



Design Appraisal Document

Lloyd's Register EMEA
Rotterdam Technical Support Office
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Date
07 February 2023

Please quote this reference number on all future communications
RTS-ENG-220109-230206-230311-MPB

Machinery General Design Appraisal

Client & Manufacturer : ESCO POWER S.r.L
Subject : Gearbox for parallel (hybrid) propulsion
Type : PHT300A, PHT420A, PHT700A, PHT700B and PHT900A
G.A. Registration No. : ROT.20.M.028 (E1)

Valid until 29 April 2026

This Design Appraisal Document (D.A.D) cancels and replaces the previous D.A.D. No. RTS-ENG-203803, Issue No. 1, dated 30 April 2021.

- The documents, as listed in paragraph 1 of the Appendix, have been examined for compliance with:-
Rules and Regulations for the Classification of Ships, July 2022, **Part 5, Chapters 5 and 6**
and will be assigned an appraisal status, as indicated, in accordance with the following conditions and comments:-

2. Machinery Details:-

Type of Gears.....	PHT300A	PHT420A	PHT700A	PHT700B	PHT900A
Prime mover.....	Diesel Engine	idem	idem	idem	Idem
Prime mover power rating (max. input torque) ..	1500 Nm	1800 Nm	3100 Nm	4875 Nm	4875 Nm
Propulsion power rating (max. output torque) ...	3000 Nm	3100 nm	3100 Nm	4875 Nm	4875 Nm
Input Coupling Type	High Flexible	idem	idem	idem	idem
Overall Reduction ratio PTO/PTI (input to main) .:	1.468	1.468	1.468	1.468	1.468
	1.697	1.697	1.697	1.697	1.697
Prime mover type, Power Take In (PTI)	E-motor	idem	idem	idem	idem
Input Coupling Type (PTI)	High Flexible	idem	idem	idem	idem
Max. power rating Power Take IN (PTI), kW / rpm:	276 / 1800	idem	idem	idem	idem
	310 / 2200				

FINAL ACCEPTANCE OF ACTUAL ITEM(S) DEPEND(S) ON SATISFACTORY SURVEY AND TESTING

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3. Shafting Details:-

Position	Outer Dia. (mm)	Inner Dia. (mm)	Material	Min. UTS (N/mm ²)
Main Direct-Drive Shaft	70 / 90 / 120	-- / -- / 45	Case Hardened Alloy Steel	950
Intermediate Gear Shaft	70 / 72	44 / 40	Carbon Steel	560
Input / Pinion Shaft (PTI)	55 / 85 / 70	-- / -- / 60	Carbon Steel	560
Loose Coupling Hub (PTI)	--	--	Carbon Steel	560
Loose Coupling Flange	478 / 134	410 / 80	Carbon Steel	560

4. Gear Details:-

Gear type	Helical Spur Gear		
Gear Mesh Ratio(s)	1.1316 (43/38) ;	1.2973 (48/37) ;	1.5 (51/34)
ISO 1328 – Quality Grade	5		
Tooth flank roughness (CLA)	6		
Tooth root roughness (CLA)	20		
Tip Relief	No		
End Relief	No		

5. Gear Elements:-

Gear Elements	No. of teeth	Surface Treatment	Material	Min. UTS (N/mm ²)
Pinion	38	Carburised	CrNiMo CH	950
Wheel	43	Carburised	CrNiMo CH	950
Pinion	37	Carburised	CrNiMo CH	950
Wheel	48	Carburised	CrNiMo CH	950
Pinion	34	Carburised	CrNiMo CH	950
Wheel	51	Carburised	CrNiMo CH	950

6. Conditions of Approval:-

6.1 Final approval of the proposed shaft sizes is subject to satisfactory vibration analysis to be carried out in accordance with the Rules. The following calculations to be submitted for appraisal (in PHT Operation):- AQS
Manufacturer

a) Torsional Vibration Analysis (for following modes; diesel mode, electric mode and boost mode)

6.1.1 Half-range torsional stress in main shaft ((drw.no. 20150800) is not to exceed 27.3 MPa at 70 mm dia. AQS
Manufacturer

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|-------|---|---------------------|
| 6.1.2 | Proposed diameter of 70 mm at driven-end (STROMAG-coupling) of main shaft (drw. 20150800) is <u>acceptable</u> for transfer of max. input torque of 4850 Nm and max. UTS of 950 MPa, as per the Rules. | -- |
| 6.1.3 | Case-Hardened Alloy Steel to be supplied in 'quenched and tempered' condition, as per the Rules for Materials. | AQS
Manufacturer |
| 6.2 | The general requirement for steel shafting components is to be a steel forging, or alternatively made of a rolled bar with reduction ratio not less than 6:1, as per Chapter 5, 1.2.9 of Rules for Materials | AQS
Manufacturer |
| 6.3 | Material of the steel shafting to be made and tested in accordance with Chapter 5 of the "Rules for the Manufacture, Testing and Certification of Materials". | -- |
| 6.4 | Carbon steel shafts (min. UTS 560 N/mm ²) to be supplied in one of following conditions of supply;-
(a) fully annealed; or
(b) normalized; or
(c) normalized and tempered; or
(d) quenched and tempered, as per the Rules | AQS
Manufacturer |
| 6.5 | Construction and test of gear is to comply with Part 5, Chapter 5, sections 4.3 and 5.1 as applicable | -- |
| 6.6 | STROMAG Flexible Coupling / Magnetic Clutch-arrangement(s) are excluded from this appraisal. | -- |
| 6.7 | PHT Parallel Drive Gears not to be subjected to a transverse load in axial direction (propeller thrust). | -- |
| 6.8 | It is noted, that roller elements bearings have been used in the construction and the design life time, L10h, of these elements is to be not less than 30.000 hours. The installation of the roller bearings is to be carried out in accordance with the Manufacturer's instructions. | -- |
| 6.9 | PHT 700A, PHT 700B and PHT900A gears to be fitted out with two (2) keys at driven end (STROMAG coupling). Reference made to plan no. 20150800, rev.02 with two keyways (min. dimensions key 85x20x12). | AQS
Manufacturer |
| 6.10 | PHT 700B and PHT900A gears to be fitted out with nine (9) fitted bolts (dia. 17 mm) with min. UTS of 800 MPa at driving end (ESCO SPF 14" – Coupling Flange).
See Plan no. 'ST P2194 PHT700 V4' with comments. | AQS
Manufacturer |
| 6.11 | All tap bolts engaged in transfer of (main, hybrid, boost) propulsive power (torque) to be bolt material quality 12.9. | -- |

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|-------|---|---------------------|
| 6.12 | The bolts in clearance holes, when fitted in bolted connections for transmission of torque, are to be pretensioned to 70 per cent of the bolt material yield strength value. | -- |
| 6.13 | Locking or securing arrangements of bolts, when fitted in bolted connections for transmission of torque, are preferred with mechanical means, and remain to be to the attending Surveyors' satisfaction. | AQS
Manufacturer |
| 6.14 | The flexible coupling/clutch to be supplied with suitable LR certificate for essential (propulsion) services. | -- |
| 7. | With regard to oil lubrication of the PHT Gearing following requirements are to be complied with:- | |
| 7.1 | Piping, joints, valves, flanges, flexible hoses and other fittings to comply with Part 5, Chapter 12. | -- |
| 7.2 | Stand-by arrangement for the lub.oil pump of gearbox is to comply with Part 5, Ch.14, Sec.8.2.3. Alternatively failure of single lubr.oil pump and loss of service is only acceptable for twin-shaft propulsion systems, subject to adequate vessel speed and steering capability can be maintained with one shaft out of action, this should be demonstrated during sea trials. (Part 5, Chapter 1, Section 5 refers). | AQS
Shipyard |
| 7.3 | For proposed installation in LR-classed vessels the lubricating oil pressure (supply) is to be alarmed and a slow-down (1st stage alarm) and automatic shutdown (2nd stage) is requested upon failure of lubricating oil supply (Part 5 Chapter 5 Table 5.6.1 refers). | AQS
Shipyard |
| 7.3.1 | The sensor and circuit stage used for second stage alarm and automatic shutdown is to be independent of the sensor / circuit required for first stage alarm (Part 5 Ch5, Section 6.2.3 refers) | AQS
Shipyard |
| 7.4 | Lubrication oil sump of PHT gearing is to accommodate continuous and uninterrupted operation under the maximum static and dynamic angles of inclination, as per the Rules (Part 5 Chapter 1 Table 1.3.2).

Sounding (level measurement) and de-aeration of the oil sump to be to the Surveyor's satisfaction | AQS
Shipyard |

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8. Keyless / Interference fit comments:-

- 8.1 The shrink fit assemblies of Gearwheels and Gearshafts have been examined and found in order to obtain Lloyd's Register's Factor of Safety, on torque transmission for keyless fit connections accessible from within the vessel, for a proposed interference fit of 0.124(min) / 0.181(max) mm with an assumed vibratory torque of 10 per cent of the mean PTI / PTO torque (equals 146 Nm (max) PTI / PTO shaft and 248 Nm (max.) at main (intermediate shaft). --

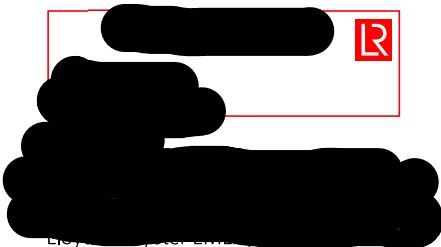
9. General Comments:-

- 9.1 Gear hammer or rough running is not expected during the normal operation of the PHT Parallel Hybrid gearbox, but this should be confirmed by means of aural observations during sea trials. --
- 9.2 As stated by ESCO Power S.r.L it is understood, that basic PHT gears and shafts will be manufactured solely at Messrs. OMSI Trasmissioni S.p.A in accordance with the mandatory conditions and comments given in this Machinery General Design Appraisal with Reg.No. ROT.20.M.028, dated 30 April 2021, under the usual conditions of survey and testing. --

Supplementary General Design Appraisal Terms and Conditions

"When Rules and Standards mentioned in this Designs Appraisal Document are changed within the validity of this Designs Appraisal Document, than this Designs Appraisal Document becomes no longer valid."

"This Designs Appraisal Document is not valid for equipment, the design, ratings or operating parameters of which have been varied from the specimen appraised and/or tested. The manufacturer should notify Lloyd's Register EMEA of any modification or changes to the equipment in order to obtain a valid Designs Appraisal Document."



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Appendix

1. The document listed below has been examined

Document No.	Rev.	Title	Status	Date
20090023	00	Volano SAE 14" Per Invertitore Marino	SI	30-Apr-2021
20110038	00	Flangia Attacco Mot. Centraggio D.553	SI	30-Apr-2021
20110039	01	Flangia Attacco SAE 1 Attacco Invertitore Marino	SI	30-Apr-2021
20150587	05	Albero Uscita Pompe (MASCLU-FEMM.LE)	AQ	30-Apr-2021
20150800	02	Albero Entrata Accoppiatore x FRIZ.STROMAG..	AQ	30-Apr-2021
20150801	07	Albero Intermedio	AQ	30-Apr-2021
20160812	05	Ingranaggio Z 34 Int. (R1.7) (Entrata/Intermedio)	AQ	30-Apr-2021
20160813	03	Ingranaggio Z 43 Int. (R1.7) (Intermedia/Uscita)	AQ	30-Apr-2021
20160814	03	Ingranaggio Z 38 Usc. (R1.7)	AQ	30-Apr-2021
20160838	07	Ingranaggio Z 37 Int. (R1.47) (Entrata/Intermedio)	AQ	30-Apr-2021
20161331	00	Ingranaggio Z 48 (R1.7)	AQ	30-Apr-2021
20161332	00	Ingranaggio Z 51 Entr. (R1.7)	AQ	30-Apr-2021
ST P2194 PHT700 V4		PHT700 Diesel Engine and Gear Marine Conn's	SI	30-Apr-2021
10810376	00	Accoppiatore Base PHT P25 1,47	SI	30-Apr-2021
10810377	00	Accoppiatore Base PHT P25 1,7	SI	30-Apr-2021
PHT300A301	--	Parallel Hybrid Transmission PHT300A301	SI	30-Apr-2021
PHT420A101	--	Parallel Hybrid Transmission PHT420A-SAE1	SI	30-Apr-2021
PHT700A101	--	Parallel Hybrid Transmission PHT700A	SI	30-Apr-2021
PHT700B101	--	Parallel Hybrid Transmission PHT700B	SI	30-Apr-2021
Detail	--	Detail PTO / PTI	SI	30-Apr-2021
SPF 14"	C	Standard PHT Flywheel 14"	AQ	30-Apr-2021
2132006-000	--	PHT900A001 Assembly	SI	07-Feb-2023

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Appendix

2. The documents listed below have been considered together with the submitted documents in the appraisal

Document No.	Rev.	Title
--	--	ESCO Power 200514 RF Statement for Lloyd
--	--	ESCO Power Asbestos Free Declaration (11/10/2016)
--	--	ESCO Power Parallel Hybrid Transmission (PHT) Manual (March 16, 2020)
--	--	ESCO Power Epeng/020420/PHT01 – Main shaft Limit calculation
--	--	Lloyd questions 25-02-2021 in reply to our email doc. RTS-ENG-201840-MPB
--	--	Gear data for 1.468 ratio / Gear data for 1.697 ratio
243-00253	--	POL R.K. MWU 400-1000 / PVN 549

Appraisal Status Key

A	Approved - provided the arrangements are to the surveyor's satisfaction
AQ	Approved subject to the matters raised that require resolution - and provided the arrangements are to the surveyor's satisfaction
AQP	Details to be submitted by the client to the Technical Support Office for approval / re-approval
AQS	
Manufacturer	Comments to be resolved at the manufacturing site
AQS Shipyard	Comments to be resolved at the shipyard
SI	Retained as supporting documentation for information only
C	Cancelled



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