



**BEML LIMITED**  
**BANGALORE**  
**R & D CENTER**

Doc No.	GR/TD/1480
Date	07/11/2019
Rev. No	1
Page	1/15

---

**Procurement Technical Specification  
Of Forgings for DMRC Metro Cars**

---

	Name	Date	Signature
Approved By	Sudharshan M	07.11.2019	
Reviewed By	Dhananjaya B	06.11.2019	
Prepared By	Jayanth C	06.11.2019	



	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	3/15

## Table of Contents

1. Introduction.....	5
1.1. General .....	5
1.2. Definitions and Abbreviations.....	5
1.3. Climatic Conditions .....	6
1.4. Defining of unclear aspects.....	6
1.5. Responsibility of Supplier.....	6
2. Standards.....	6
3. Scope of Supply.....	6
3.1. General .....	6
3.2. Submission of Documents .....	6
3.3. Submission of Macro etched sample .....	7
3.4. Submission of one no. sample Forgings for First Article Inspection.....	7
3.5. Quality Assurance Program .....	7
3.5.1. General .....	7
3.5.2. Quality assurance plan .....	8
4. Technical Requirements.....	8
4.1. General .....	8
4.2. Workmanship and finish.....	8
4.3. Forging Manufacture .....	8
4.4. Test Bars .....	9
4.5. Heat Treatment .....	9
4.6. Soundness .....	9
4.7. Dimensions .....	9
4.8. Macro structure .....	9
4.9. Micro Structure.....	10
4.10. Inclusion Rating .....	10
4.11. Grain Size .....	10
4.12. Grain Flow.....	10
4.13. Machining .....	10
4.14. Painting.....	10

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	4/15

4.15.First Article Inspection (FAI).....	11
4.16.Repair of Forgings .....	11
4.17.Packing .....	11
5. Inspection & Testing.....	11
5.1. General .....	11
5.2. Raw Material Inspection.....	12
5.2.1. Visual Inspection.....	12
5.2.2. Chemical Composition .....	12
5.2.3. Macro Structure .....	12
5.3. Forging Inspection .....	13
5.3.1. Visual Inspection.....	13
5.3.2. Dimensional Inspection.....	13
5.4. Mechanical tests .....	13
5.4.1. Tensile Test .....	13
5.4.2. Hardness Test .....	13
5.4.3. Bend Test .....	13
5.5. Micro Structure.....	13
5.6. Inclusion Rating .....	14
5.7. Grain Size .....	14
5.8. Grain flow.....	14
5.9. Ultra Sonic Examination.....	14
5.10.Paint Coating Thickness .....	14
6. Marking.....	14
7. Submittals with Technical offer.....	15

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	5/15

## 1. Introduction

### 1.1. General

This document specifies the requirements for manufacture, inspection during manufacture, testing and supply of Forgings to be supplied for Delhi Metro Rail Corporation Limited (DMRC) metro car project.

BEML shall carry out all required works and activities as Contractor for DMRC metro cars project while the supplier shall be responsible for all works required in this PTS with regard to Forgings and shall be responsible for supporting the BEML activities as contractor for DMRC metro car Project.

Presently DMRC has 4 Car Train set running at Delhi. To enhance the passenger carrying capacity, DMRC intends to convert the existing 4 Car Train set to 6 or 8 Car Train set by adding intermediate M & T Cars.

The configuration of train formation is as follows.

- DT-M-M-DT - (existing for 4 Car formation)
- DT-M-T-M-M-DT - (proposed for 6 Car formation)
- DT-M-T-M-T-M-M-DT - (proposed for 8 Car formation)

DT : Driving Trailer Car, M : Motor Car, T : Trailer Car

### 1.2. Definitions and Abbreviations

The following definitions and abbreviations are applicable to the PTS.

- “DMRC” means the Employer for the Mass Rapid Transport System (MRTS)
- “DMRC’s Representative” mean such persons appointed by DMRC to act as Engineer for the purpose of the MRTS
- “BEML” means the Contractor for procuring the Forgings for DMRC metro cars.
- “Supplier” means the Supplier for supplying Forgings to BEML for DMRC.

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	6/15

- “PTS” means BEML’s Procurement Technical Specification.

### 1.3. Climatic Conditions

The Metro Car has to operate reliably and safely under various climatic conditions specified in the relevant ERTS & ERGS of that metro car project.

### 1.4. Defining of unclear aspects

If any term or clause is not described or not clear in the specification, Supplier shall discuss those with Design Team in BEML, prior to making a contract, to confirm their definitions.

After making a contract, Supplier shall follow the definition and opinions of Design Team in BEML

### 1.5. Responsibility of Supplier

Supplier shall have the responsibility for manufacture and defined performance testing with regard to the supply of Forgings.

## 2. Standards

Test and inspection standard applicable for the Forgings shall conform to the standards as per the applicable drawing.

## 3. Scope of Supply

### 3.1. General

The supplier shall supply Forgings in conformance to this PTS, purchase order requirements and the Applicable drawings.

### 3.2. Submission of Documents

The supplier shall submit the following documents conforming to the applicable drawing/standards/specifications/PTS along with every batch of supplies.

- Dimensional check sheets for all forgings.

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	7/15

- Material test certificates for each cast & heat treatment batch.
  - ✓ Chemical composition
  - ✓ Mechanical Properties
  - ✓ Micro Structure
  - ✓ Inclusion Rating
  - ✓ Grain size
  - ✓ Macro etched test report
  - ✓ Ultrasonic test report
- Heat treatment record along with time temperature graph

### **3.3. Submission of Macro etched sample**

One No. forging in the heat treated condition shall be subjected to Macro etching and the etched sample shall be submitted for review and approval.

### **3.4. Submission of one no. sample Forgings for First Article Inspection**

The supplier shall supply one no. free sample forging in the machined / semi machined condition as per relevant drawing for First Article Inspection. BEML may decide to conduct destructive tests on the forging. After obtaining approval from BEML only, mass production has to be taken up.

### **3.5. Quality Assurance Program**

#### **3.5.1. General**

The supplier shall hold ISO 9001:2015 certification and shall manufacture the product accordingly. The supplier shall submit a copy of ISO 9001:2015 certification along with the offer. The supplier shall monitor and control the Quality systems as per ISO 9001:2015 guidelines. BEML and/or DMRC/his representative may periodically conduct compliance audits of the supplier's Quality management system.

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	8/15

### 3.5.2. Quality assurance plan

The supplier shall develop and submit a Quality assurance plan (QAP) to BEML for review and approval based on ISO 9001:2015 guidelines.

## 4. Technical Requirements

### 4.1. General

The material grade in respect of chemical composition, heat treatment, microstructure and mechanical properties shall be as stipulated in the drawing and applicable national/ international standards. The Supplier shall submit the reports for the above along with the Forgings supplies.

The material shall be made from ingot having at least four times the cross- sectional area of the products. The forgings shall be supplied in the normalized condition.

### 4.2. Workmanship and finish

All Forgings shall be made to conform to the dimensions on drawings supplied along with the purchase order. The Forgings shall be free from injurious defects that will adversely affect machining or utility of the Forgings.

In the event of any Forgings proving defective from foundry causes in the course of preparation, machining or erection, such a Forgings may be rejected notwithstanding any previous certification of satisfactory testing and/or inspection.

### 4.3. Forging Manufacture

Closed Die forging process shall be adopted for manufacture of the forging. Billets, blooms, slabs and bars for forgings shall be manufactured from killed steel made by open-hearth, electric, basic oxygen, combination of these processes, or any other suitable method which will meet the requirements of the standard. Sufficient discard shall be made from each ingot to secure freedom from piping and undue segregation.

The heating of the raw material shall be carried out in a furnace with temperature control to minimize scaling and decarburization. Best forging practices shall be adopted to produce forgings free from harmful surface discontinuities, roughness, excess scale, fins, and indications of overheating or other injurious discontinuities and to produce the



	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	9/15

desired grain flow. The forgings shall be supplied in the normalized condition.

#### **4.4. Test Bars**

Test bars shall be separately forged from the same raw material used for manufacture of the forgings. The percentage reduction given to the forged test bars shall not be greater than the minimum amount of reduction given for the forging itself. The test bars shall be heat treated along with the forgings.

#### **4.5. Heat Treatment**

The Forging along with the test bars shall be heat treated(normalised) in properly constructed furnace, having adequate means of temperature control, which shall permit the whole of the forging being uniformly heated to necessary temperature. All forgings shall be suitably heat treated as per the requirements of the applicable drawings and corresponding material standard. The Supplier shall maintain time-temperature records for the heat treatment carried out and submit the same.

#### **4.6. Soundness**

Sufficient discard shall be taken from each ingot to ensure freedom from pipe and undue segregation. Unless otherwise specified, the forgings shall be uniform in quality and shall be free from any cracks, flakes, laps, rough jagged and imperfect edges and any other surface imperfections. The Forgings shall be free from injurious defects that will adversely affect machining or utility of the Forgings.

#### **4.7. Dimensions**

Finished dimensions of the forgings shall be as specified on the drawings. The rough forgings shall have sufficient stock to permit satisfactory finishing. The forging tolerances shall conform to IS:3469.

#### **4.8. Macro structure**

The macrostructure on the raw material billet shall be determined for first Article. The macrostructure shall be determined by hot acid etching in accordance with I.S.11371. The macrostructure of the steel on the etched transverse sections, when examined shall

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	10/15

be free from harmful shrinkage porosity, blow holes, laminations, cracks, non-metallic inclusions, cavities, dendrites etc., The etched surface shall be equal to or better than S-3, R-3 and C-3 plates of ASTM E 381.

#### **4.9. Micro Structure**

Microstructure shall show a homogeneous structure of equiaxed ferrite-pearlite grains and shall be free from segregation of constituents and inclusions.

#### **4.10. Inclusion Rating**

Non-Metallic inclusions (types A, B, C & D) of the forgings shall not be worse than severity level 2 (both thick and thin series).

#### **4.11. Grain Size**

The grain size of the forgings shall be in the range of ASTM grain size no. 5 to 8.

#### **4.12. Grain Flow**

The macro structure of the forging shall not show any coarse randomly oriented dendritic structure. The flow lines shall follow the contour of the forging.

#### **4.13. Machining**

Machining as per the drawing requirement shall be carried out. Care shall be taken to ensure that the tolerances as specified in the drawing are achieved. Dimensional inspection report shall be submitted along with the Forgings. The supplier shall apply rust preventive coating on machined surfaces.

Machined Forging shall be measured for dimensions on a 3-axis Co-ordinate Measuring Machine (CMM) and the report shall be submitted.

#### **4.14. Painting**

The Forgings shall be shot blasted to SA 2 ½ & primer painted with grey colour epoxy primer to Gr. EP1119 & Thinner 024 of M/s. KCC Paints, with DFT 40-80 microns.

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	11/15

**Note:**

The primer painted forgings after finish machining shall be finish painted with colour NCS 8500N to Gr. UT 5119 & Thinner 037U of M/s. KCC Paints, with DFT 40-80 microns. The total DFT (primer + finish) of paint shall be 80-160 microns.

#### **4.15. First Article Inspection (FAI)**

The sample machined/Semi machined Forging submitted by the Supplier before mass production shall be subjected to First Article Inspection by BEML and/or customer/their representative. BEML may decide to conduct destructive tests on the Forging. Only, after clearance from BEML, mass production shall be taken up. Forgings shall be offered to BEML representative(s) for inspection before dispatch for pilot / proto lot.

#### **4.16. Repair of Forgings**

Repair of forgings by welding is not permitted. Only grinding to remove surface discontinuities is permitted.

#### **4.17. Packing**

The supplier shall apply rust preventive coating on machined surfaces and any tapped holes etc. The tapped holes shall be plugged with dummy plugs after application of rust preventive coating.

The supplier shall provide proper packing to avoid transit damages during shipment of the Forgings.

### **5. Inspection & Testing**

#### **5.1. General**

The Supplier shall perform all tests in accordance with the Standards specified in the drawing, related material standard and purchase order. BEML and/or DMRC Representative have the right to witness any of these tests at any stage of test progress.

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	12/15

Sl No.	Tests	First Article Inspection	Series Production	Frequency of Testing
<b>1</b>	<b>Raw Material Inspection</b>			
a	Visual Inspection	√	√	100%
b	Chemical Composition	√	√	Each Cast
c	Macro Structure	√	-	FAI
<b>2</b>	<b>Forging Inspection</b>			
a	Visual Inspection	√	√	100%
b	Dimensional Inspection	√	√	100%
c	Tensile Properties	√	√	One sample per each cast & heat treatment batch
d	Hardness	√	√	
e	Bend Test	√	√	
f	Micro Structure	√	√	
g	Inclusion Rating	√	√	
h	Grain Size	√	√	FAI
i	Grain Flow	√	-	
j	Ultrasonic Testing	√	√	100%
k	Paint Coating Thickness	√	√	100%

## 5.2. Raw Material Inspection

### 5.2.1. Visual Inspection

The raw material used for producing the mono-link forging shall be free from any cracks, flakes, laps, rough jagged and imperfect edges and any other injurious surface imperfections.

### 5.2.2. Chemical Composition

The supplier shall carry out product analysis on a bar stock sample of each lot and product analysis on a test piece or a Forging representing each forge as per the material standards mentioned in the drawings and shall submit test reports.

### 5.2.3. Macro Structure

The macrostructure on the raw material billet shall be determined for first Article. The macrostructure shall be determined by hot acid etching in accordance with I.S.11371. The macrostructure shall conform to clause 4.8.

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	13/15

### **5.3. Forging Inspection**

#### **5.3.1. Visual Inspection**

Every forging, irrespective of lot size shall be examined visually for surface defects and irregularities. The Forgings shall be free from cracks, laps, earns, folds, bursts and any other defect that would impair the utility of the Forgings.

#### **5.3.2. Dimensional Inspection**

The dimensions shall be measured on every forging as per drawing and dimensional Inspection report shall be submitted along with the Forgings.

### **5.4. Mechanical tests**

The hardness test, tensile test, impact test and any other test as per the requirements of the applicable drawings and corresponding material standards shall be carried out by the Supplier on the test bars either separately from or attached to the Forgings to which they refer and heat treated along with the Forgings. Reports shall be submitted along with the Forging supplies.

#### **5.4.1. Tensile Test**

The tensile test shall be carried out in accordance with IS:1608

#### **5.4.2. Hardness Test**

Hardness on each forging shall be determined in accordance with IS:1500. Hardness shall be reported for 100% of the forgings.

#### **5.4.3. Bend Test**

Bend test shall be carried out in accordance with IS 1599:1985.

### **5.5. Micro Structure**

Microstructure on samples from forging or from test bar conforming to clause 4.4 shall be examined under a metallurgical microscope at a magnification of 100X and the structure shall conform to clause 4.9. Microstructure shall be reported for each cast and

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	14/15

each heat treatment batch.

## 5.6. Inclusion Rating

Non-Metallic inclusions (types A, B, C & D) shall be determined as per IS: 4163 on samples from the forgings or from test bar conforming to clause 4.4 and the results shall conform to clause 4.10. The test shall be carried out for each cast and each heat treatment batch.

## 5.7. Grain Size

The grain size on samples from the forgings or from test bar conforming to clause 4.4, shall be measured in accordance with ASTM E112 and shall comply to clause 4.11. Grain size test shall be carried out for each cast and each heat treatment batch.

## 5.8. Grain flow

For First Article Inspection (FAI), one forging shall be sectioned. The section shall be ground and subjected to hot acid etching in accordance with IS:11371, to reveal flow lines. The Supplier shall submit the macro etched sample along with the supplies. The macro structure and grain flow shall conform to clause 4.12.

## 5.9. Ultra Sonic Examination

Ultrasonic examination of the forgings shall be carried out in accordance with ASTM A388. The acceptance criteria shall be Level BR or DA for longitudinal wave examination and level S for shear wave examination as specified in ASTM A788.

## 5.10. Paint Coating Thickness

The paint coating thickness on all painted forgings shall be measured using a paint coating thickness gauge and shall conform to clause 4.14.

## 6. Marking

Each Forging shall be legibly marked with the following details for traceability as indicated in the drawing. If not mentioned, supplier shall obtain the concurrence from Design Team in BEML:

	<b>Procurement Technical Specification of Forgings for DMRC Metro Cars</b>	Doc No.	GR/TD/1480
		Date	07/11/2019
		Rev. No	1
		Page	15/15

- a) The number or identification mark by which it is possible to trace the forge and the heat- treatment batch from which it was made
- b) The serial no. of the Forging
- c) The month & year of manufacture and
- d) The manufacturer's name or trade-mark

## 7. Submittals with Technical offer

The following requisites should be fulfilled by the suppliers:

1. Complete Technical offer for manufacturing of forging.
2. Clause by Clause comments of this PTS.
3. Supplier shall submit complete details of their earlier experience in the manufacturing, machining, inspection & painting of similar forgings.
4. BEML representative have the right to witness the facilities before placing the order.
5. Supplier shall provide presentation on the process to be adopted in the manufacturing of forgings.