VACUUM DEGASSED / ESR STAINLESS STEEL BARS FOR STEAM TURBINE BLADES, HARDENED & TEMPERED (GRADE : X22 Cr Mo V 121)

1.0 GENERAL:

This specification governs the requirements of vacuum degassed / ESR processed, hardened & tempered stainless steel bars of grade X 22 Cr Mo V121 for steam turbine blades.

2.0 APPLICATION:

For manufacture of steam turbine blades suitable for working temperatures from 400-550°C.

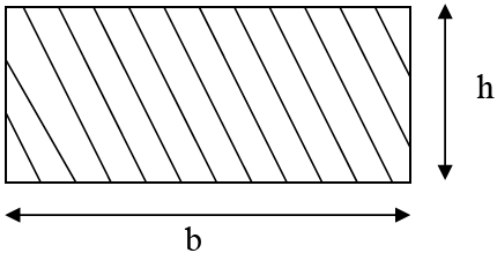
3.0 CONDITION OF DELIVERY:

Hot rolled, Hardened & Tempered.

4.0 DIMENSIONS AND TOLERANCES:

4.1 Dimensions: As specified in the order. Unless otherwise specified in the order, the bars shall be supplied in random lengths of 3 to 6 metres with a maximum of 10% shorts down to 1 metre.

4.2 Tolerances: The tolerances on cross sectional dimensions shall be as follows.



'b'width across flats, mm	Allowable deviation on 'b' mm	'h' thickness mm	Allowable deviation on 'h' mm
Upto 35	+1.5	Upto 20	+ 1.0
Over 35 and upto 75	+ 2.0	Over 20 and upto 40	+ 2.0
Over 75	+ 3.0	Over 40	+ 3.0

NOTE: Other tolerances shall be as per DIN:1017. Twisting and bending of the bars shall not exceed 1mm per metre Length of the bar. Buldging on the sides shall not be more than 0.01 x b and 0.01 x h respectively.

5.0 MANUFACTURING AND INSPECTION SEQUENCE PLAN (MIP):

Before starting production the manufacturer shall submit the following documentation to BHEL.

5.1 A manufacturing & inspection sequence plan (MIP) which is released after the prototype qualification, establishing the quality assured sequence of operations like steel melting, rolling, heat treatment and inspection plan. Information about internal & external specifications shall also be mentioned in MIP. Every change in the established process or MIP needs written permission of BHEL.

5.2 Test instructions for non-destructive testing & destructive testing, which are performed, as part of manufacturer's quality assurance shall also be submitted. The test instructions shall include precise information on the test procedures, sample location plan (illustrated by sketches).

6.0 MANUFACTURE:

6.1 The steel shall be manufactured by basic electric furnace process and subsequently vacuum degassed / electroslag remelted. Any other process steel making shall be mutually agreed in advance.

6.2 The vacuum system shall have the capacity to maintain a vacuum of 2 torr or lesser during vacuum degassing process for the sufficient time so as to lower the gas contents in the steel.

6.3 The ingot castings shall be used for the manufacture of bars. A reduction ratio of 4 (minimum) shall be maintained from the ingot to final bar size. The information regarding the ingot size to the concerned final bar size shall be mentioned in the MIP.

7.0 HEAT TREATMENT

7.1 The recommended heat treatment cycle shall be as follows

Harden in air or oil at 1020 - 1070°C
Tempering temperature shall not be less than 650°C

7.2 If the bars need be straightened after heat treatment then the bars shall be stress relieved after the straightening operation at 30° C below the actual tempering temperature with a slow cooling rate.

7.3 The process parameters shall be selected with a view to achieve lowest possible residual stresses. The distortion of the finish machined part caused by slight residual stresses from the rolling & heat treatment process shall not occur.

7.4 The details of the actual heat treatment cycle followed shall be furnished in the Test Certificate.

8.0 FREEDOM FROM DEFECTS:

8.1 The bars shall be free from cracks, scabs, seams and other harmful defects.

8.2 Decarburization and other material defects shall not exceed the dimensional tolerances and machining allowances.

9.0 FINISH:

9.1 The surface of the bars shall be smooth without any laps, rolled in scales etc. Dents roll marks, and scratches are permitted provided their depth does not exceed half the tolerance limits specified in clause 5.

9.2 Welding for improvement of surface appearance is not allowed.

9.3 The edges of bars shall be cut square by sawing or shearing and no crop ends shall be permissible.

10.0 TEST SAMPLES:

10.1 For Chemical Analysis: One sample for chemical analysis shall be taken from each melt.

10.2 For Mechanical tests: Bars of same size shall be grouped into lots belonging to same melt and heat treatment batch. This shall be treated as a single test unit and subjected to mechanical testing as per following plan.

10.2.1 The uniformity of the strength of the bars belonging to one lot (same melt and heat treatment batch of same size of bars = test unit) shall be verified by hardness test as per EN ISO 6506-1 or any other reputed international method. The hardness test shall be performed on 10% of each test unit, however on atleast 10 bars or on all the bars if the test unit comprises of less than 10 bars. The greatest permissible difference in hardness in a lot (test unit) shall not exceed 35 HBW.

10.2.2 Hardness tests are to be performed after all heat treatments including a possible stress relieving are undertaken.

10.2.3 Mechanical properties shall be determined on the hardest and softest bars identified by the hardness tests conducted as per 11.2.1 and 11.2.2.

10.2.4 The test samples locations may be as per Annexure A and B. If the cross section of the bar is more than 200 cm^2, then mechanical properties must be determined both in the centre of the bar and at the side of the bar. With the exception of toughness, the difference in the properties across the bar cross section shall not exceed 7.5%.

10.2.5 The specimen for Metallography shall be taken in longitudinal direction with a minimum cross section area of 320 mm^2.

The positions of the specimens given in the Annexure A and B are meant for guidance only. Details concerning the locations of the specimens are to be agreed mutually and must be included in MIP with a sketch.

11.0 CHEMICAL COMPOSITION:

Heat analysis (in weight %) shall be achieved as follows.

Element	C	Si	Mn	P	S	Cr	Mo	Ni	V
Minimum	0.18	0.10	0.30	--	--	11.00	0.80	0.30	0.25
Maximum	0.24	0.50	0.80	0.020	0.020	12.50	1.20	0.80	0.35

12.0 MECHANICAL PROPERTIES:

The material shall comply with the following mechanical properties.

Properties	0.2 %Yield Strength N/mm^2	Tensile Strength N/mm^2	Elonga-tion %	Reduct-ion of area %	Impact energy, J
Minimum	600	800	14	40	27
Maximum	--	950	--	--	--

NOTE: 1) The tensile test shall be carried out accordance with EN10002 resp. ASTM E8M (round tension test specimen with L_o = 50 mm and d_o = 10 mm) or any other reputed National/International standard.

2) The Charpy V – notch impact test shall be performed with standard test specimens in accordance with EN: 10045 or any other reputed National/International standard. An impact test shall consist of three specimens from a single test location, the minimum average value shall be as specified above. Only one value of the three can be below the specified minimum, but in no case below 18 J. All the three test results shall be reported in test certificate.

3) HBW 10/3000 or HBW 5/750 shall be used for hardness tests.

13.0 METALLOGRAPHY TESTS:

The examination of the cleanliness must be performed in the centre of one bar per lot. It can be conducted before or after the heat treatment. The microstructure must be uniform and free from porosity, excessive segregation and other inhomogeneities. The following properties concerning delta-ferrite and inclusions shall be achieved.

13.1 Delta ferrite content shall be less than 5%. Delta ferrite content shall be determined in a manner consistent with the evaluation technique described in ASTM E 45 Method A (Worst Field Method at a Magnification of 100X) with the specimen orientation in longitudinal direction. The distribution and size of delta ferrite must be such that it does not result in indication during MPI examination of the ready-machined surface.

13.2 Inclusion content shall be tested as per ASTM E 45 Method A and with following limits.

13.2.1 "Thin series" inclusions shall not exceed 2.0 for Type A, B, C and 2.5 for Type D.

13.2.2"Heavy series" inclusions shall not exceed 1.5 for all Types i.e. A, B, C and D.

13.2.3 All the type and sizes of the inclusions mentioned in 14.2.1 and 14.2.2 can exist simultaneously.

13.2.4 Maximum number and size of globular inclusions (type D):

IR (D) = (n1 + 2.5 n2) ≤ 10
IR(D) is converted to an area of 160 mm^2.
n= number of globular inclusions.

n1(25 μm – 50 μm); n2(51 μm – 75 μm)

The size pertains not only to the globular inclusions themselves, but also the subsequent cavities, which can occur beside them. Inclusions and cavities which are more than 75 µm are not allowed.

13.3 Grain size: The grain size must be measured at the softest and the hardest bar after all heat treatments are performed. Grain size 4 or finer per ASTM E 112 or DIN 50601 must be achieved.

A deviation from the average size of more than 2 grain size is not permissible.

14.0 EXTERNAL AND INTERNAL QUALITY/NON DESTRUCTIVE TESTING:

14.1 Test Scope: The following NDT inspections shall be carried out after all heat treatments including stress relieving operations are completed on the flats.

- Visual inspection of all bars
- UT of all bars as per to SEP 1923,inspection number D3 or D2 with dual (twin) crystal search unit.

  Requirements: 100% of the volume shall be examined with the stipulated recording level.

14.2 Criteria for Recording Limits and Decision on Further Use:

a) Surface defects: Indication of surface defects, e.g., scoring caused by the rolling process are to be ground at least at both ends, in the center of the indications and in increments of ca.250 mm to check the extension below the surface. Surface defects extending ≥1 mm or greater than half the specified dimensional tolerances below the surface are not permissible.

b) UT : Criteria stipulated in SEP 1923 quality class 2 b shall be applied with following modification : EE(single echo)and VE (numerous single echoes) with out extension ≥ 2 mm CRR are not permissible.

15.0 HIGH TEMPERATURE PROPERTIES:

The supplier shall guarantee the elevated temperature and creep properties as per EN10269 for this grade of material.

16.0 MATERIAL IDENTITY TEST:

At the time of delivery, all the bars shall be subjected to identification test by Spark test method or any other reliable means to ascertain that the material supplied is as per required by the specification.

17.0 PROCESS QUALIFICATION:

A qualification review, performed jointly by the purchaser and supplier, is required before starting production for the first order. The process qualification review will include following as a minimum requirement.

17.1 This initial process qualification is required for each manufacturing, heat treatment and testing facility.

17.2 The parameters used or stipulated during this phase shall form the basis of the MIP.

17.3 In addition to the scope of testing and examination stipulated in this specification, the following additional tests and examinations shall be performed.

17.3.1 Tensile and impact tests in transverse direction. If required, the sub-size test specimens may be used for the testing.

17.3.2 Determination of FATT according to ASTM A 370. FATT of < 25°C shall be achieved. Testing shall be carried out on minimum 10 specimens.

17.3.3 Magnetic particle testing: The distribution, type and size of micro-structural inhomogeneities (e.g. delta ferrite and segregation) shall not cause MP indications.

17.4 The manufacturer shall submit the results of creep tests conducted on the hardened and tempered samples of the steel produced by them of this grade of material. The test parameters like test temperature, duration of test and number of test samples shall be mutually agreed upon between the manufacturer and BHEL. The results of these creep tests shall form the basis of Creep property guarantee to be given by the manufacturer for their supplies of blade flats as per cl.16.0.

18.0 INSPECTION AT SUPPLIER'S WORKS:

The representative of BHEL shall have free access to the supplier's works at all times during the execution of the order, to satisfy himself that the material is produced as per the quality requirements of this specification. All reasonable facilities shall be extended to him free of charge. He may also witness the sampling testing and marking called for in this specification.

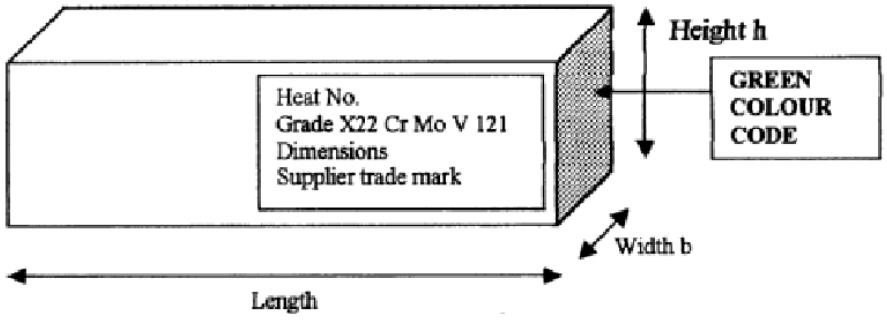
19.0 TEST CERTIFICATE:

Five copies of the test certificate shall be furnished giving the following details:

a) Specification No.: HY10766 Rev.07
b) BHEL Order No.
c) Name of the supplier.
d) Melt No.
e) Heat treatment batch no. and HT charts.
f) Process of Manufacture.
g) Results of chemical analysis and mechanical tests (including hardness test results).
h) Results of Metallographic with representative photomicrographs and Ultrasonic tests.
i) Guarantee for high temperature properties as specified in clause 16.

20.0 MATERIAL IDENTIFICATION MARKING:

Marking on each individual bar at the front and side face shall be done as given below.



21.0 PACKING:

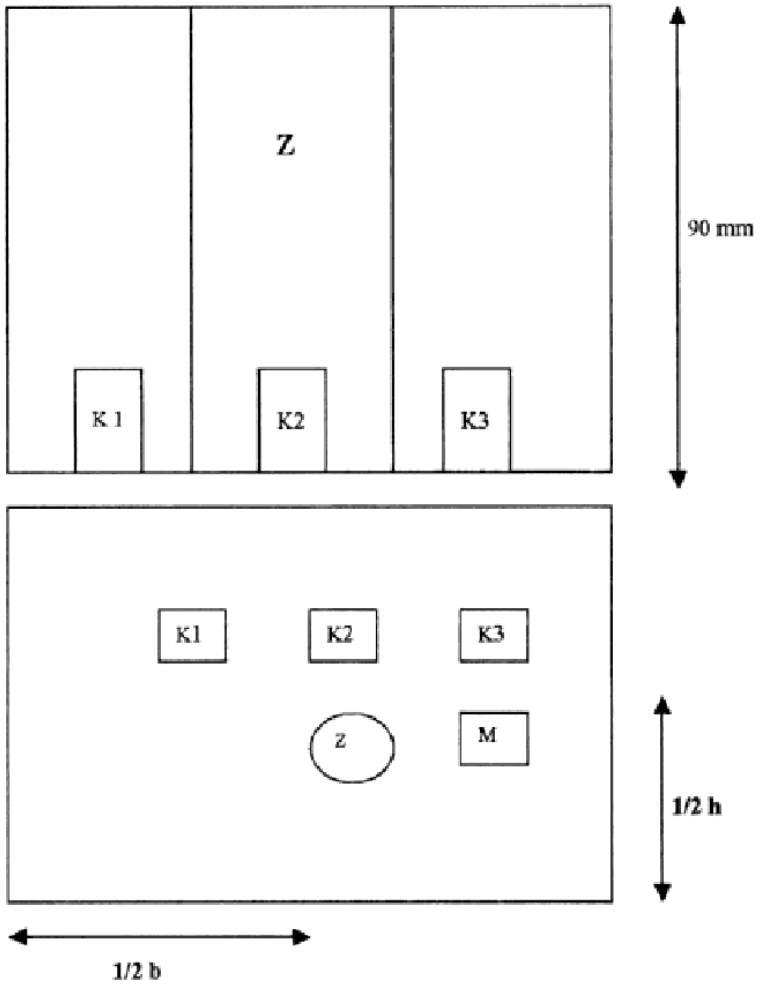
The bars shall be suitably packed to prevent from corrosion and damage during transit.

22.0 REJECTION AND REPLACEMENT:

In the event of any material proving defective during the course of further processing or testing. Such material shall be rejected and the supplier shall make immediate arrangements to replace the same free of cost.

ANNEXURE A

TEST SAMPLES LOCATIONS PLAN (CROSS SECTIONAL AREA < = 200 CM ^{2})



Z = TENSILE SPECIMENS (LONGITUDINAL DIRECTION)

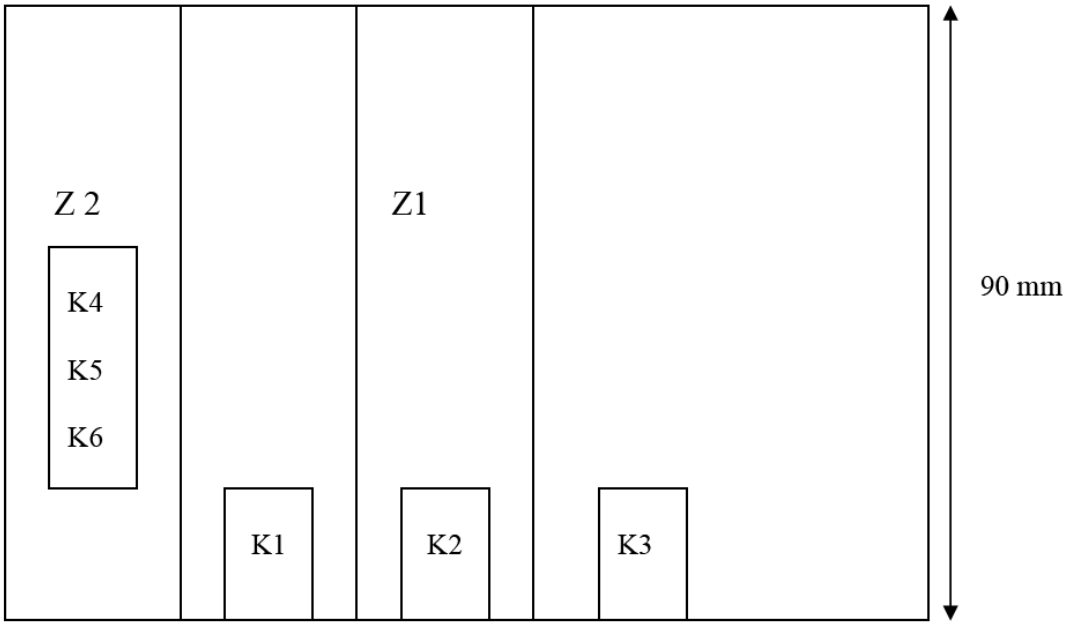
K1, K2 & K3 = IMPACT SPECIMENS

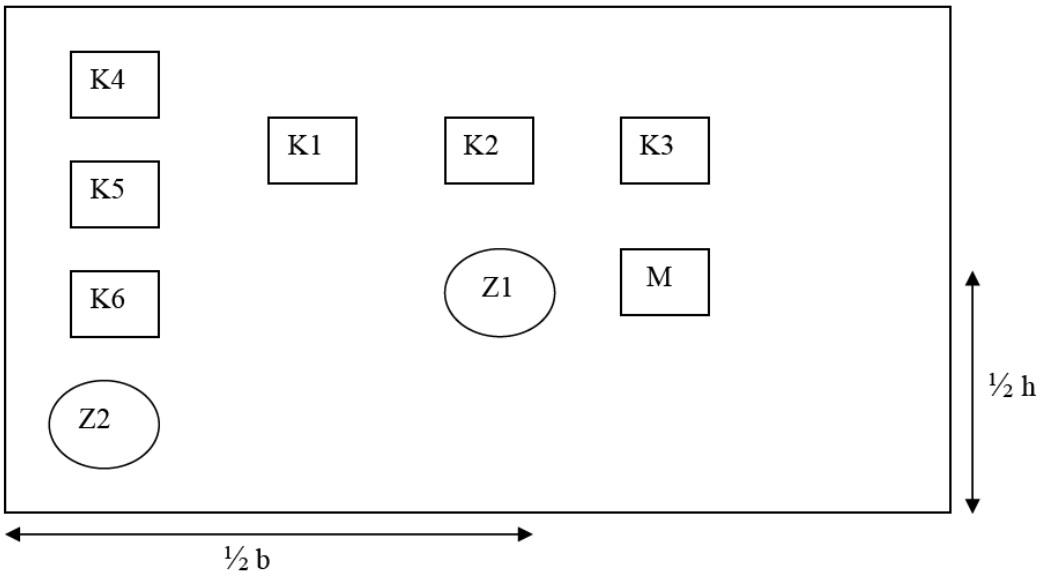
M = METALLOGRAPHY SPECIMENS

Note: Make sure that all specimens are located in the middle of the material thickness

ANNEXURE B

TEST SAMPLES LOCATIONS PLAN (CROSS SECTIONAL AREA > 200 CM²)





Z1, Z2 = TENSILE SPECIMENS (LONGITUDINAL DIRECTION)
K1 TO K6 = IMPACT SPECIMENS
M = METALLOGRAPHY SPECIMENS