Revision record: Rev 01: Cl 2: Requirement if the Carbon content is below 0.6% - Added for Bolts ; Mn for Nuts: limited to 0.25 min instead of 0.25 max. Cl 5: Hardness of Bolt & Nut: Acceptance values changed. Cl 7: Preservation and Packing added.

1. **SCOPE:**
This technical delivery condition covers the requirements for the High strength structural steel bolts, Nuts and Washers applicable for boiler structures and shall be procured from the BHEL approved manufacturers only. The applicable Indian Standard Specification:
For Bolts IS: 3757. (Latest) Property class: 8.8 Product Grade C of IS Specification IS: 1367(Latest).
For Nuts IS: 6623 (Latest) Property class: 8. Product Grade B
For Washers IS: 6649.(Latest). Type-A.: Plain Hole Circular Washers. Grade: Ordinary
Size and Qty: As per the BHEL Purchase order (PO) / BHEL Drawing
The requirements of the above IS standard has been provided below which needs to be met mandatorily.

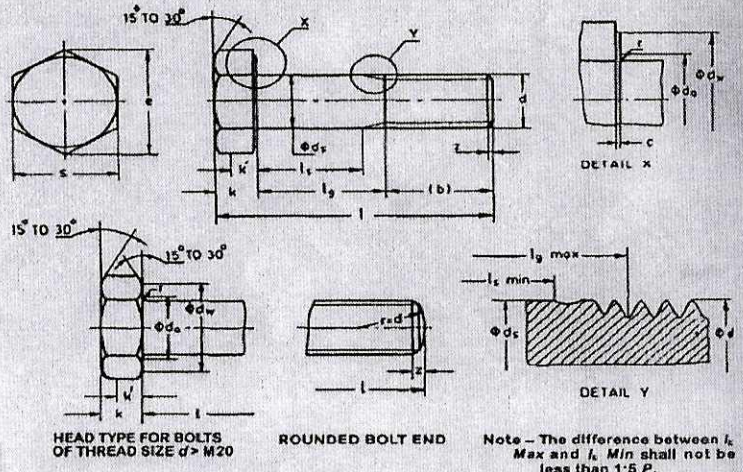
2. **RAW MATERIAL:**
BOLTS and NUTS: Carbon steel Bar: Rolled/Forged bar.
Chemical composition:
BOLTS: Carbon: 0.25-0.55; Phosphorus: 0.035 Max ; Sulphur:0.035 Max ; Boron:0.003 Max. In case of plain carbon boron steel with a carbon content below 0.25% (ladle analysis), the minimum Manganese content shall be 0.6%.
NUTS: Carbon: 0.58 Max.; Phosphorus: 0.06 Max.: Sulphur: 0.15 Max; Manganese: 0.25 Min.
WASHERS: Carbon: 0.40-0.50; Manganese: 0.6-0.9; Sulphur and Phosphorus not exceeding 0.06 % in the check analysis.
Non Destructive Test:
For sizes Diameter ≥ 40 mm: UT as per SA388. Acceptance: ASME SEC-VIII. Div-II Part: 3.3.4.
For sizes Diameter < 40 mm: MPI as per ASTM E 709.Linear indications like cracks, folds & other injurious defects are not acceptable.
Traceability records for all the tests for the production lot shall be maintained for verification during Inspection.

3. **DIMENSIONS AND TOLERANCES:**
Process: Cold/Hot Forging with Dies and tools clean of loose scale and sheet particles.
Threads on the bolts shall be checked with a properly calibrated ring gauge with a tolerance class 6g.
Threads on the nuts shall be checked with a properly calibrated plug gauge with tolerance class 6H.

Dimensions of the Bolts shall be as per the Table below:

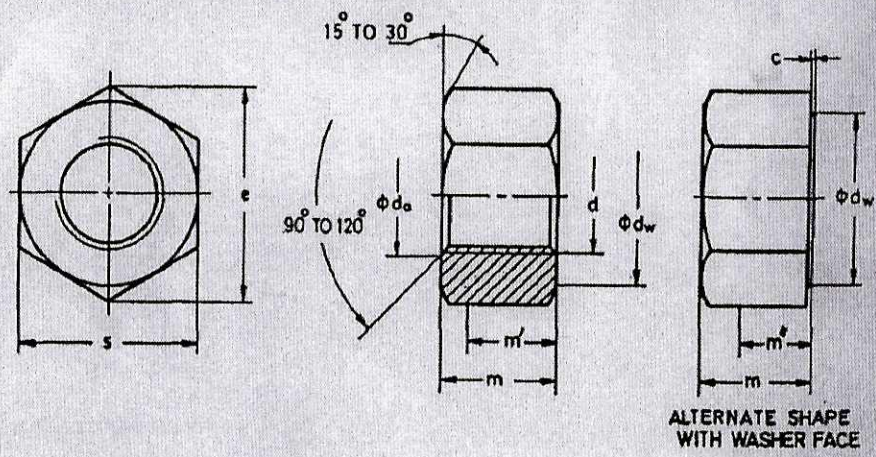
Thread Size d		M24
p Pitch of thread		3
b_{ref} For length/Nom ≤100		41
>100		48
c	*Max*	0.8
	Min	0.4
d_a	*Max*	27.64
d_s	*Max*	24.84
	Min	23.16
d_w	*Max*	†
	Min	38.0
e	*Min*	45.20
k	*Nom*	16
	Max	15.90
	Min	14.10
k'	*Min*	9.9
r	*Min*	1.0
s	*Max*	41
	Min	40
Chamfer length z	*Max*	4.5

All dimensions in millimetres.



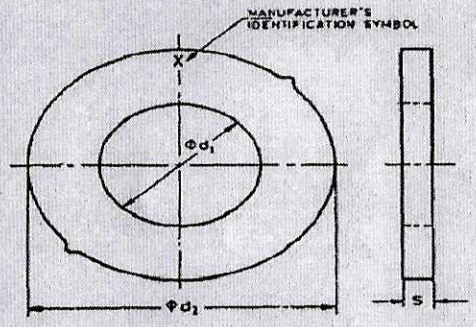
Dimensions of the Nuts shall be as per the Table below :

Sl No.		Thread Size, d	M 24
i)	p[1]		3
ii)	d_a	*Max*	25.9
		Min	24.0
iii)	d_w	*Max*	3)
		Min	38.0
iv)	e	*Min*	45.20
v)	m	*Max*	24.2
		Min	22.9
vi)	m'	*Min*	18.3
vii)	m''	*Min*	16.0
viii)	c	*Max*	0.8
		Min	0.4
ix)	s	*Max*	41.0
		Min	40.0



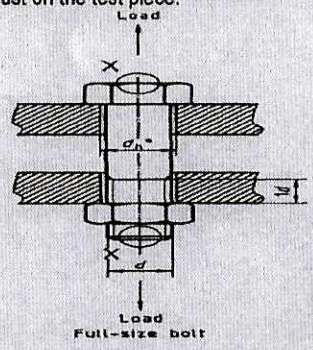
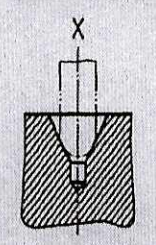
Dimensions of the Washers shall be as per the Table below:

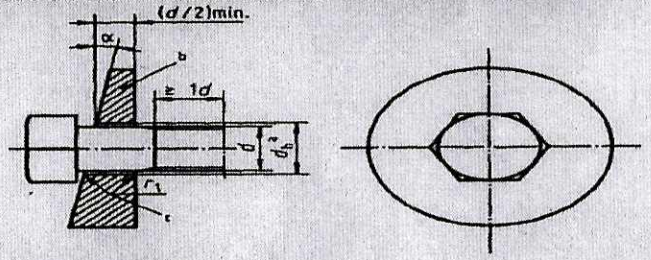
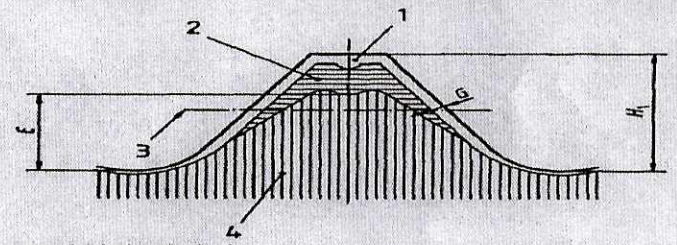
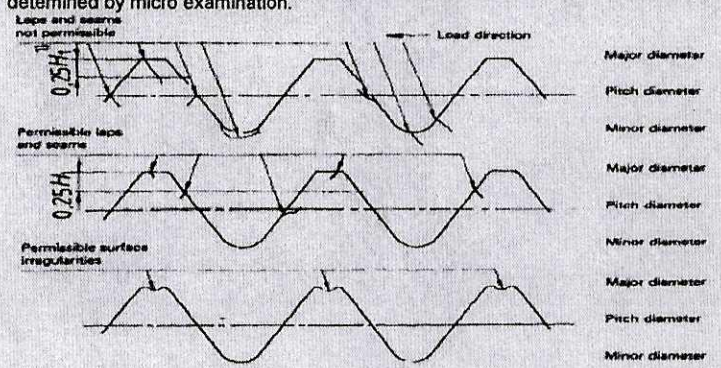
Nominal size (thread size d of associated bolt)		M24
d_1	*Min*	26
	Max	26.52
d_2	*Min*	48.4
	Max	50
s	*Min*	3.4
	Max	4.6



4. **Post Forming Heat Treatment (HT):**
Bolt: After forming: Normalize at 860°C, 30 minutes per inch, oil quenching, followed by tempering at 425°C minimum,60 minutes per inch.
Nut: Shall be hardened and then tempered at a temperature of 425°C minimum,
Washer: Shall be hardened and tempered. Carburized washers are not permitted.

5. **CHEMICAL & MECHANICAL & NDE: on Heat Treated finished product.**
Sample Size for Chemical test: One per TC
Sample Size for Mechanical test: As per Sampling Plan
Sample Size for NDE: As per Sampling Plan
BOLT :

Sl No	Test	Test Method	Acceptance
1	Chemistry	Spectro / Wet Analysis Method	As per Cl 2.0 of this TDC.
2	Hardness Test	The head and end of the bolt are to be faced &Vickers Hardness measurements shall be made with 98N (or) 10kg load. Minimum 3 measurements to be made & reported.	Min 255 HV Max 335 HV
3	Minimum Tensile Strength *if wedge load test is satisfactory the axial tensile test is not required. %Elongation on 5.65√A % Reduction in Area after fracture	Round specimen of size as given in Table 1 with fillet radius r as below : Diameter d (mm) / Fillet radius r (mm): 20 / 4; 10 / 4; 5 / 1 Rate of stressing : 6 - 60 N/mm²/sec **Table 1 — Circular cross-section test pieces** k: 5,65 Diameter d mm: 20 ± 0,15 / 10 ± 0,075 / 5 ± 0,040 Original cross-sectional area S_0 mm²: 314 / 78,5 / 19,6 Original gauge length $L_0 = k\sqrt{S_0}$ mm: 100 ± 1 / 50 ± 0,5 / 25 ± 0,25 Minimum parallel length L_c mm: 110 / 55 / 28 Total length L_t: Depends on the method of fixing the test piece in the machine grips In principle: $L_t > L_c + 2d$ or $4d$	830N/mm² 12 min 52% min
4	Proof Load Test	Proof Load of 212 KN shall be applied axially to the bolt in a calibrated tensile testing machine for 15sec. The length of free thread subjected to the load shall be one diameter (1d). For measurement of permanent extension,the bolt shall be suitably prepared at each end, as given in the fig. Before & After the application of the load, the bolt shall be placed in a bench-mounted measuring instrument fitted with spherical anvils. Gloves or tongs shall be used to minimize measurement error. Speed of testing ,as detemined with a free running cross head,shall not exceed 3mm/min.The grips of the testing machine should be self aligning to avoid side thrust on the test piece.   Required "sphere to cone" contact between the measuring points and the centre-drilled holes in the end of the bolt or screw. Nominal Thread Diameter d = 24 mm ; Hole Diameter dh = 26 mm Some variables such as straightness and thread alignment (plus measurement error), may result in apparent elongation of the fasteners when the proof load is initially applied. In such cases, the fasteners may be retested using a 3% greater load, and	Length of the bolt after loading shall be the same as before loading within a tolerance of ± 12.5 µm allowed for measuremnt error.

5	Strength under Wedge load test	Test for strength under wedge loading shall be carried out in a calibrated UTM / tensile testing equipment using a wedge as illustrated in below figure. The minimum distance from the thread run-out of the bolt to the contact surface of the nut of the fastening device shall be d. A hardened wedge in accordance with tables 10 & 11 shall be placed under the head of the bolt. A tensile test shall be continued until fracture occurs.  Radius r1 = r max + 0.2 in which, r max = (da max – ds min) /2 where r – radius of curvature under head ; da – transition diameter ds – diameter of unthreaded shank ; α = 6° ± 0° 30' a – Nominal Thread Diameter d = 24 mm ; Hole Diameter dh = 26 mm b – Hardness : 45 HRC min c – Radius or Chamfer of 45 °	Strength under Wedge load test : ≮ 830N/mm2 The fracture shall occur in the shank or the Free threaded length of the bolt and not between the head and shank. The bolt shall meet the requirements for minimum tensile strength during wedge tensile testing.
6	Decarburization Test	Determination of the following by MICROSCOPIC Method. a)Minimum Height of non decarburized thread zone - E b)Maximum depth of complete decarburization – G The specimems to be used are longitudinally sections taken through the thread axis approximately half a nominal diameter (1/2 d) from the end of the bolt, after all heat treatment operations have been performed on the product. The specimen shall be mounted for grinding & polishing in a clamp or preferably, a plastic mount. After mounting, grind & polish the surface in accordance with good metallographic practice. Etching to be done in a 3% Nital solution(concentrated nitirc acid in ethanol). 200X min magnification shall be used for examination. If the microscope is of a type with a ground glass screen,the extent of decarburization can be measured directly with a scale. If an eyepiece is used for measurement, it should be of an appropriate type, containing a cross-hair or a scale. Also image may be captured & decarburisation depth may be measured using Image Analysis System with proper calibration.  1 - completely decarburized 2 - partially decarburized 3 - pitch line 4 - base metal H1 - external thread height in the maximum material condition (For Thread Pitch = 1.75 mm, H1 = 1.074)	E = ½ H1 = 0.537 mm G = 0.015 mm
7	Hardness after Retempering # test not mandatory, applied in case of dispute only.	Shall be retempered at a part temperature of 10°C less than the Specified minimum tempering temperature and held for 30 minutes. The mean of three core hardness readings on a bolt , tested before and after retempering shall be reported	Reduction of hardness 20 HV10 maximum
8	NDE for Surface Intergrity	Wet Fluroscent MPI as per ASTM E 709	Linear indications like cracks, folds & other injurious defects are notacceptable.
9	Micro Examination for Surface Integrity – Laps at threaded region.	If any defectives found in visual and NDE examinations, the extent of defect can be detemined by micro examination. 	Max depth of laps in thread = 0.41 mm Laps of any depth or length are not permitted in the following places: • at the root of the thread • at the loaded flank of screw thread below the pitch diameter, even if they start beyond the pitch diameter. The following laps are permissible : • laps in the crest of the threads of 0.25 H1 max.; • crest of the threads not entirely rolled out, maximum half a turn on one thread; • laps below the pitch diameter, if they run on the non-loaded flank towards the major diameter and not deeper than 0.25 H1 and not longer than half a turn on one thread.

NUT:

Sl.No	Test	Test Method	Acceptance Value
1.	Chemistry	Spectro / Wet Analysis Method	As per Cl 2.0 of this TDC.
2.	Hardness Test	The bearing surfaces of the nut are to be faced and Vickers Hardness measurements shall be made with 294 N or 30 kg load. Minimum 3 measurements to be made and reported.	Min 233 HV Max 353 HV
3.	Proof Load Test	Proof Load of 379.5 KN shall be applied axially to the nut in a tensile testing machine for 15sec. Hardness of the test mandrel shall be minimum 45 HRC. Speed of Testing as determined with a free running cross head shall not exceed 25 mm/min.	The nut shall resist the load without failure by stripping or rupture, and shall be removble by the fingers after the load is released. If the thread of the mandrel is damaged during the test, the test should be discarded. It may be necessary to use a manual wrench to start the nut in motion.Such wrenching is permissible provided that it is restricted to one half turn and that the nut is then removable by the fingers.
4.	NDE for Surface Intergrity	Wet Fluroscent MPI as per ASTM E 709	Linear indications like cracks, folds & Other injurious defects are not acceptable.

WASHER:

S.No	Test	Test Method	Acceptance Value
1.	Chemistry	Spectro / Wet Analysis Method	As per Cl 2.0 of this TDC.
2.	Hardness Test	Rockwell Hardness Test : The washer surface to be faced & Rockwell Hardness measurements shall be made in C Scale. Minimum 3 measurements to be made and Reported.	Min 35 HRC Max 45 HRC

6. **MARKING, PRESERVATION AND PACKING:**
BOLT & NUT :The following to be hot stamped on the top surface of the bolt/nut:
1. Manufacturer's Identification Symbol
2. Property Class Identification Symbol (8.8S/8S)
WASHERS: Shall be identified by the provision of 2 nibs and manufacturers identification symbol being placed as near to the outer edge as possible.
The following details shall be clearly indicated in the tags tied to the bundle:
1) Customer Name 2) Manufacturer's Name 3) Vendor Code 4) Purchase Order No and SPI W.O No 5) Quantum and Weight
6) BHEL Material Code 7) Item Description

The bolts, nuts and washers shall be supplied in the dull black heat treated condition with residual coating of light oil. Shall be packed in bituminous coated Polythene lined Hessian Cloth/Bag.

7. **INSPECTION AND CERTIFICATION:**
All the finished components shall be visually and dimensionally inspected as per sampling plan. All the test results shall be documented and maintained. Products to be inspected at works & test certificates (in English) shall be submitted with the following details counter signed by BHEL/BHEL Authorized Inspection agency as indicated in the PO. Manufacturers Test certificate shall contain the following:

1. Purchase Order No. (BHEL), TDC No, Specification and Grade.
2. Dimensional reports for each product.
3. Forming process
4. Chemistry including incidental elements on the finished product.
5. HT details of materials temperature, soaking time, ROH/ROC medium etc.
6. Mechanical test result report.
7. MPI, Micro examination and decarburization test report with the reference & acceptance standard.

8. **AUDITS AT BHEL:**
BHEL reserve the right to reject any item found to be not meeting the requirements during check tests or during subsequent processing at BHEL.

PREPARED BY	NANTHINI.J / QA	J. Nanthini 19/04/2012				
	HARITHA.C / QA					
REVIEWED BY	KALYANARAMAN.V / QA	19/4/12	19/4/12	19.04.12	19/4/12	
	RAVI.N / QC					
	SUNDARAMOORTHY.P / LAB					
	ARUNACHALAM / ENGINEERING					
	SANKARARAJAN.S / MM					
APPROVED BY	EASWARAN.R / QC	19/4/12				
	RAVIKUMAR.V / QA					