QUALITY ASSURANCE
QWI NO: TDC:RTF:307 Rev.06 Dtd.28.02.2017
Amendment to Quality Work Instruction (QWI)   **Amendment No: A2** **Date: 04.09.2018**
Title: *TDC FOR Impeller Components (Made of Forged Steel)*

Details of Amendment	
Clause No	**Amended As**
2.1	Chemical composition revisited as follows: For Clause 2.1 Chemical composition of 'Al' to be read as Min.0.020.

Prepared By (QA)	**Reviewed and Approved By**
Rakesh kr Madhu(SE/QA)	K C Gandhi Parimalam (DGM/QA)

QUALITY ASSURANCE
QWI NO: TDC:RTF:307 Rev.05 Dtd.27.07.2015
Amendment to Quality Work Instruction (QWI)
Amendment No: A1 **Date:16.11.2016**
Title: *TDC FOR Impeller Ring, Hub disc, Supporting Body & FAN Forgings.P355NJ/QH of EN 10222-4, WSTE 500/P500 NH of 1.8937,P460NH(1.8935)and SA 592 Gr.F of ASTM A 592*

Details of Amendment	
Clause No	**Amended As**
Note:2	Note.2 revisited as follows: For P355NH/QH, hot tensile test shall be done at 150°C instead of 300°C .For FD & PA Fan application and counter weight for all axial FANs hot tensile test not applicable.

Prepared By (QA)	Reviewed By	Approved By
16.11.2016	16/11/16	16/11/2016
Rakesh kr Madhu(SE/QA)	R. Arunachalam (SM/QA)	C. Srinivasan (DGM/QA)

Technical Delivery Conditions

For

Impeller Components

(Made of Forged Steel)

Prepared by	Reviewed by	Reviewed by	Signature of Reviewer	Approved by
RK Madhu	ENGG (Fans)	A Vaithinathan	20/3/17	03/03/2017
	QC (Proc)	R Kesavan		
	MPLG	P Annamalai		
	PUR	T Valluvan		(Head/QA)
	QA	R Arunachalam		

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1.0 SCOPE

1.1 This TDC specifies the requirements for the supply of proof machined condition fan forgings.

1.2 This TDC is in line with EN 10222-4 for P355NH/QH, AM004 REV'C'(DIN 17103)for 1.8937 of WSTE 500/P500NH, DIN EN 10028-3 for 1.8935 of P460NH, ASTM A 592 for SA 592 Gr F additional requirements are incorporated in This TDC.

1.3 In accordance with the dimensions in the drawing of the purchaser, the forgings (load ring, welded-in hub etc.) shall be supplied in the pre-machined condition.

1.4 Applicable standards value alone to be taken for Material properties.

2.0 MATERIAL: WSTE 500/ P500 NH, 1.8937- AM004 REV C(DIN 17103)

2.1 CHEMICAL COMPOSITION

As-received condition: Products having a thickness of >100mm are quenched and tempered whereas products with a thickness of ≤100 mm are normalized.

Chemical composition of the steels as determined by ladle analysis

Steel grade	Percentage by mass														
Material Designation	Material number	C ≤	SI	Mn	P ≤	S ≤	N ≤	Al total[1] ≤	Cr ≤	Cu ≤	Mo ≤	Ni ≤	Nb ≤	V ≤	Nb+v ≤
StE 500 WStE 500 TStE 500	1.8907 1.8937 1.8917	0.21	0.10 To 0.60	1.00 To 1.70	0.035 0.035 0.030	0.030 0.030 0.025	0.020	0.02	0.30	0.20 (1)	0.10 (2)	1.00 (3)	0.05	0.22	0.22
	1.If copper is added as an alloying element, the maximum molybdenum content by mass may be 0,70%. 2. For thickness exceeding 150mm, the maximum molybdenum content shall be 0,15%. 3. For thickness exceeding 150mm, the maximum nickel content shall be 1,20%														

2.2 Mechanical properties: As per below Table

To be determined on longitudinal (L) or transverse (T) specimens at room temperature, except for the impact energy, which shall be determined at -20°C.

For forged and rolled stock	**Definitive Product Thickness (d) in [mm]**				
	≤ 50	**51 - 100**	**101- 150**	**151- 375**	**376– 600**
Tensile strength R_m [N/mm^2]	610-780		540-740		
Yield point R_{eH} min. [N/mm^2]	480	450	430	410	390
Fracture elongation L min. in (%) T	17 16			16 15	
Impact energy min. on ISO-V L specimens at -20°C [J=Nm] mean value from Three (3) individual specimens T	39 21				

3.0 MATERIAL: **P355NH/QH, EN 10222-4**

As-received condition: Normalized (N) or Quenched(QT)

Chemical composition: by cast analysis, Weight in (%), as per below table

3.1 CHEMICAL COMPOSITION

Ruling thickness	C Max.	Mn	Si	P Max.	S Max.	Al # Total		N Max.	Cr Max.	Cu Max.	Mo Max.	Nb Max.	Ni Max	V Max	Nb+ V
d ≤ 400 (in mm)	0.20	0.90-1.65	0.10-0.50	0.025	0.015	Min. 0.02	Max. 0.06	0.02	0.30	0.20	0.08	0.05	0.30	0.10	0.12

Minimum Al level need not apply when Nb, V and Ti are used to control N content.

3.2 Mechanical properties:

To be determined on longitudinal (L) or transverse (T) specimens at room temperature, except for the impact energy, which shall be determined at –20°C.

For forged stock	Definitive Product Thickness (d) in [mm]					
	$t_r \leq 16$	16<d≤35	35<d≤70	70<d≤100	100<d≤250	250<d≤400
Tensile strength R_m [N/mm²]	490 to 630			470 to 630		
Yield point R_{eH} min. [N/mm²]	355	355	335	315	295	275
Fracture elongation **L** min. in [%] **T**	23 21			21 19		
Impact energy min. **L** on ISO-V specimens at -20°C **T** [J=Nm] mean value from Three (3) individual specimens	40 -				47 27	

*For Rod & Rounds (d) =Diameter
*For Rectangular bar (d) = thickness

Note 1. For product thickness d ≤100 mm heat treatment condition is normalized while for
d ≤400 it is quenched and tempered.

Note 2. For P355NH/QH, hot tensile test shall be done at 150°C.Yield strength shall be as per

Material standard. For FD & PA Fan application and counter weight for all axial Fans hot tensile test not applicable.

4.0 MATERIAL: P460NH (1.8935) DIN EN 10028-3

4.1Chemical composition: As per below table

C Max.	Si Max.	Mn	Ni Max.	P Max.	S Max.	Cr Max.	Mo Max.	V Max.	N Max.	Nb Max.	Ti Max.	Al Max.	Cu Max.	Nb+Ti +V Max
0.20	0.6	1.1-1.7	0.8	0.025	0.010	0.30	0.1	0.20	0.025	0.05	0.03	0.02	0.70	0.22

4.2 Mechanical properties:

To be determined on longitudinal (L) or transverse (T) specimens at room temperature, except for the impact energy, which shall be determined at -20°C.

For forged stock	**Definitive Product Thickness (d) in [mm]**			
	d ≤ 16	16<d≤60		60<d≤100
Tensile strength R_m [N/mm²]	560 to 730	570 to 720		540-710
Yield point R_{eH} min. [N/mm²]	d ≤ 16	16< d≤ 40	40< d ≤60	60< d≤100
	460	445	430	400
Fracture elongation min. in [%]	17			
Impact energy (J) min. on ISO-V specimens at -20°C [J=Nm] mean value from Three (3) individual specimens	L: 45 T: 30			

5.0 MATERIAL: SA 592 Gr F, ASTM A 592

5.1 CHEMICAL COMPOSITION

5.1.1 The chemistry shall be as per respective specification.

5.2 MECHANICAL PROPERTIES

5.2.1 Tensile strength, yield strength, % elongation at room temperature shall be carried out melt wise / heat treatment batch wise.

5.2.1.1 Tensile test results shall meet the specification requirements. Tensile requirements as per below table –

	Product thickness (t≤65 mm)	Product thickness (65<t≤100mm)
Tensile strength, min [N/mm²]	795 to 930	725 to 930
Yield strength, min [N/mm²]	690	620
Elongation min, %	18	17
Reduction of area, min, %	45	40

Note: The maximum thickness of forging under this specification (ASTM A592) shall be 100mm for grade F.

5.2.2 Hot tensile test shall be carried out melt wise for impeller ring forgings only.

5.2.2.1 In case of SA 592 Gr. F, Hot tensile test shall be done at 400°C. Yield strength shall be 560 Mpa upto 65mm and 510 Mpa above 65mm.

5.2.2.2 Impact test: This test shall be conducted on 3 ISO V specimen melt wise / HT batch wise.

5.2.2.3 In case of SA 592 Gr F impact test shall be conducted at 0°C. Lateral expansion opposite to notch shall not be less than 0.38 mm. Impact energy in joules shall be also be reported.

5.2.2.4 The ring for the mechanical testing shall be extended to accommodate the test specimen as per ASTM A 668.

6.0 FORGINGS

6.1 The forging shall be made from fully killed steel of fine grain practice. Suggested minimum forging reduction ratio of 4:1 from starting piece to finished forgings must be ensured.

6.2 Weld repairs are prohibited.

6.3 Impeller ring forgings may also be produced by ring rolling process.

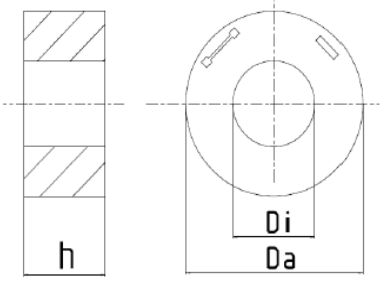
6.4 The acceptance of our purchase order shall constitute your agreement to the following conditions:

- Chemical composition (ladle analysis) for each heat.
- Tensile strength, yield point, and fracture elongation shall be determined on at least one (1) specimen from each lot. Depending on the size of the part to be examined, removal of the specimens shall be in horizontal (L) or transverse (T) direction.
- The impact energy shall be determined on three (3) ISO-V impact specimens at –20°C from each lot to be delivered.

The mean value derived from three (3) tests shall constitute the test result. The lowest individual value may not be below 2/3 of the required minimum value. Specimens may be taken in longitudinal or transverse direction.

7.0 Definitive Thickness of Product and Sampling.

The definitive product thickness for fixing of the mechanical properties is determined by means of below table. For this purpose, the component dimensions indicated in the purchase order have to be used.
Regarding sampling and preparation of specimens please observe the below table.

Component	Definitive Product Thickness d	Positions of specimens
Load ring Support ring Welding hub	for $h > \frac{Da - Di}{2}$ $d = 1{,}5 \cdot \frac{Da - Di}{2}$ otherwise $d = 1{,}5 \cdot h$	
The specimen sections are to be taken from the extensions of the forgings which have a diameter and cross section which corresponds to the respective forging at the time of heat treatment. The specimen must not be separated before final termination of the heat treatment. The positions of the specimens are as shown above.		

8.0 NON-DESTRUCTIVE TESTING

8.1 All the forgings shall be ultrasonically tested radially and axially as per ASTM A 388.

8.2 ACCEPTANCE CRITERIA

Forgings Length	Radial Scanning	Axial Scanning
≤ 1 meter	3 mm equivalent reflector size by DGS method	3 mm equivalent reflector size by DGS method
> 1 meter	3 mm equivalent reflector size by DGS method	One or more discontinuities resulting in complete loss of back wall reflection to 10% of the full scale height not attributing to geometric configuration when tested by back wall echo method are not acceptable.

9.0 MARKING AND PRESERVATION

9.1 All forgings shall be marked with specification, melt No. and supplier's emblem/Name legibly by hard stamping on the material surface. This area shall be framed with white paint for easy identification.

9.2 Forgings shall be applied with rust preventive coating.

10.0 INSPECTION & TEST CERTIFICATE

10.1 The items manufactured within India, shall be subjected to inspection by BHEL or authorized agency.

10.2 The supplier shall furnish the test certificate in English as per EN 10204. It shall contain the following information.

a) PO No.
b) Specification and grade
c) Size, No. and weight
d) Melt No.
e) Heat treatment particulars
f) Chemical composition - melt wise
g) Mechanical properties
h) TDC No.

11.0 Record of Revisions

Rev No.	Clause Revised	Revision made	Date
00	---	original issue	27.06.94
01	1.1	StE500 V spec added hub disc & body forgings included	25.12.94
	1.3	New clause added	
	2.0,2.1,2.4,3.1	Editorial Correction	
	2.2.1	Forgings reduction ratio included	
	2.3.2	Clause revised	
	2.4.2	Impeller ring hot tensile strength empowered	
	4.2	ASTM A 668 is included in place of ASTM 370	
	7.2	Packing requirements in case of Imported forgings added	
02	---	Change of name of WstE355V to P355NH/QH is	26.12.00
	2.3 & 3.2	and Corresponding Standard is included. Deleted & other clause numbers altered accordingly.	
	1.2,2.1.1,2.3.2, 2.3.3	clause modified	
03	---	Totally modified	02.05.02
04	2.0 & 5.4	1. Required contents from TFN: 359, Rev:02, Dt: 17.02.2014 added.	05.08.14
	3.0	2. For material P355NH/QH as per EN10222-4 chemical & mechanical properties added.	
	4.2.1.1	3. Tensile requirements for SA592 Gr.F-Table added.	
	6.2	4. NDT acceptance criteria revised.	
05	---	1. Header changed.	27.07.15
	---	2. P460NH (1.8935) added.	
06	2.0	Chemical composition revised and definitive thickness of product & sampling added as per AM004 Rev C.	28.02.17