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	PRODUCT STANDARD HYDRO TURBINE ENGINEERING	HT 00259
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<u>PURCHASE SPECIFICATION FOR GUIDE VANE SERVOMOTOR</u> <u>(HYDRAULIC CYLINDER)</u>		

1. SCOPE OF SUPPLY

- 1.1 Oil operated double acting servomotors, each set comprising of 2 modules (1 no. of Module – 1 & 1 no. of Module – 2) as given below. (For total no. of sets to be supplied refer enquiry)
Module-1: Consists of one servomotor with lock as shown in sketch-1(In Guide vane closed position) with cushioning arrangement.
Module-2: Consists of one servomotor without lock as shown in sketch-2 with cushioning arrangement.
(Refer Annexure-I for major design input parameters for specific project & enquiry.)
- 1.2 **Spares:** As per **Annexure-II** for specific project or as specified in the BHEL's enquiry.
- 1.3 Apart from the main servomotor (hydraulic cylinder) the scope of supply broadly includes the following items mounted on the cylinders / servomotors:
- Pipes for opening & closing ports along with blank flanges, hardware & seals, flow control valve for speed adjustment, additional non-return valve along with isolating valve. (Size of inlet / outlet pipe must be so as to limit the flow velocity of oil through it up to 2.5 m/sec.)
 - Lock in module-1 to stop the servomotor in closed position (corresponding to closed position of guide vanes). A sleeve type lock is also to be supplied when servomotor in open position (corresponding to open position of guide vanes)
 - Air release port with plug & Drain port with plug
 - Pointer on piston rod, seals, scale & scale bracket fixing arrangement (only in module-1), limit switches for fully closed position, for lock engaged in closed & open positions.
 - Connecting Link
 - Fork end, fork end pin, lock nuts & self-lubricating bushes on piston rod.
 - Foundation block, mounting strip and leveling screws
 - All other items for specific project & BHEL's enquiry as shown in **Sketch – 1&2.**
- 1.4 **Tools:** Two sets of following tools to be compulsorily supplied
- Allen keys for hexagon socket head screws and spanners of all required sizes.
- 1.5 **Paint:** For touch-up work at site, one litre paint of the same shade is required for each servomotor at the time of dispatch.

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2. DESCRIPTION

- 2.1. Oil operated double acting servomotors (hydraulic cylinders) as shown in the sketch – 1 & 2 enclosed are required to operate guide vane turning mechanism of guide apparatus of a hydro turbine / pump.
- 2.2. Cross section of the servomotors shown in the enclosed sketch – 1 & 2 are for reference only. Vendor to design servomotor based on the oil pressure mentioned in the **Annexure-I** and use materials of construction as specified below.

3. MATERIAL AND STRESS CONSIDERATION OF MAJOR COMPONENTS

S.No.	Description	Material	Stress Consideration / Make / Remarks
3.1	* Piston rod	High tensile steel conforming to IS 5517 Gr40, Ni6,Cr4,Mo3 type H&T or equivalent with hard chrome plating (min. thickness 40µ)	To be designed for buckling load equivalent to full load (at design pressure) of 2 servomotors in case of emergency in the fully drawn out position by <u>Euler's formula</u> with a factor of safety of 5.
3.2	*Cylinder	- Forged steel bar / cylinder to ASTM A350 Gr. LF-6 Class-2 or equivalent. - or - Seamless steel tube to DIN 2391 Part-2 Gr ST52 or equivalent.	- To be designed for design pressure indicated in Annexure-I. - To be designed for end pull equivalent to full load of 2 servomotors in case of emergency (In this case the stress should not exceed 2/3rd of yield strength of the cylinder material) - Cylinder to be checked for bending in the fully drawn out position of piston rod i.e. for servomotor in fully open position

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3.3	*Hardware for joining cylinder to front & rear covers, foundation stud and nut.	High tensile steel as per IS:1367 (Part 3), property class 8.8 (Property class 10.9 and class 12.9 hardware are not acceptable)	- Hardware at each end to be designed for full load (at design pressure) of servomotor in normal working condition and the direct tensile stress^s should not exceed 1000 kg/cm² for property class 8.8 hardware. - In emergency case the hardware must be designed for load of 2 servomotors (in this case the stress should not exceed 2000 kg/cm².)
^s Direct tensile stress = $\frac{0.7854 \times (\text{servomotor bore dia.})^2 \times (\text{Design pressure})}{(\text{No. of bolts}) \times (\text{Root area of each bolt})}$			
3.4	*Front & rear cover	- Fabricated from BQ plate as per IS 2002, Or - Carbon steel casting as per IS:2708 Gr 1, Or - Carbon steel forging as per IS:2004 Class2 (20C8)	- Tapped holes for holding the cylinder should be designed for loads of two servomotors. - The tapped holes depth and material of end cover should be chosen to bear this load.
3.5	Piston	Forged bar as per IS1570 : 40C8 or equivalent	Piston height should be adequate to accommodate piston seal & guide rings.
3.6	Fork end	1.5% Ni-Cr-Mo steel forging to IS 4367 Gr. 40Ni6Cr4Mo3 (H&T) or equivalent	- Threaded connection between fork end & piston rod must be designed for load of two servomotors in emergency condition. - Lifting hole to be provided at top of spherical surface.
3.7	*Connecting Link	- Fabricated from steel plates and forged bars Or 1.5% Mn steel forging or equivalent	Connecting link should be designed for a buckling load equivalent to load of two servomotors under emergency condition (in this case the stress should not exceed 2/3 rd of the yield strength).

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3.8	Piston seals	- Piston seal should be of two piece construction i.e. the sealing / rubbing element and the preload component / energiser. - The material of sealing ring should be polyurethane or any suitable material having low co-efficient of friction and should sustain abrasive wear. - The material of sealing ring and the energizer, shape and construction should be chosen so as to provide sealing for a long time	- Of Simrit/Merkel make or - James Walker U.K. or - Economous, Austria or - Trelleborg or - IDG or - Walter Hunger or - Parker or - Hallite
3.9	Piston guide ring	- The width of guide ring should be widest possible. - The guide ring should be a composite of phenolic resin impregnated into a fine cotton fabric. - It should have high wear resistance. - Good wiping effect. - Long service life	As mentioned above for piston seals
3.10	Piston rod seals at front cover	- Polyurethane / better material - Should have long life and very low co-efficient of friction - Seals to prevent ingress of moisture droplets.	As mentioned above for piston seals

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3.11	Piston rod bush at front end	The bush shall be self-lubricating type. The bush should be of Aluminum bronze with buttons of graphite / PTFE. The bush should be one single piece & should be of sufficient length. These bushes should be collared type having minimum wall thickness of 7.5 mm.	- Oilless of Japan or - Tenmat. or equivalent. Chinese make bushes are not acceptable
3.12	Self-lubricating bushes in connecting link	The bush should be self-lubricating type. The bush should be of bronze with buttons of graphite / PTFE at both end of connecting link. The bush should be one single piece & should be sufficient length. These bushes are to be shrink fitted & locked half & half by grub screws.	As mentioned above at Sl. No. 3.11
3.13	Pivot Pin between fork end & connecting link.	Martensitic Stainless steel bar to IS 6603 Grade 15 Cr 16 Ni 2 or equivalent	To be designed for full load of servomotor and the tensile stress should not exceed $1/3^{rd}$ of the yield point of the material.
3.14	Lock in Module-1 of servomotors for open and closed position	High tensile steel	- Stud type locking arrangement must be provided for closed position of servomotor. - Sleeve type locking arrangement must be provided for open position of servomotor. - Both locks must be designed for 2 times of one servomotor load.

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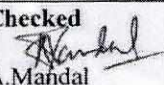
3.15	Flow control valve	Suitable to application	- The sizing of flow control valve in combination with non-return valve should be able to achieve a cushioning time of 0-12 sec. - Make: Hydac, Vickerssperry, Rexroth
3.16	Limit Switches	220 VDC with 2 NO & 2 NC - Hermetically sealed - IP-67 Protection	Make: Schnieder, Telemecanique
3.17	Scale & pointer	Stainless steel with mounting arrangement	Scale & pointer to be provided with module-1 servomotor to indicate the stroke

Note: * Two hydraulic servomotors are connected to one regulating ring. Thus during normal working, servomotor components would be subjected to force of one servomotor. However, there could be certain condition where the * marked components could be subjected to force of 2 servomotors as indicated in the above table.

4. SPECIAL MANUFACTURING PROCESSES TO BE ADOPTED

4.1 Stress relieving of cylinder, piston, piston rod, connecting link and fork

- Cylinder if manufactured from seamless pipe shall be stress relieved after welding with flanges. It shall be subjected to a second stress relieving after rough machining but before final machining.
- Cylinder if machined out of forged bar, shall be subject to stress relieving after machining-off bulk material and leaving small allowance for finish machining and grinding after stress relieving.
- Rod end shall be subject to stress relieving after machining-off bulk material and leaving small allowance for finish machining and grinding after stress relieving.
- Piston shall be subject to stress relieving after machining-off bulk material and leaving small allowance for finish machining and grinding after stress relieving.
- Connecting link and fork shall be subject to stress relieving after welding.

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4.2 Grinding & Honing

Cylinder should be subject to grinding & honing / burnishing to get very good geometrical accuracies and fine finish. This is must for ensuring good performance and long life of servomotors.

4.3 Painting & protection

(The following is to be followed unless specific requirement is given in Annexure-I.)

➤ Priming Paint

- Two coats (DFT 25 micron/coat) of chemical resistant epoxide red oxide Zinc Phosphate priming paint.
- General compliance with national standards: IS: 14506 - 1998: Epoxy red oxide Zinc Phosphate primer, two components.

➤ Finishing Paint (Light grey shade as per IS 5:2007, Table-1, ISC No. 631)

- Two coats (DFT 25 micron/coat) of chemical resistant epoxide finishing paint.
- General compliance with national standards: IS: 14209-1994: Epoxy enamel, two component, glossy.
- The thickness of dried paint film after 4 coats i.e. after 2 coats of primer and 2 coats of finishing paint shall be 100 to 150 micron.

4.4 Alignment accuracy of components

Machining shall be carried out to achieve good geometrical accuracies of concentricity & perpendicularity of moving and stationary components, so as to ensure smooth movement of piston & piston rod. The piston should move smoothly with an oil pressure not exceeding 4 kg/cm².

5. DOCUMENTATION

5.1 Along with offer

- OGA drawing of servomotor showing overall dimensions, material of major components, design pressure, test pressure & pressure at which lock shall be tested.
- List of deviations

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If the vendor is unable to fulfill any requirements mentioned in our purchase specification then a list of deviations is to be prepared by the vendor & and the same should be submitted along with the offer. Otherwise it will be understood that the vendor is meeting all the requirements specified in the spec. and no deviations will be allowed at the time of delivery.

- Filled in check list (Page 13 & 14)

5.2 After placement of order

- QA plan for approval by BHEL / BHEL's customer.
- Detailed OGA drawing of servomotor with overall dimensions, limits/fits, clearances and complete BOM. (with description, material, make, unit weight & quantity).
- Calculations as mentioned below for BHEL's approval.
 - Calculation for hoop stress in the cylinder.
 - Calculation for buckling of piston rod and servo cylinder.
 - Calculation for bending of servo cylinder.
 - Calculation for piston thickness.
 - Calculation for piston rod end thread.
 - Calculation for cylinder flange thickness.
 - Calculation for fork end.
 - Calculation for all major hardware used.
 - Calculation for front and rear cover thickness.
 - Calculation for closed position mechanical lock.
 - Calculation for stresses in self-lubricating bushes.

IMPORTANT

1. *Manufacturing / procurement of components shall commence only after approval of calculations, drawing and QA Plan by BHEL.*
2. *During evaluation of drawing & calculations submitted by the vendor for approval; modifications / additions which are required for satisfactory functioning of the servomotor and which are required in line with this specification, shall be carried out by the vendor without any price repercussion.*

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5.3 At the time of supply of equipment

- 3 copies of O & M manual.
- Test certificates / test reports / inspection records, performance test certificates / guarantee certificates & material TCs.
- Shipping / Packing Lists of the components being supplied.
 - 3 copies to BHEL.
 - 1 copy inside each case / package.

Note: The shipping lists should contain following information for each case /package.

- List of items contained in the case giving drawing / catalogue no., item no. of BOM, description of item and quantity.
- Case number, dimensions of case, and gross weight of case, net weight of items.

6. **GUARANTEE PERIOD**

All the equipment must be guaranteed for trouble free operation, good workmanship for a period of 18 months from the date of commissioning of the equipment or 24 months from the date of dispatch whichever is earlier. Vendor shall undertake to replace any material / components free of cost if found defective in operation during guarantee period.

7. **COMPLETENESS OF EQUIPMENT**

Vendor to give compliance certificate stating that the equipment has been manufactured as per the purchase specification in all respects.

8. **INSPECTION & TESTING**

8.1 Vendor should have the following facilities at his works

- Accumulator / piston pumps for simulating time of opening.
- Facility for stopping piston in mid stroke position and checking for leakage across piston seals under full pressure of oil. The piston should not move when the throttle valve is closed.
- Facility for checking effectiveness of dampening under load.

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8.2 Material test certificates, dimensional reports and reports of NDT of major components like cylinder, front & rear covers, piston, piston rod, mounting plate, fork, connecting link and locks for open & closed condition, etc. are required to be submitted.

8.3 **Hydraulic test for checking soundness**

Front and rear covers and cylinder shall be pressure tested at test pressure for a minimum of 30 minutes to check the soundness. No leakage allowed through any of welds or body.

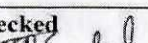
8.4 **Hydraulic test for leakage check**

- When opening / closing chambers are hydraulically tested with oil at test pressure, there should not be any leakage through cylinder joints, opening pipe, connections, and connections of flow control valve.
- Leakage across piston should be checked at design pressure in the following three positions:
 - Fully closed
 - Fully open
 - Mid position (by suitably holding cylinder and piston rod) #

Amount of oil leakage across piston in fully open & fully close position should be less than as listed in the table below:

Cylinder I.D. (mm)	Amount of oil leakage (ml/min.)	Cylinder I.D. (mm)	Amount of oil leakage (ml/min.)	Cylinder I.D. (mm)	Amount of oil leakage (ml/min.)
32	0.06	140	0.9	350	7.6
40	0.09	160	1.5	400	9.4
50	0.15	180	1.9	450	12
63	0.24	200	2.3	500	13.2
80	0.39	220	3	550	16.2
100	0.6	250	3.3	600	19.2
125	0.84	300	4.8		

Leakage across piston in mid position to be recorded in the test certificate for reference.

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8.5 Check for Smoothness of Operation

Stroke servomotor 10 to 15 times for free movement. Free movement of piston and piston rod should be checked by applying oil pressure. The piston / piston rod should move easily with oil pressure of less than 4 Kg/cm².

After successful testing, dismantle the servomotor to check for scouring marks on the cylinder. Re-assemble the servomotor and retest at test pressure for 30 min. Also check the stroke of servomotor between fully open and fully closed position.

8.6 Load test for closed & open position lock (Only on module-1)

Stroke the module-1 of servomotor to closed position and engage the mechanical lock. Now pressurize the opening chamber upto design pressure as given in Annexure-I. Maintain the pressure for 30 minutes. Repeat the same process for testing the mechanical lock (sleeve type) in open position.

8.7 Check for effectiveness of cushioning operation of module-1 (with lock)

This check is to be carried out as follows:

- Fill the opening chamber i.e. space between piston and rear cover with oil.
- Connect the closing chamber of servomotor to a pressure receiver at P1_{cushion}* and stroke the servomotor towards cushioning zone.
- Adjust the opening of cushioning ports (meant for external adjustment of cushioning) by using "flow control valve with throttle & NRV**" so that the time taken for movement of servomotor in the cushioning zone of length L_{cushion}* should be 't'* seconds, in other words this is the time taken for oil trapped in the last L_{cushion}* length between piston and rear cover to escape out through the cushioning port.
- Again, connect the closing chamber of servomotor to a pressure receiver at P2_{cushion}* and stroke the servomotor towards cushioning zone.
- Re-adjust the opening of cushioning ports (meant for external adjustment of cushioning) by using "flow control valve with throttle & NRV**" so that the time taken for movement of servomotor in the cushioning zone of length L_{cushion}* should be same as 't'* seconds.

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8.8 Check for effectiveness of cushioning operation of module-2 (without lock)

This check is to be carried out as follows:

- Fill the opening chamber i.e. space between piston cum piston rod and front cover.
- Connect the closing chamber of servomotor to a pressure receiver at $P_{1\text{cushion}}^*$ and stroke the servomotor towards cushioning zone.
- Adjust the opening of cushioning ports (meant for external adjustment of cushioning) by using "flow control valve with throttle & NRV**" so that the time taken for movement of servomotor in the cushioning zone of length L_{cushion}^* should be 't'* seconds, in other words this is the time taken for oil trapped in the last L_{cushion}^* length between piston and rear cover to escape out through the cushioning port.
- Again, connect the closing chamber of servomotor to a pressure receiver at $P_{2\text{cushion}}^*$ and stroke the servomotor towards cushioning zone.
- Re-adjust the opening of cushioning ports (meant for external adjustment of cushioning) by using "flow control valve with throttle & NRV**" so that the time taken for movement of servomotor in the cushioning zone of length L_{cushion}^* should be same as 't'* seconds.

* For values of cushioning oil pressure " $P_{1\text{cushion}}$ " and " $P_{2\text{cushion}}$ ", Cushioning length " L_{cushion} " and cushioning time 't', refer Annexure-I.

** The size of the flow control valve with throttle & NRV should be so selected that its opening is not more than 75% when pressure " $P_{2\text{cushion}}$ " is applied.

Rev. No.	Date of Rev.	Remarks	Approved		
01	30.01.16	Reviewed	J.S.Hanspal, AGM (HOD)-HTE		
02	03.02.17	Sl.no.29 updated in checklist	Prepared	Checked	Date of issue 23.06.2015
03	28.06.17	Clause no. – 1.4, 3, 4.4, 8.4, 8.7, 8.8 & Annexure – I revised.	Anuj Raizada Dy. Mgr. – HTE	A.Mandal AGM – HTE	
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	PRODUCT STANDARD	HT 00259
	HYDRO TURBINE ENGINEERING	Rev. 03
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<u>PURCHASE SPECIFICATION FOR GUIDE VANE SERVOMOTOR</u> <u>(HYDRAULIC CYLINDER)</u>		

CHECK LIST

(To be filled in by the vendor and submitted along with the offer)

Sl. No.	Description	Vendor's comments
1	Scope of supply shall be in line with clause – 1 of spec.	Yes / No
2	Material of piston rod	
3	Thickness of chrome plating on piston rod (40µ min.)	
4	Material of cylinder	
5	Material of hardware for joining cylinder with covers (See clause – 3.3)	
6	Material of front & rear covers	
7	Material of piston	
8	Material of fork end & connecting link	
9	Make & material of piston seals	
10	Make & material of piston guide ring	
11	Make & material of piston rod seals in front cover	
12	Material of self-lubricating bush for connecting link and other bushes	
13	Material of mechanical lock	
14	Size of oil inlet and outlet pipe	
15	Bore & stroke of servomotor	
16	Design pressure of servomotor	
17	Test pressure of servomotor	
18	Test pressure for mechanical lock	
19	OGA drawing of servomotor attached along with the offer and it contains overall dimensions, material of major components, design pressure, test pressure & pressure at which lock shall be tested	Yes / No
20	Painting shall be done as per	Annexed sheet / clause – 4.3
21	Inspection & testing shall be done as per clause – 8	Yes / No
22	TCs shall be submitted as per clause – 5.3	Yes / No

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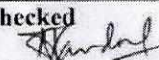
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PURCHASE SPECIFICATION FOR GUIDE VANE SERVOMOTOR (HYDRAULIC CYLINDER)		Page 14 of 14

23	Calculations shall be submitted after award of contract	Yes / No
24	O&M manual and shipping lists shall be submitted	Yes / No
25	Documents are attached in line with clause – 5	Yes / No
26	QAP shall be submitted for approval after award of contract	Yes / No
27	Deviations (if any) shall be listed in a separate sheet	
28	Manufacturing shall start only after approval of drg., calculations and QAP	Agreed / Not agreed
29	During evaluation of drawing & calculations submitted by the vendor for approval; modifications / additions which are required for satisfactory functioning of the servomotor and which are required in line with this specification, shall be carried out by the vendor without any price repercussion.	Agreed / Not agreed
30	Size of oil pipe connection is selected such that the velocity of oil flow inside it is 2 to 2.5 m/sec during full stroke of servomotor in duration as given in Annexure-I	Yes / No
31	The bushes are to be shrink fitted & locked half & half by grub screws.	Yes / No

BHEL's enquiry no. & date _____

Name of the project _____

Signature and stamp of vendor _____

Rev. No.	Date of Rev.	Remarks	Approved		
01	30.01.16	Reviewed	J.S.Hanspal, AGM (HOD)-HTE 		
02	03.02.17	Sl.no.29 updated in checklist	Prepared 	Checked 	Date of issue 23.06.2015
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