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FORGED COMPONENTS-PRECIPITATION HARDENING STAINLESS STEEL (FULLY HARDENED / OVER AGED 550)

1.0.0 GENERAL:

This specification governs the quality requirements of precipitation hardening corrosion resisting stainless steel forged components.

2.0.0 COMPLIANCE TO NATIONAL STANDARD:

There is no Indian standard for this grade of steel. The steel grade in general complies with BS-2S-143 of British Aerospace standards.

3.0.0 APPLICATION:

These components are required for Wearing rings, Packing rings, balancing drum restriction bushes, Balance drum liners etc; of Boiler feed pumps, Booster Pumps and Condensate extraction pumps.

4.0.0 CONDITION OF DELIVERY:

4.1.0 The components shall be manufactured from forgings.

4.2.0 All components shall be supplied in 'Fully Hardened-(FH)' or 'Over Aged 550-(OA)' condition as indicated in the variant table.

4.3.0 All the components shall be supplied in machined condition as per the dimensions and tolerances indicated in the variant table.

5.0.0 HEAT TREATMENT:

The recommended heat treatment for 'Fully Hardened-(FH)' components and 'Over Aged 550-(OA)' components shall be as follows.

5.1.0 For Fully Hardened (FH) components:

5.1.1 Solution treatment:

The rough forging shall be heated slowly to 1050°C±10°C. After a period of not less than 30 minutes the material shall be removed from the furnace and allowed to cool in still air to a temperature not exceeding 30°C.

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5.1.2 Primary Hardening:

- The component shall be heated to 850°C and held at that temperature for 2 hours.
- The component shall then be removed from the furnace and allowed to cool in still air to a temperature not exceeding 30°C.
- It is advisable at this stage to allow the component to stand for a period of 24 hours at a temperature 20°C or below. This procedure may be assisted by placing the component in cold water.

5.1.3 Precipitation Hardening:

- The component shall be heated to 450°C and held at that temperature for 4 hours.
- The component shall then be removed from the furnace and allow to cool in still air.

5.2.0 **For Over Aged 550 (OA) components:**

5.2.1 Solution treatment:

- The component shall be suspended vertically in the furnace hanging freely from one end. The furnace temperature shall not exceed 400°C.
- Where the furnace temperature lies above 200°C, one hour shall elapse before commencing the heat treatment operation in order to allow temperature equalization of furnace and component.
- The temperature shall be raised to 650°C±20°C and held at this temperature for a minimum period of one hour.
- The temperature shall be raised to 850°C±20°C and again held at this temperature for a minimum period of one hour.
- The temperature shall then be raised to 1000°C-1050°C and held at this temperature for a minimum period of one hour plus 30 minutes minimum for every inch of section thickness at maximum diameter of the component.
- The component shall be removed from the furnace and cooled in still air while being suspended vertically.

5.2.2 Primary Hardening:

- The component shall be suspended vertically in the furnace hanging freely from one end. The furnace temperature shall not exceed 400°C.
- Where the furnace temperature lies above 200°C, one hour shall elapse before commencing the heat treatment operation in order to allow temperature equalization of furnace and component.

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- The temperature shall then be raised to 750°C±10°C and held at this temperature for a minimum period of 2 hours.
- The component shall be removed from the furnace and cooled in still air while being held vertically in a cooling pit to a temperature not exceeding 30°C.
- After primary hardening, it is advisable that the component is allowed to remain at temperature 30°C or below for a period of 24 hours prior to the precipitation hardening operation.

5.2.3 Precipitation Hardening:

- The component shall be suspended vertically in the furnace hanging freely from one end. The furnace temperature shall not exceed 400°C.
- Where the furnace temperature lies above 200°C, one hour shall elapse before commencing the heat treatment operation in order to allow temperature equalization of furnace and component.
- The temperature shall then be raised to 540°C±10°C and held at this temperature for a minimum period of 2 hours.
- The component shall be removed from the furnace and cooled in still air while being suspended vertically in a cooling pit.

6.0.0 FREEDOM FROM DEFECTS:

6.1.0 Foundry defects like blow holes, shrinkage cavities, porosity, non-metallic inclusions etc., appearing on the surface to be opened out, smoothly ground, provided the depth of any of these defects when so ground does not exceed 0.3mm.

6.2.0 Cracks are not permitted on any surface of the components.

6.3.0 Weld repairs shall not be accepted.

7.0.0 CHEMICAL COMPOSITION: (for Fully Hardened and Over Aged 550)

Element		C	Si	Mn	Cr	Ni	Cu	Mo	Nb	P	S
Melt analysis	Min.	--	--	--	13.2	5.0	1.2	1.2	0.20	--	--
	Max.	0.07	0.60	1.00	14.7	6.0	2.0	2.0	0.70	0.030	0.035

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8.0.0 **MECHANICAL PROPERTIES:**

8.1.0 **For Fully Hardened (FH) components:**

8.1.1 All the machined components shall be tested for hardness after complete heat treatment cycle mentioned at cl.no.5.1.0 and the hardness values shall be 363-401 BHN max. and test certificate to be furnished with the details as mentioned in clause no.12.2.0

8.1.2 The test samples after complete heat treatment cycle mentioned at clause no. 5.1.0 shall confirm to the following mechanical properties.

Tensile strength, N/mm²	0.2% proof stress N/mm², Minimum	% Elongation L=5d Minimum	Hardness BHN
1130 - 1330	1030	5	363-401

8.2.0 **For Over Aged 550 (OA) components:**

8.2.1 All the machined components shall be tested for hardness after complete heat treatment cycle mentioned at cl.no.5.2.0 and the hardness values shall be 280 - 330 BHN max. and test certificate to be furnished with the details as mentioned in clause no.12.2.0.

8.2.2 The test samples after complete heat treatment cycle mentioned at clause no. 5.2.0 shall confirm to the following mechanical properties.

Tensile strength, N/mm²	0.2% proof stress N/mm², Minimum	% Elongation L=5d Minimum	Hardness BHN
920-1080	780	15	280-330

9.0.0 **TEST SAMPLES:**

9.1.0 Minimum two samples per melt shall be poured, identified and stamped by the inspector. These shall be taken for complete heat treatment cycle indicated at cl.no.5.10 or 5.2.0 as per the condition indicated in variant table.

9.2.0 Chemical analysis shall be carried out and Mechanical properties as per cl.no. 8.1.0 or 8.2.0 shall be tested on one sample. One sample for each melt shall be supplied along with each consignment of the components for testing at BHEL works.

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10.0.0 **NON DESTRUCTIVE TESTS:**

10.1.0 Following NDTs shall be carried out on 100% quantity of the components, after heat treatment and machining.

10.2.0 Ultrasonic Test:

100% area of the component shall be tested ultrasonically as per BHEL standard AA0850118 and the acceptance norm shall be category-2 of above standard.

10.3.0 Dye penetrant Test:

Dye penetrant Test shall be done on 100% area of the component as per BHEL standard AA0850131 and the acceptance norm shall be AA0850130.

11.0.0 **INSPECTION AT SUPPLIER'S WORKS:**

11.1.0 All the components shall be inspected at supplier's works by BHEL inspector or BHEL appointed Third Party Inspection Agency (TPIA). The inspector shall have free entry and access to all areas where manufacture of the ordered castings/forgings is carried out. All reasonable facilities shall be provided to him including labour where necessary. The inspector shall be given sufficient advance intimation to witness/inspect the components at various stages during manufacture.

11.2.0 Supplier shall prepare their internal manufacturing quality plan which shall include the activities mentioned at cl.no.11.3.0 and shall offer the same for review by the inspector.

11.3.0 Scope of inspection at supplier's works shall include the following:

a) Identification and stamping of test samples for each melt.
b) Review of chemical analysis report.
c) Witness of Mechanical tests on the test samples.
d) Witness of Hardness test on all the components.
e) Dimensional inspection of all the components.
f) Review of heat treatment charts.

12.0.0 **TEST CERTIFICATES:**

12.1.0 Supplier shall furnish 2 copies of test certificates of Chemical analysis, Hardness test on the machined components, Mechanical properties on test samples fully heat treated as per cl.no.5.0.0 and Non-destructive Tests.

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12.2.0 Following information shall be included in all the test certificates.

1. BHEL Drawing no, Specification No: FP50595
2. BHEL Order No. & Item no.
3. BHEL Material code & Item description
4. Supplier's name
5. Melt No. or Heat No.
6. Casting / Forging Sl.no. per melt

13.0.0 MARKING AND PACKING:

13.1.0 Following details shall be printed with non-erasable ink or engraved on each of the machined component.

a. 12 digit Material code, Specn No. & Drawing no.
b. Melt No. / Heat no.
c. BHEL / BHEL approved Inspector's Stamp (may be punched on the un-tolerated surfaces.

13.2.0 Each finish machined component shall be wrapped with polythene paper and packed individually in a hard board box. Following details shall be marked on each box. Cases. All such boxes shall be packed in a suitable packing case, which shall be marked with the BHEL PO no., Item nos. & Quantities.

a. BHEL Purchase order no. & Item No.
b. 12 digit Material code, Specn No. & Drawing no.
c. Name of the Supplier.

14.0.0 REJECTION AND REPLACEMENT:

The final decision regarding acceptance or rejection rests with BHEL, if the component is not complying with this specification at any time during further operations on the components. The supplier shall replace the rejected component at his own cost.

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15.0.0 VARIANT TABLE:

All dimensions are in mm; Tolerances: OD (+) 1.0; ID (-) 1.0; L (+) 2.0

VAR. NO.	SIZE OD/ID x L	HT CYCLE FH / OA	PUMP TYPE	APPLICATION	WT. Kg.	FINAL M/C DRG.	MATL CODE
01	229/203 x 27	FH	FK6D30	Imp. wearing ring, eye, 1st stage	1.9	31804015555	FP9750632010
02	202/176 x 27	FH	"	Imp. wearing ring, eye inter stage	1.7	31804015556	FP9750632028
03	148/124 x 25	FH	"	Imp. wearing ring neck all stage	1.0	31804015557	FP9750632036
04	250/216 x 23	OA	"	Suction guide packing ring	2.3	31804315391	FP9750632044
05	220/190 x 23	OA	"	Ring section packing ring	1.8	31804215409	FP9750632052
06	163/138 x 16	OA	"	Diffuser wearing ring	0.8	31804215410	FP9750632060
07	230/186 x 148	FH	"	Balance drum bush	16.6	31804415469	FP9750632079
08	224/200 x 33	FH	FA1B56	Impeller wearing ring	2.1	31891215422	FP9750632087
09	265/236 x 36	FH	FK4E36	Imp. wearing ring, eye, all stages	3.2	31804015558	FP9750632095
10	228/202 x 28	FH	"	Imp. wearing ring, eye kicker stage	2.0	31804015559	FP9750632109
11	180/155 x 42	FH	"	Imp. wearing ring neck all stages	2.2	31804015560	FP9750632117
12	285/249 x 31	OA	"	Ring section wearing ring	3.7	31804215411	FP9750632125
13	196/165 x 31	OA	"	Diffuser wearing ring, Inter & Last	2.2	31804215412	FP9750632133
14	245/211 x 24	OA	"	Outlet guide wearing ring	2.3	31804215413	FP9750632141
15	276/223 x 184	FH	"	Balance drum bush	30.0	31804415470	FP9750632150
16	324/296 x 49	FH	FA1B75	Impeller wearing ring	5.2	31891215421	FP9750632168
17	344/316 x 49	OA	"	Casing wearing ring	5.6	31891115418	FP9750632176
18	236/189 x 34	OA	EN7H32	Bell mouth & 1st stg NDE W. ring	4.2	31812515398	FP9750632184
19	214/191 x 36	OA	"	1st & inter casings & spool piece wearing ring, for SS impellers	2.1	31812515399	FP9750632192
20	270/244 x 26	FH	EN5J40	Imp. wearing ring, 1st stage	2.2	31811215555	FP9750632206
21	264/238 x 26	FH	"	Imp. wearing ring inter stage	2.1	31811215556	FP9750632214
22	284/260 x 40	OA	"	BM & 1st Casing NDE wear ring	3.2	31811115394	FP9750632222
23	278/254 x 40	OA	"	1st&Inter stage casing wear ring DE	3.2	31811115395	FP9750632230
24	285/261 x 29	FH	EN8J40	Imp. wearing ring, 1st stage	2.4	31811215557	FP9750632249
25	258/232 x 39	FH	"	Imp. wearing ring inter stage	3.1	31811215558	FP9750632257

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VAR. NO.	SIZE OD/ID x L	HT CYCLE FH / OA	PUMP TYPE	APPLICATION	WT. Kg.	FINAL M/C DRG.	MATL CODE
26	298/241 x 41	OA	EN8J40	BM & 1st Casing wearing ring	7.7	31812515400	FP9750632265
27	273/248 x 42	OA	"	Ele-vi, Inter, Del & RM top casing wear ring (1+6+2+1)	3.4	31812515401	FP9750632273
28	255/211 x 24	OA	200KH1/S 150KH1/C	Suction casing wearing ring	3.0	31804315390	FP9750632281
29	255/196 x 25	OA	200KH1/S	Stage casing wearing ring	4.1	31804215407	FP9750632290
30	149/121 x 31	OA	200KH1 200KH1/S	Diffuser sealing ring Diffuser wearing ring	1.5	31804215408 31801315382	FP9750632303
31	319/180 x 165	FH	200KH1/S 150KH1/C 150KH1/CZ	Balance drum liner	69.9	31804415467 31804415468	FP9750632311
32	255/190 x 24	OA	200KH1 150KH1 150KH1/CZ 150KH1/C	Stage body sealing ring; stage casing wearing ring	4.3	31801315381	FP9750632320
33	156/131 x 31	OA	150KH1 150KH1/CZ 150KH1/C	Diffuser sealing ring Diffuser wearing ring	1.4	31801315383	FP9750632338
34	300/243 x 36	FH	MDG405	(LTAA) Casing 1st stg both sides, 2nd&3rd coup side, 4th&5th end side	6.8	21804214961 21804214962 21804214964	FP9750632346
35	234/154 x 44	FH	MDG405	Neck bush suction cover & casing cover	8.6	21804314656 21804214963	FP9750632354
36	310/204 x 38	FH	MDG405	Inter stage bushing 2nd & 4th stage neck, Balancing bushing coup side (split)	12.8	21804214966 21804214967 21804214968	FP9750632362
37	316/204 x 135	FH	MDG405	Inter stage bushing center (split)	48.5	21804214965	FP9750632370
38	262/214 x 130	FH	MDG405	Balancing bushing end side	18.2	21804415064	FP9750632389
39	380/335 x 45	FH	MLC400 x 300H	Casing ring both sides (LTAA) TD	8.9	21891114960 21891114961	FP9750632397
40	430/380 x 52	FH	MLC450 x 350H	Casing ring both sides TD	12.9	21891114964 21891114965	FP9750632400
41	362/293 x 48	FH	144RND-660&800	Casing ring 1st stage	13.3	21812814941	FP9750632419
42	374/304 x 51	FH	144RND-660&800	Casing ring 2nd & over	14.8	21812913003	FP9750632427
43	385/313 x 51	FH	144RND-800 LTAA	Casing ring 2nd & over	15.7	21812913001	FP9750632435
44	340/264 x 42	FH	MDG455	Casing ring 1st stage coup & end sides	11.8	21804214973 21804214974	FP9750632443
45	340/274 x 42	FH	MDG455	Casing ring 2nd&3rd coup side, 4th&5th end side	10.4	21804214975 21804214976	FP9750632451
46	350/212 x 41	FH	MDG455	Inter stage bushing 2nd & 4th neck (split)	19.6	21804214977 21814214978	FP9750632460
47	350/212 x 146	FH	MDG455	Inter stage bushing center (split)	69.8	21804214979	FP9750632478
48	350/214 x 46	FH	MDG455	Balancing bushing coup side (split)	21.9	21804214980	FP9750632486

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VAR. NO.	SIZE OD/ID x L	HT CYCLE FH / OA	PUMP TYPE	APPLICATION	WT. Kg.	FINAL M/C DRG.	MATL CODE
49	280/220 x148	FH	MDG455	Balancing bushing end side	27.2	21804415065	FP9750632494
50	254/194 x 34	FH	MDG346	Casing ring 1st stage coup & end sides	5.6	21804214981 21804214982	FP9750632508
51	254/204 x 36	FH	MDG346	Casing ring 2nd & 3rd coup side Casing ring 4th, 5th & 6th end side	5.1	21804214983 21804214984	FP9750632516
52	180/124 x 46	FH	MDG346	Neck Bush coup & end sides	4.8	21804314659	FP9750632524
53	264/176 x 131	FH	MDG346	Inter stage bushing center (split)	31.3	21804214988	FP9750632532
54	264/176 x 36	FH	MDG346	Inter stage bushing 2nd, 4th & 5th neck Balancing bushing coup side (split)	7.6	21804214985 21804214986 21804214987	FP9750632540
55	254/173 x 141	FH	MDG346	Balancing bush end side	29.8	21804415066	FP9750632559
56	305/187 x 55	FH	MDG405 BARH	Casing ring 1st stage, Coup. & End sides	19.5	21804214971 21804214972	FP9750632567
57	377/246 x 56	FH	MLC 400 (BARH)	Casing ring, Coup.& End sides, TD & MD	28.2	21891114967 21891114968 21891114969 21891114970	FP9750632575
58	310/194 x 12	OA	FK6D30	Spring Disc	4.3	31804215415	FP9750632583
59	396/194 x 12	OA	FK8C36	Spring Disc	8.8	31804215417	FP9750632591
60	478/360 x 12	OA	FK4E36	Spring Disc	7.3	31804215414	FP9750632605
61	555/398 x 16	OA	FK2C45	Spring Disc	14.8	31804215416	FP9750632613
62	212/183 x 28	FH	FRH27	Impeller sealing ring 1st stage eye	2.0	41804014640	FP9750632621
63	185/162 x 28	FH	"	Impeller sealing ring inter stage eye	1.4	41804014639	FP9750632630
64	140/116 x 25	FH	"	Impeller sealing ring 1st&inter stage neck	1.0	41804014641	FP9750632648
65	156/128 x 18	OA	"	Diffuser wearing ring	0.9	41804214665	FP9750632656
66	230/200 x 23	OA	"	Wearing ring inlet stage body	1.9	21804213430	FP9750632664
67	205/174 x 23	OA	"	Wearing ring normal stage body	1.7	21804213429	FP9750632672
68	268/165 x 176	FH	"	Balance drum bush	48.4	21801113433	FP9750632680
69	350/273 x 50	FH	144RND-PV	Casing ring, 1st stage, 660&800	14.8	21812814942	FP9750632699
70	240/170 x 45	FH	MDG455-NSS	Neck bush suction cover & casing cover	8.0	21804314664 21804415068	FP9750632702
71	285/236 x 34	FH	MDG366	Casing ring (2 & 3 stage Coup. Side) (4th, 5th & 6th stage)	5.3	21804214997 21804214998	FP9750632710

VAR. NO.	SIZE OD/ID x L	HT CYCLE FH / OA	PUMP TYPE	APPLICATION	WT. Kg.	FINAL M/C DRG.	MATL CODE
72	294/182 x 32	FH	MDG366	Inter stage bushing 2nd, 4th & 5th stage Neck (split)	10.5	21804214999 21804215001	FP9750632729
73	220/137 x 41	FH	MDG366	Neck bush Coup. side (Suction cover) Neck bush End side (Casing cover)	7.3	21804314662 21804214995	FP9750632737
74	252/174 x 132	FH	MDG366	Balancing bushing (End side)	27	21804415067	FP9750632745
75	294/182 x 134	FH	MDG366	Inter stage bushing center (split)	44.0	21804215000	FP9750632753
76	285/216 x 35	FH	MDG366	Casing Ring,1st stage Coupling & End side	7.5	21804215009 21804215010	FP9750632761
77	294/182 x 39	FH	MDG366	Balancing Bushing Coup. Side (split)	12.8	21804215011	FP9750632770
78	406/354 x 52	FH	MLC450-NSS	Casing ring, Coup.& End sides, TD & MD	12.7	21891114975 21891114976	FP9750632788
79	70/42 x 50	FH	150CJAV	Bushing-Suction cover	0.96	41811316464	FP9750632796
80	245/220 x 25	FH	150CJAV	Bearing Ring	1.79	41811316465	FP9750632800
81	110/75 x 65	FH	150CJAV	Bushing-Discharge cover	1.75	41811316466	FP9750632818
82	105/75 x 40	FH	150CJAV	Stage Bushing	1.33	41811316467	FP9750632826
83	205/185 x 25	FH	150CJAV	Wear Ring-Stage Body	1.20	41811316468	FP9750632834
84	135/90 x 27	OA	EN7J40/ EN8J40	Restriction Bush (Inter and Del Stage)	1.68	31812913781	FP9750632842

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RECORD OF REVISIONS

Rev. No.	Date	Revision Details	Revised By	Approved By
01	08.06.12	Var. Nos. 62 to 68 added.	MSR	BRK
02	21.06.12	Ts, Ys, % EL values revised at 8.2.2	J.N.MANI	M.S.RAM
03	18.10.12	Var. No. 52 application added.	J.N.MANI	M.S.RAM
04	05.03.14	Var. No. 41 & 42, drawing no. corrected. Var. No. 42 & 43, pump type corrected.	J.N.MANI	M.S.RAM
05	04.12.14	Var. no. 69&70 added	ASK	MSR
06	19.01.15	Var. Nos. 71 to 77 added.	SANGEETHA	M.S.RAM
07	17.10.15	Dimn 'L' revised for Var. Nos.15&73. Drg nos. added for Var.Nos.76&77.	M.S.RAM	M.S.RAM
08	28.10.15	Var. Nos. 78 added.	ASK	M.S.RAM
09	10.01.16	Var. Nos. 79 TO 83 added.	ASK	M.S.RAM
10	16.01.16	Var. No. 79 dimension corrected.	ASK	M.S.RAM
11	27.02.17	Dimensions & weights revised for Var nos. used for Split design ring application of MHI pumps.	M.S.RAM	KHRK
12	14.07.18	VARIANT No. 84 ADDED.	PRANAV	M.S.RAM
13	26.11.18	Application and Final-M/c drawings are Corrected for Var. No. 51 & 52 in the variant table.	JNM	M.S.RAM

BHEL-HYD SAP INFORMATION SERVICE