of plates prior to hardening and tempering provided the thickness does not get reduced below the specified limit after removal of defects. However, ground area is well faired into surrounding metal.

5.2 No extensive grinding is permissible on finally heat treated plates.

5.3 Visual laminar edge defects less than 6 mm long are acceptable. Laminar edge defects 6 mm long and over should be explored by ultrasonics on plate surface adjacent to the affected area. Edge defects that extend into the plates to such extent that they will result in rejectable defects according to the ultrasonic acceptance standards specified, shall be the cause for rejection of the plates.

6.0 SURFACE DEFECTS

6.1 Heat treated plates shall be shot blasted. The shot blasted surface shall be free from cracks, laminations, blisters, rolled scales and other harmful defects. The surface defects like pits, dents etc. may be removed by approved method so that the plate thickness is not reduced below the specified minimum.

7.0 SURFACE TREATMENT

7.1 Finally accepted plates may be painted / applied with protective coating as agreed Between the supplier and purchaser.

8.0 DIMENSION AND TOLERANCE

8.1 The plates shall be rolled such that the treated plates/ components and trimmed plates meet the dimensional requirement as per contract. Heat treated and flame cut plates/ components should be burr cleaned and stress relieved before supply.

8.2 Thickness

8.2.1 Unless otherwise specified in the drawing , the nominal thickness tolerance of the plates shall be as per Table 1 below :

TABLE 1

Nominal thickness (mm)	Tolerance (mm)	Width of rolled plate up to (mm)
8 - 10	+ 1.20 - 0.00	1500
11 - 19	+ 1.30 - 0.00	1500
20 - 24	+ 1.75 - 0.25	1500
25 - 30	+ 1.75 - 0.50	2200
31 - 49	+ 2.00 - 0.50	2200
50 - 74	+ 2.00 -1.00	2200
75 - 85	+ 2.00 - 2.00	2200
86 - 100	+ 2.00 - 2.00	2200
101 - 150	+ 2.00 - 3.00	2200
151 - 300	+ 2.00 - 4.00	2200

Note: (1) Positive limit of tolerance of plate thickness to be increased by 0.1 mm for each additional 100 mm of plate width, in case the plate width is more than the one specified in Table 1.

(2) The tolerance mentioned above are for general requirements, unless otherwise specified in the drawing or as agreed upon between purchaser and supplier.

8.3 **Flatness**

8.3.1 Plates / components must conform to the flatness tolerances specified on drawings and code of standard flatness tolerances for plates are as follows :

Code letter	Tolerance (mm)
A	0.80
B	1.75
C	3.50
D	5.25
E	7.50

The flatness of plates must be such that when laid down on a surface table it shall in no way exceed the specified tolerance over a length not exceeding 2000 mm in any direction. No corrugated or buckled plates are acceptable.

8.3.2 Where the flatness tolerances are not stated on drawing, plates shall conform to code 'D'.

9.0 HEAT TREATMENT

9.1 Following heat treatment schedule is recommended. The plates shall be oil quenched and tempered. The manufacturer shall determine the detailed procedure to produce plates meeting the mechanical properties requirements.

9.1.1 **Soft Annealing** : Heated to 700° C at the rate of 20° - 25° C per hour and soaked for 12-14 hours. Furnace cooled at the rate of 20° -25° C per hour to 100° C and then air cooled.

9.1.2 **Hardening** : Heating at the rate of 1½ min/mm of thickness and soaking 1 min/mm of thickness at 910° C. Total heating and soaking time should be 2 min/mm of thickness.

Quenching with following schedule :-

Thickness range (mm)	Quenched Medium	Time in sec/mm of thickness
8 - 30	Oil	20
31 - 50	Oil	25
51 - 79	Oil	30
80 and above	Water	

9.1.3 **Tempering** at 640° C- 680° C for 4 min/mm of thickness and cooled in air.

9.1.4 **Stress Relief** : If the plates are to be stress relieved after final tempering, the stress relieving temperature shall be at least 50° C below the final tempering temperature. Air cooling shall be employed after stress relief.
All the above parameters are for general guidance only to get the end results.

9.1.5 The manufacturer shall maintain a record of heat treatment given to the plates including stress relief.

10.0 INSPECTION / TESTING

10.1 The steel / plate maker is to inform the Quality Assurance Authority when he is in a position to start work and is to inform of all sub-contractors in connection with the contract as soon as they are placed in order that arrangements may be made for tests and quality assurance inspection.

10.1.1 The steel may be inspected at any time during manufacture and is subject to the approval of and acceptance by the Quality Assurance Authority.

10.1.2 Casts are to be certified as complying with the specified composition as per Table 2 by the Quality Assurance Authority on the results of analysis. All tests as per section two are to be witnessed / carried out by the representative of Quality Assurance Authority as decided by him.

10.1.3 Selection of test samples shall be as per section Two.

SECTION - TWO

11.0 COMPOSITION

11.1 The chemical composition of the steel (ladle analysis) when analysed in accordance with IS- 228 shall conform to limits specified in Table 2 & 2A.

Table-2 '1½ % Ni Cr Mo' Steel (for plate up to 85 mm thick)

Elements	Percentage	Elements	Percentage
Carbon	0.28-0.33	Nickel	1.50-1.70
Manganese	0.40-0.60	Molybdenum	0.40-0.45
Silicon	0.10-0.25	Vanadium	0.08-0.12
Sulphur	0.010 max	Aluminum	0.02-0.04
Phosphorus	0.015 max.	Hydrogen	2.5 ppm max
Chromium	1.30-1.50		

Table-2A '3 % Cr Mo' Steel (for plate over 85 mm thick)

Elements	Percentage	Elements	Percentage
Carbon	0.28-0.33	Phosphorus	0.015 max.
Manganese	0.40-0.70	Chromium	3.10-3.50
Silicon	0.10-0.35	Nickel	0.60 max
Sulphur	0.015 max	Molybdenum	0.40-0.60

11.2 The manufacturer will supply the report of ladle analysis/ cast analysis to the Quality Assurance Officer.

11.3 Periodical check analysis from products shall be carried out at the discretion of Quality Assurance Officer.

12.0 MECHANICAL TESTS

12.1 Mechanical test results shall conform to the requirements of Table 3.

Table 3

Nominal thickness (mm)	Yield Strength, Mpa (min)	Tensile Strength Mpa	% Elongation on 5.65 √So (min)	Charpy Impact 3mm'U'notch(Joules /Cm²)		Hardness(HB)
				RT	- 40° C	
8-16	-	-	-	-	-	Mentioned in drawing
20-85	883 ✓	981(min) ✓	13.0 ✓	78.5 ✓	59.0 ✓	290-341 ✓
86-100	-	925-1050	15.0	-	31.0	321-377
101-139	-	880-990	15.0	-	35.5	262-302
140-179	-	835-940	17.0	-	38.0	248-285
180-219	-	770-880	17.0	-	46.0	229-269
220-250	-	725-835	18.0	-	50.0	217-255
251-300	-	710-820	20.0	-	54.0	207-248

Note : Mechanical tests including charpy impact should be carried out on plates of 10 to 16 mm thick and tensile test on 8 mm thick plate and the results are to be recovered to compile data.

12.2 Tensile and Impact Test

12.2.1 Sampling : At least three sets of tensile and impact test pieces are required to be tested for each cast. Samples are to be so selected that each 10 tons of heat treated material of a cast is presented by at least one set of test samples. Above samples are to be taken from the ends of the plates corresponding to both top and bottom ends of the ingot.

Tensile and charpy test pieces are to be cut transverse to the rolling direction. Each set to be comprised of following test pieces :-

Tensile test piece - 1 No

Impact test pieces - 3 Nos for testing at room Temp. (up to 85mm thick plate only).
3 Nos for testing at - 40° C (for all thickness up to 300 mm)

12.2.2 Tensile test results when tested in accordance with IS -1608 and charpy impact test results when tested in accordance with IS - 1499 with 3 mm 'U' notch shall meet the requirements of Table 3.