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**5.0 MANUFACTURE:**

**A) Raw material (Ingot/Bloom):**

- Gear & pinion blanks shall be manufactured from forging quality steel made according to DIN3990 part 5 or by open hearth, electric, duplex, basic oxygen or a combination of these processes.
- Steel used for ingots shall be fully killed and homogeneous. The steel shall also be subjected to secondary refining involving vacuum degassing.
- Forging supplier to ensure availability of above mentioned steel making facilities with raw material (ingot/bloom) supplier as selected by it. Also, forging supplier shall ensure that the process route (steel melting furnace, secondary refining, vacuum degassing & any other process) followed during manufacturing of raw material (ingot/bloom), shall be mentioned in mill TC provided by steel maker.

**Note:** The manufacturer shall give a certificate to the effect that the initial bar stock has been made from ingot having at least four times cross- sectional area. Source of manufacture of bloom / bar stock must be mentioned in the certificate. Also certificate for secondary refining – vacuum degassing of the steel should be submitted by the supplier.

**B) Quality of ingot/bloom:**

- Ingots shall be adequately cropped so as to be free from pipe, segregation and other harmful defects.
- The discard from top and bottom of the ingot must not be less than 15% of the weight of balance of ingot. The material shall be fine grained in order to obtain correct grain size, as called for in clause 13 of this specification, after forging and heat treatment.
- The forgings shall not be manufactured from continuously cast blooms / billets / bars.

**C) Reduction ratio:**

- The minimum reduction ratio from the minimum section of the ingot to maximum section of the round bloom / billet / bar shall be 4:1 and the reduction ratio in height by upset forging from round bloom /billet / bar to blank stage for gear wheel & pinion blanks shall be minimum 4:1.

**Note:** Details of product, details of manufacture including method of forging & forging ratios (in compliance of clause 5.(vii) of this specification) with stage wise sketches, dimensions and forging reduction ratios of the intermediate stages, stage wise inspection plans shall be submitted by the supplier at the time of his offer and shall achieve the same in actual gear/pinion blank forgings. The dimensions and forging reduction ratios, along with photographs of the intermediate & final stages of the actual forgings, shall be submitted along with each consignment. BHEL can witness the manufacturing process compliance as per the requirements of drawing & specification at any stage of manufacturing at supplier's works.

**D) Method of forging:**

- The pinion blanks shall be forged by the method of upset forging.
- The gear wheel forgings shall be made by close die forging by process of upset forging, followed by peripheral forging under a power hammer or press. The forging and rolling process shall be performed in such a manner that the central axis of the bloom coincides with the axis of the gear wheel.





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## Note for Conditioning of blooms:

- i) During processing, the blooms shall be conditioned to remove injurious surface defects, provided the depth of conditioning does not exceed 1mm for every 15mm of concerned dimension, up to a maximum depth of 20mm and provided that the width of the conditioning is at least four times its greatest depth. The maximum depth of conditioning on two parallel sides at opposite locations shall not exceeds one & half times the maximum allowed for one side. The transition between conditional & non conditional areas shall be gradual. All heavy swarf and/or slag shall be removed. After removal of surface defects from the blooms, magnetic particle testing & ultrasonic examination may be carried out on all the blooms to ensure freedom from surface defects & internal defects respectively.

## 6.0 FREEDOM FROM DEFECTS:

The forging shall be free from defects, such as cracks, fold, flakes, seams, segregations, non metallic inclusions and other injurious defects which may affect the utility of the forging. The internal material shall be homogeneous.

No welding shall be permitted on the forged blanks.

## 7.0 CHEMICAL COMPOSITION:

- 7.1 The material TC for chemical composition & mechanical properties shall have reference of specification DIN17210 Gr. 17CrNiMo6 as shown in annexure-I sl. no. 12.

- 7.2 The ladle analysis of the steel and permissible variation in the composition of the forgings (material grade 17CrNiMo6 to DIN17210) shall be as follows:-

| Element    | Composition |           | Permissible deviation in melt analysis |
|------------|-------------|-----------|--|
|            | % Minimum   | % Maximum |  |
| Carbon     | 0.15        | 0.20      | ±0.02                                  |
| Silicon    | -           | 0.40      | ±0.03                                  |
| Manganese  | 0.40        | 0.60      | ±0.04                                  |
| Nickel     | 1.40        | 1.70      | ±0.05                                  |
| Chromium   | 1.50        | 1.80      | ±0.05                                  |
| Molybdenum | 0.25        | 0.35      | ±0.04                                  |
| Sulphur    | -           | 0.035     | ±0.005                                 |
| Phosphorus | -           | 0.035     | ±0.005                                 |

**Note:** If several product analyses are to be carried out, the deviations shown by an element within one cast shall be either only above the upper limit or below the lower limit of the range specified for the cast analysis.

## 8.0 HEAT TREATMENT:

Forgings shall be homogenised at 900 - 930 ° C.

Forgings shall be normalised at 900 to 1000 ° C and air-cooled.


Tempered / sub-critical annealed at 650 to 700 ° C. The soaking time shall be given according to ruling section/thickness of forged blanks.

Test pieces shall also be heat-treated as mentioned above along with forgings they represent.

## 9.0 TEST SAMPLES WITH CONSIGNMENT:

- i) 4 nos. separately forged longitudinal test samples (18±1 mm dia and 610 mm long) per heat & heat treatment batch (for each batch size of max. 50 nos. gear blanks/200 nos. pinion blanks or part thereof), shall be provided for testing at BHEL along with the forgings. The supplied test samples to be machined from duly forged test bar, having similar reduction ratio, heat and heat treatment as the forging it represents.

- ii) In case forgings of same heat & heat treatment batch are supplied in different consignment, the test samples shall be supplied along with 1<sup>st</sup> consignment.

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**Notes:** 1) The supplier should ensure that the test samples supplied shall be of same heat as the gear/pinion blank forgings they represent and heat treated along with the forgings as per clause 8.0 of this specification. The supplied test samples shall be duly stamped with supplier's name, heat no., heat treatment batch no. & PO no.

2) Refer clause no. 13.2.3 for the requirement of test sample with consignment for macro-etch test.

**10.0 HARDNESS AS RECEIVED:**

The forgings when tested in accordance with IS: 1500 shall show a hardness value of 179 - 229 HB.

**11.0 RESPONSE TO HEAT TREATMENT:**

18mm dia. bar machined to 16mm bar for tensile testing and 18mm square for impact test. After machining the following heat treatment shall be followed:-

Samples after heating to carburizing temperature and single quench heat treatment, as detailed below shall show the mechanical properties given in clause 12 of this specification. The heat treatment cycle to be adopted on test bar is as per the requirements mentioned in DIN-17210.

|                                  |   |
|----------------------------------|---|
| <b>Blank Carburising</b>         | : 880-980° C (For sample sizes up to 25mm, 1-1½ hrs)<br>(Heating to carburizing temperature in the absence of carburizing atmosphere) |
| <b>Single Quench Temperature</b> | : 830-870° C (For sample sizes up to 25mm, 1-1½hrs)   |
| <b>Quenching Agent</b>           | : Oil (IOCL make Servo Quench-11) (At normal room temperature)  |
| <b>Tempering temperature</b>     | : 150 - 200° C (For sample sizes up to 25mm, 1-1½ hrs)  |

**Notes:** 1) In the test samples submitted by the supplier for testing at BHEL as per clause 9.0 (in the condition as mentioned in clause 8.0), the heat treatment as per clause 11.0 will be done in BHEL.

2) The heat treatment cycle followed by supplier during internal testing of test sample shall be furnished along with consignment.

**12.0 MECHANICAL PROPERTIES:**

The material TC for chemical composition & mechanical properties shall have reference of specification DIN17210 Gr. 17CrNiMo6 as shown in annexure-I sl. no. 12.

Test pieces after heat treatment as detailed in clause 11 of this specification, shall show the properties given below:

**12.1 Tensile:**

When tested to IS: 1608, test pieces shall show the following values:

|  |                     |
|--|---------------------|
| i) Tensile strength                      | : 1080 - 1320 Mpa   |
| ii) Yield Stress                         | : 785 Mpa (Minimum) |
| iii) Elongation on 5.65 √So gauge length | : 8% (Minimum)      |
| iv) Reduction in area                    | : 35% (Minimum)     |



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Izod impact value : 27 Joules (Minimum)

i) In case of supply of any gear/pinion blank as per different drawing (which involves manufacturing of different die) by the regular supplier for the first time, one extra gear/pinion blank forging for macroetch test shall be supplied to BHEL along with first consignment.





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**16.0 PACKING & MARKING:**

Forgings shall be suitably packed to prevent damage during transit.

Each forged blank shall be stamped with: TM 98256 / Melt / Heat No.

Each package shall bear the following information:

DIN 17210 - Steel forgings for case hardening.

BHEL Order No.

Supplier's Name

Consignment / Identification No.

Weight

**17.0 REJECTION & REPLACEMENT:**

In the event of any forging proving defective in the course of preparation, machining, heat treatment, testing, such forging shall be rejected, notwithstanding any previous certification of satisfactory testing and / or inspection.

The supplier shall replace the rejected forgings at his own cost and the rejected forgings shall be sent back to the supplier after fulfilling the commercial terms & conditions.

**18.0 REFERRED STANDARDS (Latest publications Including Amendments):**

1) IS: 1500      2) IS: 1608      3) IS:1598      6) ASTM E 45      7) ASTM E 112  
8) ASTM E 381      9) AA 0850118

**19.0 REFERENCES:**

1) DIN – 17210, Gr. 17CrNi Mo6.

2) RDSO specification MP.0.2800.19 (REV.01).



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ANNEXURE-I

RECOMMENDED TEST CERTIFICATE FORMAT FOR FORGINGS

SUPPLIER'S NAME & ADDRESS  
TEST CERTIFICATE FOR FORGINGS

1. Customer:

2. TC No. & Date:

3. PO No.:

4. Process of Melting Ingot:

5. Deoxidisation Process:

6. Forging Method (Open/closed die):

7. BHEL's Reference for Approval of Bloom

8. Discard: Top % ; Bottom %

9. Reduction Ratio } Ingot to Bloom  
Bloom to Blank

10. Heat / Melt No.

11. Heat treatment batch No.:

12. Spec. No.: DIN17210 Gr. 17CrNiMo6

13. Test Bar Size & Nos.

14. Supplier of the Ingot/ billet/ Bloom & TC reference

15. FORGINGS COVERED BY TEST CERTIFICATE:

| Heat no. | Heat treatment batch no. | Quantity | Sl. No. of gear/pinion blanks |
|----------|--------------------------|----------|-------------------------------|
|          |                          |          |                               |

16. GAS CONTENT (PPM):

17. CHEMICAL COMPOSITION (PERCENT)

| Gas           | H <sub>2</sub> | O <sub>2</sub> | N <sub>2</sub> | C | Si | Mn | S | P | Cr | Mo | Ni | Other trace elements like Al, Cu | Radioactive Contamination |
|---------------|----------------|----------------|----------------|---|----|----|---|---|----|----|----|----------------------------------|---------------------------|
| As Per Specn. | Min.           |                |                |   |    |    |   |   |    |    |    |                                  |                           |
|               | Max.           |                |                |   |    |    |   |   |    |    |    |                                  |                           |
| Actual Values |                |                |                |   |    |    |   |   |    |    |    |                                  |                           |

18. HEAT TREATMENT  
(To be accompanied by Recorder Chart)

| Condition | Heating Rate, °C/hr. | Temp., °C | Soaking Time, Hrs. | Cooling Rate, °C/hr. | Cooling Medium |
|-----------|----------------------|-----------|--------------------|----------------------|----------------|
|           |                      |           |                    |                      |                |

19. MECHANICAL PROPERTIES

|               | T.S.<br>N/mm <sup>2</sup> | Y.S.<br>0.5/0.2%<br>Proof<br>N/mm <sup>2</sup> | % Elongation<br>5.65 √So<br>GL | % R.A.<br>Min. | Hardne<br>ss<br>BHN<br>(Min.3<br>Values) | Impact<br>Value<br>Joules | Bend Test     |                 |        |
|---------------|---------------------------|--|--------------------------------|----------------|--|---------------------------|---------------|-----------------|--------|
|               |                           |  |                                |                |  |                           | Angle of bend | Dia. of mandrel | Result |
| As Per Specn. | Min.                      |  |                                |                |  |                           |               |                 |        |
|               | Max.                      |  |                                |                |  |                           |               |                 |        |
| Actual Values |                           |  |                                |                |  |                           |               |                 |        |

20. SURFACE FINISH  
(when called for in the order/drg.)

21. DIMENSIONAL INSPECTION

22. NON-DESTRUCTIVE TESTS

| Nature of Test                         | Acceptance level | Instrument used | Range | Result | Any other detail |
|--|------------------|-----------------|-------|--------|------------------|
| Ultrasonic                             |                  |                 |       |        |                  |
| Radiographic                           |                  |                 |       |        |                  |
| Dye Penetrant/<br>Magnetic<br>Particle |                  |                 |       |        |                  |

23. METALLOGRAPHIC EXAMINATION  
(To be conducted if called for and photo micrographs to be attached along with a report)

| Location of Sample | Etchant used | Magnification    | Constituent observed | Relative % |
|--------------------|--------------|------------------|----------------------|------------|
|                    |              |                  |                      |            |
| Microstructure     | Macroetch    | Inclusion Rating |                      |            |

24. OTHER TESTS IF ANY (MICROSCOPIC, SULPHUR PRINTS, ETC)

25. IDENTIFICATION OF FORGINGS AS PER PURCHASE SPEC.

We hereby certify that the items mentioned above have been tested and inspected in our presence and are found to be in accordance with drawings, specifications and purchase order.

SIGNATURE, NAME & SEAL OF THE  
INSPECTING OFFICER  
DATE:

SIGNATURE, NAME & SEAL OF THE  
CHIEF OF QUALITY CONTROL/  
CHIEF METALLURGIST OF THE SUPPLIER  
DATE:

INSTRUCTIONS

a) Details of all heat treatment processes carried out should be furnished sequentially in 17.

b) Test certificates are to be furnished as per Purchase order and specification, in A4 size preferably in transparent paper.

c) All the entries including signature should be in black colour ink.

d) If testing is done by outside agencies, the original TCs shall be furnished.


e) The actual TC may run into more than one A4 size paper, if needed, to facilitate filling up of details.

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## Annexure-II

### Checklist for Supplier for Submission of Documents with offer

The documents to be submitted by the suppliers along with their offer against each enquiry are as mentioned below. Duly filled checklist as per annexure-II is to be submitted by the suppliers along with their offer.

| Sl. No. | Documents to be submitted  | Submitted (Yes/No) |
|---------|--|--------------------|
| 1.      | Confirmation of the compliance of this specification. In case of any deviation, the same should be clearly mentioned (shown in bold under the heading "Deviation from the specification") in the offer.  |                    |
| 2.      | Details of product (gear/pinion blank forgings) analysis (as per clause 5 note (ii) of this specification).  |                    |
| 3.      | Details of manufacture including method of forging & forging ratios (in compliance of clause 5.(vii) of TM98256) with stage wise dimensional sketches (as per clause 5 note (ii) of this specification). |                    |
| 4.      | Forging supplier's stage wise inspection plans (as per clause 5 note (ii) of this specification).  |                    |
| 5.      | Dimensional sketch of gear/pinion blank forging section showing grain flow pattern (in compliance of clause 13.2.2 of this specification).   |                    |
| 6.      | Confirmation for supply of one additional gear/pinion blank for macroetch test (as per the requirement of clause 13.2.2 of this specification).  |                    |
| 7.      | Details of PO no. & date in which one additional gear/pinion blank has been supplied by the supplier for macro-etch test at BHEL.  |                    |
| 8.      | Supplier to furnish capacity of heat treatment furnace w.r.t quantity of enquired gear/pinion blank forgings that can be heat treated in single batch.   |                    |

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### Annexure-III

#### Checklist for Supplier for Submission of Documents with each consignment

The documents to be submitted by the suppliers with each consignment are as mentioned below. Duly filled checklist as per annexure-III is to be submitted by the suppliers along with each consignment.

| Sl. No. | Documents to be submitted   | Submitted (Yes/No) |
|---------|---|--------------------|
| 1.      | Three copies of test certificates including original copy as per the requirements mentioned in clause 15.0 of this specification. Test certificates in original shall be on testing agency/supplier letter head with seal, signature & date. The material TC for chemical composition & mechanical properties shall have reference of specification DIN17210 Gr. 17CrNiMo6 as shown in annexure-I sl. no. 12. |                    |
| 2.      | Heat treatment chart (showing heat treatment cycle adopted for forgings) from graphical recorder of furnace with heat no. & batch number. The chart shall be duly signed with supplier's seal, signature & date.  |                    |
| 3.      | Details of heat treatment cycle as per clause 11 adopted on test bar for mechanical tests.  |                    |
| 4.      | Coloured photograph showing microstructure & grain size of the forgings.  |                    |
| 5.      | Dimensions, reduction ratio calculation sheet and photographs of the intermediate & final stages of the actual forgings (as per clause 5.0 note(ii) of this specification).   |                    |
| 6.      | Copy of original invoice of procurement of raw material for forgings or supporting documents, giving information about ingot size & establishing the quantity of steel procured is in correlation with no. of blank forgings ordered to the supplier.   |                    |
| 7.      | The test certificate from the steel mill for the raw material procured by the forging supplier, indicating process route as per the requirements mentioned in clause 5.(iii) of this specification.   |                    |
| 8.      | In case new/regular vendor has carried out internal macroetch test, the coloured photograph of the macroetched section shall also accompany the consignment for reference.  |                    |
| 9.      | Ultrasonic test report (in original) duly signed & stamped by Level-II inspector.   |                    |