12.3 **Hardness Test**

12.3.1 Every plate will be tested for Brinell hardness after final heat treatment. When tested in accordance with IS- 1500, hardness values so obtained shall conform to the requirement of Table 3. However, variation of hardness in a single plate should not be more than 20 points. T he test is carried out once every 2 meters of plate length at about 100mm form each edge and also once at centre of head end as well as tail end of the plate . With plates of less than 2 meters length, there will be at least one Brinell test for every square meter of plate surface.

12.3.2 Tensile Retest : If the results on an original tensile specimen are lower than 2 % of the required yield stress, tensile strength and Elongation%, a retest on duplicate specimens (one selected form the same plate and other from another plate of same lot and same cast) will be permitted. If the percentage Elongation of any tensile specimen is less than that specified and specimen from essentially the same location may be selected in its place provided hardness, yield stress and tensile strength are within specified values.

Charpy Impact Retest: In the event a charpy specimen does not meet the individual requirements, a retest of three specimens shall be permitted on the same plate. If any of the retest specimen does not meet the requirements, the lot represented by the specimen shall be rejected.

13.0 **ULTRASONIC EXAMINATION**

13.1 Each plate shall be subjected to ultrasonic examination for internal defects as per specification ASTM Desig : A435 - 74.

14.0 **INCLUSION RATING**

14.1 Inclusion rating will be as per Specification IS - 4163/ 1982 and should meet the following requirements :

Inclusion Type	Rating
Sulphide, Type (A)	2 Thin max.
Alumina, Type (B)	2 Thin max.
Silicate, Type ©	2 Thin max.
Globular Oxide, Type (D)	2 Thin max.

Note: (1) Though the specification does not mention determination of nitride, it is to be checked and should conform to 2 Thin max, similar to Globular Oxide Type (D).

(2) Inclusion rating will be reviewed after the manufacturer develops sufficient data on this in about 6 months time on the existing steel and inform to all concerned.

15.0 **FRACTURE TEST-** This test to be carried out for Armour plates upto thickness 85mm only.

15.1 **Sampling** : Fracture test samples are to be selected from the heat treated plates along with the tensile and impact test samples as per para 12.2.1. Samples may also be subjected to heat treatment along with the mother plates before testing, if not already heat treated.

15.2 Dimension of test samples :

Length	200 mm (min)
Width	Not less than 60mm for thickness of plates up to 60mm. For plates thickness above 60 mm, the width of the samples should not be less than the thickness of the plates.
Thickness	Same as the thickness of plate
Depth of cut	Not Exceeding 3/10 th of width

15.3 Samples are fractured by applying static load and the fractured faces are examined with naked eyes in day light or artificial light and the results are interpretated as per Appendix 'A'.

15.4 When a test specimen representing a lot of heat treated plates as per para 12.2.1 fails to meet the specification requirements, the lot is rejected. The manufacturer may reheat treat or rework i.e. re-roll the lot or lower thickness. Rehardening is permissible as per clause B.4.1. The manufacturer should keep the rejected lot duly identified separately from the acceptable lot until the rejected lots are withdrawn or demonstrated as meeting the specification requirements with double the number of samples.

16.0 **BALLISTIC TEST**

16.1 One No of ballistic test plate from each cast is to be subjected to ballistic testing. The test plates are to be cut from the mother plates with satisfactory mechanical, impact and fracture test results. Also the mother plate ends from which the ballistic test plates would be cut should correspond to top and bottom ends of the ingot.

16.1.1 Size of ballistic test plates would be **nominal thickness X 1220 mm X 1200 mm.** Ballistic test plates may be selected from the heat treated batch or the same may be heat treated along with the production batch. If from one cast of steel ingots different thicknesses of plates are rolled, ballistic test plates would be so selected that over a period of time all the thicknesses are covered.

16.1.2 Thickness of plates requiring the ballistic test, procedure and interpretation of the test result are given in Appendix 'B'.

17.0 **WELDABILITY TEST**

17.1 **Sampling** : Sampling for test for compliance with the weldability test requirements shall be at the discretion of the Quality Assurance Authority.

17.1.1 **Failure and Retest** : Failure to comply with the requirements of specification (to be incorporated later on) shall be the cause for rejection of the plates associated with the test sample selected.

At he discretion of the Approval Authority two further tests may be carried out following failure of the initial tests. Both tests are required to be satisfactory.

18.0 **QUALITY ASSURANCE DOCUMENTATION**

18.1 Quality assurance documents giving the following information will be supplied to the consignee along with the material :

Cast No, Plate No, Cast analysis report, Copies of test certificates of tests mentioned in section Two, dimension and surface inspection report.

18.1.1 Each plate will be identified with the marking which will relate to corresponding quality assurance documents.

A.0 **FRACTURE TEST**

A.1 Fractured surfaces of the test samples are estimated in accordance with Table A1.

Table A1

	Type of fracture	Number	Estimation of Fitness
	Fibrosity		
i.	Fibrous fracture	1	Fit
ii.	Fibrous fracture with fine grained aggregates or zone of crystalline grains at area not more than 20% of fractured surface.	2	Fit
iii.	Fibrous fracture with fine grained aggregates or zone of crystalline grains at area more than 20% of fractured surface.	3	To be re-heat treated
	Fish Scale Fracture		
iv.	Smooth fracture without any traces of fish scale	1	Fit
*v.	Closed fish scale fracture on the area up to 1/3rd of total area of fracture with 10 lines of open fish scale.	2	Fit
*vi.	Closed fish scale fracture occupying up to ½ of total area of fracture or opened and closed fish scale fracture on area up to 1/3rd of total area of fracture.	3	Fit
	* Minor closed fish scales having lines not more than 2 mm long for plates up to 80 mm thick and not more than 3 mm long for 80 mm thick and above are allowed on the entire area of fracture.		
vii.	Closed fish scale fracture along the entire section of fracture and marks of opened fish scale fracture in the central zone on area up to 1/3rd of total area of fracture or opened and closed fish scale fracture on area up to 2/3rd of total area of fracture.	4	Fit

	Type of fracture	Number	Estimation of Fitness
viii.	Opened and closed fish scale fracture on the area above 2/3rd of total are of fracture.	5	To be rejected
	Laminations		
ix.	Smooth fracture without laminations	1	Fit
x.	Fracture with one large and two outlined laminations	2	Fit
xi.	Fracture with three laminations or two laminations and two outlined laminations.	3	Fit
xii.	Fracture with three or four large laminations	4	Fit
xiii.	Fracture with five or more laminations	5	To be rejected.

A.1.1 The entire area of fracture consists of the fractured area proper and the shear lip zone.

A.2 While estimating the fractured surface following indications should be taken into account.

Fibrosity

(a) Crystalline zones are clearly outlined fractured area which have crystalline structure and occupy more than 10 mm each.

(b) Fine grained aggregates or crystalline grains are located on the main dull fibrous background.

Fish Scale Fracture

© Closed fish scale fractures are those which are short (up to 15 mm and inclusive) clear lines on the fractured surface oriented parallelly to the surface of the plate and do not disturb the continuity of metal.

(d) Opened fish scale fractures are short (up to and inclusive 15mm) splitting lines oriented parallelly to the surface of the plate and which disturb the continuity of metal.

Laminations

(e) Lamination in general will mean a lamination of length more than 15 mm oriented parallely to the surface of the plate and which do not disturb the continuity of the metal.

The outlined laminations are light traces of lines of more than 15 mm length oriented parallelly to the surface of the plate and which do not disturb the continuity of the metal.

Large laminations are of length exceeding 2/3rd of the width of fracture.

Laminations which are found in layer of thickness mot exceeding 5 mm are considered as single lamination.

B.0 **BALLISTIC TEST**

B.1 Ballistic testing of armour plates of CQA(M)-51 will be governed by the Table B1. Ballistic test of plates above 85mm to be mutually agreed between the Indenter (Purchaser) and the manufacturer (Supplier).

Table B1

Thickness of plate (mm)	Caliber of Projectile (mm)	Drawing No. of projectiles	Angle of attack	Striking velocity (min) (m/s)	Remarks
20	12.7 B-32 bullet	3-016113 3-24465	35^0	799	
30	30mm AP	AMK 613A	0^0	445	
40	30mm AP	AMK 613A	0^0	735	
45 #	57 INDEX BR 271M (30mm AP/T)	2-0134416'A' 3-016327 (AMK 613A)	45^0 0°	625± 5 830	
50	30mm AP	AMK 613A	0^0	925	
60 ## 70	57 INDEX BR 271M (40mm AP/T) 100mm AP/T	2-0134416'A' 3-016327 4-017070 or 2-011801 or 2-019268 DD(U)12495 2 US 9392120.	45^0 0° 0^0	485± 5 770 410± 5	
80	105mm FSAPDS/T	AMK 330A	0^0	670	
85	105mm FSAPDS/T	AMK 330A	0^0	690	

Amended vide DC No. 16348 dated 17.6.2008

" " " " 16273 dated 10.8.2008.

B.2 Procedure for conducting ballistic test on armour plate.

B.2.1 First shot is fired at a velocity 30 m/s more than that of stipulated minimum striking velocity as per table B1. If the first shot results in a standard damaged (acceptable damage). 2nd shot is fired with same charge weight. If 2nd shot results in a standard damage, plate will be considered acceptable. If 2nd shot results in a non-standard damage, clause B.2.2 is applicable.

B.2.2 If the first shot results in a non- standard damaged (unacceptable damage), two more shot are fired at a velocity specified in Table- B1. If any one of the shots records standard damage at a velocity not less than the specified velocity as per TableB1. the plate will be considered ballistically satisfactory provided the other shot does not record non-standard damage at a velocity less than that of the specified minimum. If any shot records non-standard damage at velocity less than that of the specified, the plate will be rejected.

B.2.3 For 20 mm thick plates, standard damages with minimum of 7 Nos record shot to be obtained.

B.2.4 Type of damage due to firing to be assessed in the following manner.

Standard Damaged

(a) Bulge of any size at the rear side of the plate

(b) Bulge of any size with non-through cracks on the bulge at the rear side of the plate. Cracks will be examined to see that kerosene oil does not pass through.

Non-Standard Damaged

(a) Cracks of any size through which kerosene oil passes.

(b) Plugging

(c) Scabing / Flaking from rear side of the plate.

(d) Non-through crack of length 3 calibre of shot or more at the rear side of the plate.

B.3 Record / Non-record shot

B.3.1 Standard damage caused due to the shot fired at a velocity less than the specified minimum striking velocity is not taken into account and is called Non-Record shot.

B.3.2 Non-standard damage formed at distance less than 2.5 calibre of shot from the edge of the another damage or the edge of the plate is also a non-record shot.

B.3.3 Non-standard damage caused with a striking velocity less than that of the specified minimum velocity is a record shot i.e. the results to be taken into account.

B.3.4 Standard damage formed at a distance less than 2.5 calibre of shot from the edge of the another damage or the edge of the another damage or the edge of the plate is a record shot.

B.4 Re-testing / Rejection

B.4.1 On obtaining un-satisfactory result in ballistic test double re-test may be carried out. One BTP may be cut from the mother plate from which the rejected BTP was taken and another BTP to be selected from the same cast. If on re-testing , the ballistic results are found satisfactory, the batch is accepted. If, however, any one of the re-test BTPs fails to meet the ballistic requirements, the producer may submit the batch after re-heat treatment. Re-hardening is allowed only once with any number of re-tempering.

B.4.2 The batch rejected due to un-satisfactory ballistic test results may be re-rolled to lower thickness plates and submitted as a new batch.