OPERATING MANUAL
MANUALE D'USO - MANUEL DE SERVICE
MANUAL DE USO - BETRIEBSANLEITUNG

ZF 600 Family

ZF MARINE
ZF PADOVA S.p.A.

ZF Marine GmbH

D-88038 Friedrichshafen

GERMANY
Phone +49 (7541) 77-2207
Fax +49 (7541) 77-4222

ZF Padova S.p.A.

Via Penghe, 48
I-35030
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ZF do Brasil S.A.

Avenida Conde Zeppelin, 1935
Cep. 18103-000 Sorocaba - SP

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Phone +55 (15) 235 2586/2389
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ZF MARINE
ZF PADOVA S.p.A.

30.80.758.101
Ed. 03/2002

Thank you for choosing a
Vi ringraziamo per aver scelto un invertitore
Nous vous remercions d'avoir choisi un inverseur
Gracias por elegir un inversor
Wir danken Ihnen für Ihre Wahl eines Schiffsgetriebes der Marke

ZF MARINE

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Copia da ritornare in ZF Padova S.p.A.
Copy to be mailed back *to* ZF Padova S.p.A.

scheda di garanzia
warrantycard

DESCRIZIONE / *DESCRIPTION*

CLIENTE / *CUSTOMER*

MATRICOLA / *S/NUMBER*

DATA ENTRATA IN SERVIZIO / *ENTRY ON DUTY DATE*

INDIRIZZO / *ADRESS*

VALIDITÀ GARANZIA / *WARRANTY PERIOD*

GENERALE :12 mesi dalla data di entrata in esercizio/24 mesi dalla data di spedizione da ZF PADOVA quella che si verifica prima.

DIPORTO :24 mesi dalla data di entrata in esercizio/36 mesi dalla data di spedizione da ZF PADOVA, quella che si verifica prima. Limite max (media) ore di utilizzo:500/anno.

STANDARD :12 months after commissioning/24 months exw ZF PADOVA, whichever occurs first.

PLEASURE ONLY :24 months after commissioning/36 months exw ZF PADOVA, whichever occurs first. Average operating hours limit:500/year.

CITTÀ / *CITY*

NAZIONE / *NATION*

SCHEDA DI GARANZIA: La ZF Padova S.p.A., entro il periodo di validità sopra citato, assumerà la responsabilità nei confronti di ogni componente del gruppo nuovo contro ogni difetto del materiale da lei stessa approvvigionato e nel caso la lavorazione non si rivelasse a regola d'arte, tuttavia non contro difetti dovuti ad inconvenienti generati dalle condizioni di applicazione o a seguito di manovra errata, incerta o mancata manutenzione, incidenti. La ZF Padova S.p.A. non risponde neppure degli elementi quali anelli di tenuta, guarnizioni in generale, cinghie di trasmissione, soffietti, protezioni e membrane in gomma che, considerata la loro natura strutturale, sono soggetti a continue sollecitazioni ed a logorio prematuro, salvo tuttavia in casi ove le carenze di montaggio, di applicazione o di origine degli elementi stessi risultino inequivocabili. I gruppi oppure gli elementi degli stessi dovranno essere installati rispettando in modo assoluto le prescrizioni della ZF Padova S.p.A. o altrimenti, esclusivamente previo benestare da parte dell'Ufficio Progetti o applicazioni della ZF Padova S.p.A.. La ZF Padova S.p.A. riparerà o sostituirà, a titolo gratuito, i gruppi oppure gli elementi realmente difettosi presso il proprio Stabilimento od una officina autorizzata ZF-Service, e se il proprietario dell'imbarcazione o del veicolo avrà provveduto preventivamente al pagamento di ogni spesa di spedizione. Ogni spesa inerente alle operazioni atte a favorire l'accesso del personale tecnico autorizzato dalla ZF Padova S.p.A. al gruppo o a componenti dello stesso andranno esclusivamente a carico del proprietario dell'imbarcazione o del veicolo. ZF Padova S.p.A. declina ogni responsabilità per danni, spese, rivalse di qualsivoglia tipo. Ogni spesa derivante e non preventivamente autorizzata non verrà rimborsata. Interventi di riparazione o modifica effettuati sul gruppo o elementi dello stesso senza il preventivo benestare della ZF Padova S.p.A. oppure da personale non autorizzato dalla ZF Padova S.p.A. o ancora l'impiego di pezzi di ricambio non originali, rendono nulla la presente Garanzia. Nel firmare la presente scheda di garanzia l'Utente s'impegna a rispettare le clausole, ivi comprese quelle emanate nelle Condizioni Generali di Vendita della ZF Padova S.p.A..

GARANTIESCHEIN: *ZF Padova S.p.A. innerhalb der o.a. Gültigkeitsdauer, übernimmt für alle Teile des neuen Getriebes wegen schlechten, von ihr beaschfften Werkstoffes und mangelhafter Bearbeitung, die Haftung. Dies gilt nicht, soweit Störungen durch die Einbauverhältnisse oder unsachgermaße Bedienung und fehlerhafte oder nachläßige Wartung, Unfälle auftreten. Für Liefergegenstände (z. B. Dichtungsringe, Dichtungen, Triebriemen, Gummibalegen-Schutzelemente-und Membranen), die infolge ihrer stofflichen Beschaffenheit , einer kontinuierlichenBeanspruchung oder einem vorzeitigen Verbrauch unterliegen, übernimmt die ZF Padova S.p.A. keine Hftung, jedoch wird die Haftung wegen unzweideutiing unsachgemäßer Montage, mangelhften Einbaus oder Ursprungmängel von der ZF Padova S.p.A. übernommen. Die Getriebe oder iher Teile müßen gemäß den ZF Padova S.p.A.-ZF Padova S.p.A.Vorschriften oder erst nach vorherig erteilter Freigabe seitens derKonstruktions-oder Applikations-Stelle der ZF Padova S.p.A. installiert werden. Di e ZF Padova S.p.A. wird unzweideutiing mangelhfte Getriebe und/oder iher Teile im eigenen Werk oder bei einer ZF-Service-Stelle untentgeltlich ausbessern bzw. neu liefern und dies, erst nachdem der Eigentümer des Schiffes oder des Fahrzeuges die Vorausbezahlung hinsichtlich des Versands des Getriebes oder der beanstandeten Teilezur Zeit der Sendung selbst geleisten hat. Alle entstandenen kosten um das Getriebe oder seine Teile den von der ZF Padova S.p.A. Befugten Technikern zugänglich zu machen trägt der Eigentümer des Schiffes oder des Fahrzeuges allein. ZF Padova S.p.A. weist jede Verantwortung wegen Schäden, Spesen, Regreße irgendwelcher Art zurück. Dadurch entstandene Kosten werden nicht vergütet. Die Haftungerlischt, wenn Nacharbeiten, Änderungen oder Instandsetzungsarbeiten ohne vorherige Zustimmung der ZF Padova S.p.A. bzw. von unbefugtem Personal vorgenommen werden oder Nichtoriginal-Ersatzteile zum Einsatz. Mit seiner Unterschrift verpflichtet sich der Benutzer den o.g. Klause In sowie den der Allegemeinen Verkaufsbedingungen der ZF Padova S.p.A. Nachzukommen.*

D **F**

TALON DE GARANTIE: La ZF Padova S.p.A. durant la période de validité dont ci-dessus, assumera la responsabilité à l'endroit de chaque élément du nouveau groupe contre tout du matériel qu'elle-même aura fourni et au cas où l'usinage se révélait hors des règles de la tecnique, toutefois non à celui des défauts dûs à des inconvénients engendrés par les conditions d'application ou à la suite de manoeuvre erronée,d'entretien douteux ou négligé, d'accidents. La ZF Padova S.p.A. ne répondra non plus des éléments, tels que joints d'etanchèitè, joints en général, courroies de trasmission, soufflets, protections et membranes en caoutchouc qui, vue leur nature structale, sont sujets à une fatigue continue et à une usure prématurée, sauf çependant au cas où des montage, d'application ou d'origine de l'élément résultent évidents. Les groupes ou bien leurs éléments doivent absolument être installés selon les prescriptions de la ZF Padova S.p.A. ou, autrement, exclusivementsur approbation préalable du Bureau ou de celui d'Application de la ZF Padova S.p.A.. Celle-ci réparera ou remplacera à titre gratuit, auprès de son Usine ou d'un atelier agreé ZF-Service, les groupes ou les éléments réellement défectueux et si les frais d'expédition du groupe ou des éléments contestés auront été payés d'avance par le propriétaire de l'embarcation ou bien du véhicule au de leur expédition. Tout frais concernant les operations pour favoriser l'accès des techniciens autorisés per la ZF Padova S.p.A. au groupe ou à ses éléments sont àla charge exclusive du propriétaire de l'embarcation ou du véhicule. ZF Padova S.p.A. décline toute responsabilité dûe à dommages, frais,compensations, quels qu'ils soient. Tout frais en derivant et non autorisé auparavant ne sera pas remboursé. La cessation de la Garantie intervient lorsque des travaux de réparation ou de modification sont effectués sur le groupe ou ses éléments sans l'accord préalable de la ZF Padova S.p.A.respectivement s'ils sont effectués par un personnel non autorisé par la ZF Padova S.p.A. ou bien en cas d'emploi de pièces détachées non originales. En signant ce talon de garantie l'usager à respecter les clause y contenues, y compris celles des Conditions Générales de Vente de la ZF Padova S.p.A.

WARRANTY CARD: *ZF Padova S.p.A. within the above period of validity, is liable for all defective components of the new unit due to materials used by ZF Padova S.p.A. and incorrect machining, but not for failures caused by improper use and improper installation, inaccurate or missing maintenance, accidents. ZF Padova S.p.A. assumes no liability for components (e.g. oil seals, gaskets, driving belts, rubber bellows, guards and diaphragms) which, because of their material compositions, are subject to continuos fatigue or premature wear, except when assembling, application or origin faults are unequivocal. The units or their parts must absolutely be installed in compliance with ZF Padova S.p.A. specifications or with the approval from ZF Padova S.p.A. Design Engineering or Application Departments. ZF Padova S.p.A. will provide free of charge either new components or components repaired at its own Works or at a ZF-Service-Workshop for really defective units or elements, provided all shipment costs have been prepaid by the owner of the boat or of the vehicle. All expenses concerning the operations carried out by technicians authorized by ZF Padova S.p.A. to get access to the unit or its components are and remain at the exclusive charge of the owner of the boat or of the veichle. ZF Padova S.p.A. assumes no liability for consesequent damages, expenses, compensation of any kind whatsoever . All unauthorized expenses will not be reimbursed. ZF Padova S.p.A. is entitled to cancel the warranty if repairs or modifications are carried out without its previous approval or if such works are carried out by staff not previosly authorized by ZF Padova S.p.A. or ZF Padova S.p.A. genuine spare parts are not used. In signing this warranty card the User commits himself to comply with the above clauses as with those set by ZF Padova S.p.A. General Sales Conditions.*

GB **E**

NORMAS DE GARANTIA: La firma ZF Padova S.p.A. dentro del plazo de validez anteriormente citado, asumirá la responsabilidad de todos los components del nuevo grupo por cualquier tipo de defecto del material suministrado por ella misma, o en caso de que la fabricación hubiera demostrado no aber sido efectuada correctamente. Sin embargo, no se hará responsable de los defectos por condiciones de aplicación o de manobras erróneas, mantenimiento incorrecto o inexistente y accidentes. Las firma ZF Padova S.p.A. no respo nderá tampoco de los elementos como juntas toricas juntas en general, correas de transmisión, fuelles, protecciones y membranas de goma que, debido a su naturaleza estructural, se encuentran sometidos a continuos esfuerzos y a desgaste prematuro, exceptuando todos aquellos casos en los que defectos de montaje, de aplicación o de fabricación de estos elementos resulten inequívocos. Los grupos, o bien los componentes de los mismos, tendrán que ser instalados respetando fielmente las indicaciones de ZF Padova S.p.A. o exclusivamente previa aprobación de la oficina de proyectos o aplicaciones de la firma ZF Padova S.p.A.. ZF Padova S.p.A. reparará o cambiará gratuitamente los grupos o componentes que resulten realmente defectuosos en su propio taller central o en un taller autorizado por ZF-Service, y solo si el propietario del barco o del vehiculo ha pagado previamente todos los gastos de envio. Todas las operaciones necesarias para favorecer el acceso del personal técnico autorizado poZF Padova S.p.A. al grupo o componentes del mismo, correrán exclusivamente por cuenta del proprietario del barco o del vehiculo. ZF Padova S.p.A. declina toda responsabilidad por danos, gastos y resarcimientos de cualquier tipo. Todo gasto que derive de elloy que no haya sido autorizado previamente, no será reembolsado. Las intervenciones de reparación o de modificación efectuadas en el grupo o componentes del mismo sin autorización previa de ZF Padova S.p.A., o bien por personal no autorizado por ZF Padova S.p.A., así comoel empleo de piezas de repuesto no originales, anulan la presente garantía. Al firmar la presente ficha de garantía, el usuraio se compromete a respetar las cláusulas, incluyendo en ellas las que se encuentran en las condiciones generales de venta de ZF Padova S.p.A.

DATA / *DATE*

FIRMA CLIENTE / *CUSTOMER SIGNATURE*

ZF Padova S.p.A.

ZP Padova S.p.A.
I - 35030 Caselle di Selvezzano
via Penghe, 48 - PD (Italy)
Phone 049/8299311
Fax comm. 049/8299569
Fax ricambi/assistenza 049/8299570

Copia da ritornare in ZF Padova S.p.A.
Copy to be mailed back *to* ZF Padova S.p.A.

scheda di garanzia
warrantycard

DESCRIZIONE / *DESCRIPTION*

MATRICOLA / *S/NUMBER*

DATA ENTRATA IN SERVIZIO / *ENTRY ON DUTY DATE*

VALIDITÀ GARANZIA / *WARRANTY PERIOD*

GENERALE :12 mesi dalla data di entrata in esercizio/24 mesi dalla data di spedizione da ZF PADOVA quella che si verifica prima.

DIPORTO :24 mesi dalla data di entrata in esercizio/36 mesi dalla data di spedizione da ZF PADOVA, quella che si verifica prima. Limite max (media) ore di utilizzo:500/anno.

STANDARD :12 months after commissioning/24 months exw ZF PADOVA, whichever occurs first.

PLEASURE ONLY :24 months after commissioning/36 months exw ZF PADOVA, whichever occurs first. Average operating hours limit:500/year.

CLIENTE / *CUSTOMER*

INDIRIZZO / *ADRESS*

CITTÀ / *CITY*

NAZIONE / *NATION*

SCHEDA DI GARANZIA: La ZF Padova S.p.A., entro il periodo di validità sopra citato, assumerà la responsabilità nei confronti di ogni componente del gruppo nuovo contro ogni difetto del materiale da lei stessa approvvigionato e nel caso la lavorazione non si rivelasse a regola d'arte, tuttavia non contro difetti dovuti ad inconvenienti generati dalle condizioni di applicazione o a seguito di manovra errata, incerta o mancata manutenzione, incidenti. La ZF Padova S.p.A. non risponde neppure degli elementi quali anell i di tenuta, guarnizioni in generale, cinghie di trasmissione, soffietti, protezioni e membrane in gomma che, considerata la loro natura strutturale, sono soggetti a continue sollecitazioni ed a logorio prematuro, salvo tuttavia in casi ove le carenze di montaggio, di applicazione o di origine degli elementi stessi risultino inequivocabili. I gruppi oppure gli elementi degli stessi dovranno essere installati rispettando in modo assoluto le prescrizioni della ZF Padova S.p.A. o altrimenti, esclus ivamente previo benestare da parte dell'Ufficio Progetti o applicazioni della ZF Padova S.p.A.. La ZF Padova S.p.A. riparerà o sostituirà, a titolo gratuito, i gruppi oppure gli elementi realmente difettosi presso il proprio Stabilimento od una officina autorizzata ZF-Service, e se il proprietario dell'imbarcazione o del veicolo avrà provveduto preventivamente al pagamento di ogni spesa di spedizione. Ogni spesa inerente alle operazioni atte a favorire l'accesso del personale tecnico autorizza to dalla ZF Padova S.p.A. al gruppo o a componenti dello stesso andranno esclusivamente a carico del proprietario dell'imbarcazione o del veicolo. ZF Padova S.p.A. declina ogni responsabilità per danni, spese, rivalse di qualsivoglia tipo. Ogni spesa derivante e non preventivamente autorizzata non verrà rimborsata. Interventi di riparazione o modifica effettuati sul gruppo o elementi dello stesso senza il preventivo benestare della ZF Padova S.p.A. oppure da personale non autorizzato dalla ZF P adova S.p.A. o ancora l'impiego di pezzi di ricambio non originali, rendono nulla la presente Garanzia. Nel firmare la presente scheda di garanzia l'Utente s'impegna a rispettare le clausole, ivi comprese quelle emanate nelle Condizioni Generali di Vendita della ZF Padova S.p.A..

GARANTIESCHEIN: *ZF Padova S.p.A. innerhalb der o.a. Gültigkeitsdauer, übernimmt für alle Teile des neuen Getriebes wegen schlechten, von ihr beaschfften Werkstoffes und mangelhafter Bearbeitung, die Haftung. Dies gilt nicht, soweit Störungen durch die Einbauverhältnisse oder unsachgermaße Bedienung und fehlerhafte oder nachläßige Wartung, Unfälle auftreten. Für Liefergegenstände (z. B. Dichtungsringe, Dichtungen, Triebriemen, Gummibalegen-Schutzelemente-und Membranen), die infolge ihrer stofflichen Beschaffenheit , einer kontinuierlichenBeanspruchung oder einem vorzeitigen Verbrauch unterliegen, übernimmt die ZF Padova S.p.A. keine Hftung, jedoch wird die Haftung wegen unzweideutung unsachgemäßer Montage, mangelhften Einbaus oder Ursprungmängel von der ZF Padova S.p.A. übernommen. Die Getriebe oder iher Teile mußen gemäß den ZF Padova S.p.A.-ZF Padova S.p.A.Vorschriften oder erst nach vorherig erteilter Freigabe seitens derKonstruktions-oder Applikations-Stelle der ZF Padova S.p.A. installiert werden. Di e ZF Padova S.p.A. wird unzweideuting mangelhfte Getriebe und/oder iher Teile im eigenen Werk oder bei einer ZF-Service-Stelle untentgeltlich ausbessern bzw. neu liefern und dies, erst nachdem der Eigentümer des Schiffes oder des Fahrzeuges die Vorausbezahlung hinsichtlich des Versands des Getriebes oder der beanstandeten Teilezur Zeit der Sendung selbst geleisten hat. Alle entstandenen kosten um das Getriebe oder seine Teile den von der ZF Padova S.p.A. Befugten Technikern zugänglich zu machen trägt der Eigentümer des Schiffes oder des Fahrzeuges allein. ZF Padova S.p.A. weist jede Verantwortung wegen Schäden, Spesen, Regreße irgendwelcher Art zurück. Dadurch entstandene Kosten werden nicht vergütet. Die Haftungerlischt, wenn Nacharbeiten, Änderungen oder Instandsetzungsarbeiten ohne vorherige Zustimmung der ZF Padova S.p.A. bzw. von unbefugtem Personal vorgenommen werden oder Nichtoriginal-Ersatzteile zum Einsatz. Mit seiner Unterschrift verpflichtet sich der Benutzer den o.g. Klause ln sowie den der Allegemeinen Verkaufsbedingungen der ZF Padova S.p.A. Nachzukommen.*

D **F**

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WARRANTY CARD: *ZF Padova S.p.A. within the above period of validity, is liable for all defective components of the new unit due to materials used by ZF Padova S.p.A. and incorrect machining, but not for failures caused by improper use and improper installation, inaccurate or missing maintenance, accidents. ZF Padova S.p.A. assumes no liability for components (e.g. oil seals, gaskets, driving belts, rubber bellows, guards and diaphragms) which, because of their material compositions, are subject to continuos fa tigue or premature wear, except when assembling, application or origin faults are unequivocal. The units or their parts must absolutely be installed in compliance with ZF Padova S.p.A. specifications or with the approval from ZF Padova S.p.A. Design Engineering or Application Departments. ZF Padova S.p.A. will provide free of charge either new components or components repaired at its own Works or at a ZF-Service-Workshop for really defective units or elements, provided all shipment costs have been prepaid by the owner of the boat or of the vehicle. All expenses concerning the operations carried out by technicians authorized by ZF Padova S.p.A. to get access to the unit or its components are and remain at the exclusive charge of the owner of the boat or of the veichle. ZF Padova S.p.A. assumes no liability for consesequent damages, expenses, compensation of any kind whatsoever . All unauthorized expenses will not be reimbursed. ZF Padova S.p.A. is entitled to cancel the warranty if repairs or modifications are carried out without its previous approval or if such works are carried out by staff not previosly authorized by ZF Padova S.p.A. or ZF Padova S.p.A. genuine spare parts are not used. In signing this warranty card the User commits himself to comply with the above clauses as with those set by ZF Padova S.p.A. General Sales Conditions.*

GB **E**

NORMAS DE GARANTIA: La firma ZF Padova S.p.A. dentro del plazo de validez anteriormente citado, asumirá la responsabilidad de todos los components del nuevo grupo por cualquier tipo de defecto del material suministrado por ella misma, o en caso de que la fabricación hubiera demostrado no aber sido efectuada correctamente. Sin embargo, no se hará responsable de los defectos por condiciones de aplicaciòn o de manobrias erróneas, mantenimiento incorrecto o inexistente y accidentes. Las firma ZF Padova S.p.A. no respo nderá tampoco de los elementos como juntas toricas juntas en general, correas de transmisión, fuelles, protecciones y membranas de goma que, debido a su naturaleza estructural, se encuentran sometidos a continuos esfuerzos y a desgaste prematuro, exceptuando todos aquellos casos en los que defectos de montaje, de aplicación o de fabricación de estos elementos resulten inequivocos. Los grupos, o bien los componentes de los mismos, tendrán que ser instalados respetando fielmente las indicaciones d e ZF Padova S.p.A. o exclusivamente previa aprobación de la oficina de proyectos o aplicaciones de la firma ZF Padova S.p.A.. ZF Padova S.p.A. reparará o cambiará gratuitamente los grupos o componentes que resulten realmente defectuosos en su propio taller central o en un taller autorizado por ZF-Service, y solo si el proprietario del barco o del vehiculo ha pagado previamente todos los gastos de envio. Todas las operaciones necesarias para favorecer el acceso del personal técnico autorizado por ZF Padova S.p.A. al grupo o componentes del mismo, correrán exclusivamente por cuenta del proprietario del barco o del vehiculo. ZF Padova S.p.A. declina toda responsabilidad por danos, gastos y resarcimientos de cualquier tipo. Todo gasto que derive de elloy que no haya sido autorizado previamente, no será reembolsado. Las intervenciones de reparación o de modificación efectuadas en el grupo o componentes del mismo sin autorización previa de ZF Padova S.p.A., o bien por personal no autorizado por ZF Padova S.p.A., asi comoel empleo de piezas de repuesto no originales, anulan la presente garantis. Al firmar la presente ficha de garantia, el usuraio se compromete a respetar las cláusulas, incluyendo en ellas las que se encuentran en las condiciones generales de venta de ZF Padova S.p.A.

DATA / *DATE*

FIRMA CLIENTE / *CUSTOMER SIGNATURE*

ZF Padova S.p.A.

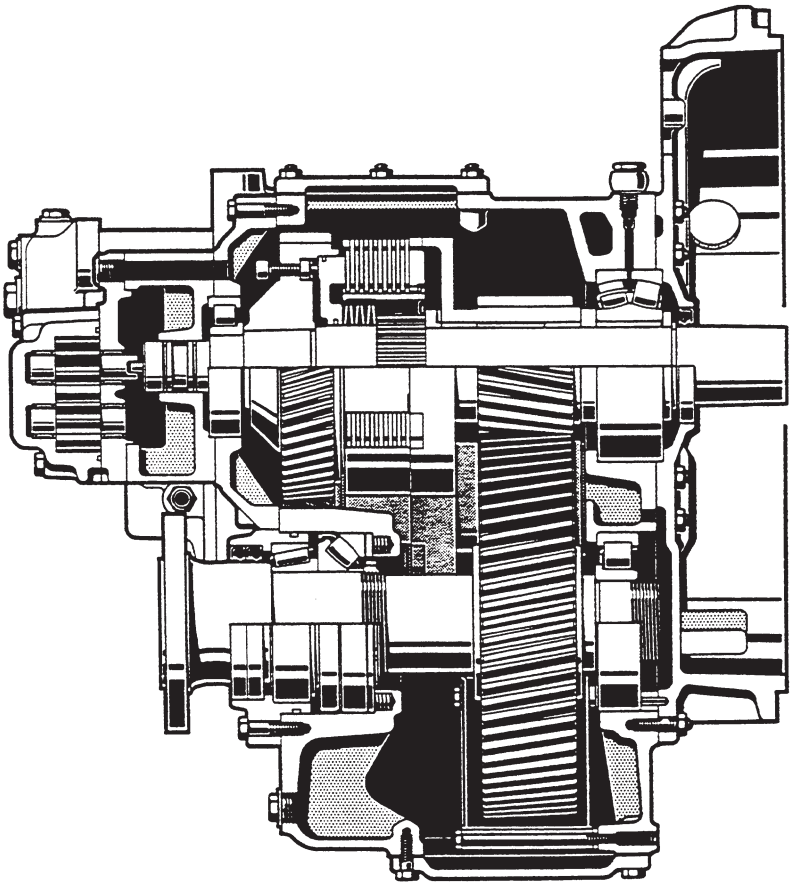
ZF Marine gears

ZF 600 Family

Description
installation
operation
and maintenance

The description, operation and maintenance sections are applicable to the standard gearbox version.
Variations are possible according to special customer requirements and operating conditions. If the data in the description, installation, operation and maintenance sections are different from those in the technical or commercial specification, then the data in the specifications apply.

The "ZF list of lubricants TE-ML 04 for ZF marine gears" is valid.



Important Note:

1. Warranty conditions agreed with ZF apply for these gearboxes. However, ZF can only honour warranty claims on the condition that,

   - the gearbox has been installed, monitored, operated and maintained in accordance with the instructions in the operating manual,

   - ZF-approved lubricants have been used,

   - the limit values specified on the gearbox for the ratio of input power to input speed, and the limit on input speed — dependent on gearbox application group in use — are respected.

2. The gearbox manufacturer, as a supplier of one individual component of a ship's entire drive system, cannot be held responsible for vibrations or vibrational problems arising from this system.

   If follows from this that ZF will not accept liability for gearbox noise or damage to the gearbox, flexible coupling or other parts of the drive unit caused by such vibrations.

   We therefore recommend that a vibrational calculation be performed, and where appropriate load-free gearbox components should be included in this calculation, wherever feasible.

Table of Contents

Monitoring values

For gears ZF W 650

	Monitoring function	Filter blockage	Clutch oil pressure	Oil temperature
	Measuring point	5	2	11, 12, 41
Version with nominal pressure 18 bar	Nominal reading	max. 24 bar	17.5 to 19 bar [4] 7.5 to 10.0 bar [5]	normal: 30 to 80 °C max. 90 °C (normal operation) for trailing operation: max. 105 °C with trailing oil pump max. 75 °C without trailing oil pump (see section III. 2)
	Warning	24 bar ▲	16.5 bar ▼ [1) 2)]	95 °C ▲ [1)]
	Minimum monitoring facility	Pressure sensing switch	Pressure gauge 0 to 25 bar	Thermometer 0 to 120 °C
	Additional monitoring	Pressure gauge 0 to 40 bar	Pressure sensing switch [3) 6)] or pressure gauge 0 to 25 bar	Temperature sensing switch [1)] or thermometer 0 to 120 °C

For gears ZF 600A - ZF 600V - ZF 600

	Monitoring function	Filter blockage	Clutch oil pressure	Oil temperature
	Measuring point	5	2	11, 12, 41
Version with nominal pressure 20 bar	Nominal reading	max. 24 bar	19.5 to 21 bar [4] 7.5 to 10.0 bar [5]	normal: 30 to 80 °C max. 90 °C (normal operation) for trailing operation: max. 105 °C with trailing oil pump max. 75 °C without trailing oil pump (see section III. 2)
	Warning	24 bar ▲	18.5 bar ▼ [1) 2)]	95 °C ▲ [1)]
	Minimum monitoring facility	Pressure sensing switch	Pressure gauge 0 to 25 bar	Thermometer 0 to 120 °C
	Additional monitoring	Pressure gauge 0 to 40 bar	Pressure sensing switch [3) 6)] or pressure gauge 0 to 25 bar	Temperature sensing switch [1)] or thermometer 0 to 120 °C

For gears ZF 650 - ZF 650A - ZF 650V - ZF 660 - ZF 660A - ZF 660V

	Monitoring function	Filter blockage	Clutch oil pressure	Oil temperature
	Measuring point	5	2	11, 12, 41
Version with nominal pressure 21.5 bar	Nominal reading	max. 24 bar	21 to 22.5 bar [4] 7.5 to 10.0 bar [5]	normal: 30 to 80 °C max. 90 °C (normal operation) for trailing operation: max. 105 °C with trailing oil pump max. 75 °C without trailing oil pump (see section III. 2)
	Warning	24 bar ▲	20 bar ▼ [1) 2)]	95 °C ▲ [1)]
	Minimum monitoring facility	Pressure sensing switch	Pressure gauge 0 to 25 bar	Thermometer 0 to 120 °C
	Additional monitoring	Pressure gauge 0 to 40 bar	Pressure sensing switch [3) 6)] or pressure gauge 0 to 25 bar	Temperature sensing switch [1)] or thermometer 0 to 120 °C

For gears ZF 670 - ZF 670A - ZF 670V

	Monitoring function	Filter blockage	Clutch oil pressure	Oil temperature
	Measuring point	5	2	11, 12, 41
Version with nominal pressure 23.5 bar	Nominal reading	max. 24 bar	23 to 24 bar [4] 7.5 to 10.0 bar [5]	normal: 30 to 80 °C max. 90 °C (normal operation) for trailing operation: max. 105 °C with trailing oil pump max. 75 °C without trailing oil pump (see section III. 2)
	Warning	24 bar ▲	22 bar ▼ [1) 2)]	95 °C ▲ [1)]
	Minimum monitoring facility	Pressure sensing switch	Pressure gauge 0 to 25 bar	Thermometer 0 to 120 °C
	Additional monitoring	Pressure gauge 0 to 40 bar	Pressure sensing switch [3) 6)] or pressure gauge 0 to 25 bar	Temperature sensing switch [1)] or thermometer 0 to 120 °C

Details see section II.8

1) For optical and acoustic warning

2) With 5 to 10 sec. time delay

3) Use branch pipe

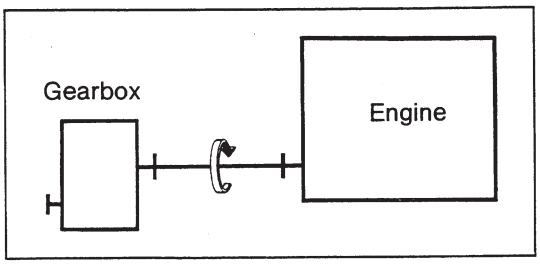
4) At an oil temperature of 60 to 80°C, “engine or counter-enginewise” position

5) In neutral

6) Warning system must be put out of action when in neutral

Summary of technical data (general)

Direction of rotation of gearbox input shaft of standard version



Identification mark for the oil pump	Design engine speed	Engine idling speed
A	approx. 1 700 to 2 600	≧ 500
B	approx. 1 100 to 1 700	≧ 390

Additional forces on gearbox input	in radial direction	max. 1 200 N
	in axial direction	max. 400 N

Alignment of propeller shaft

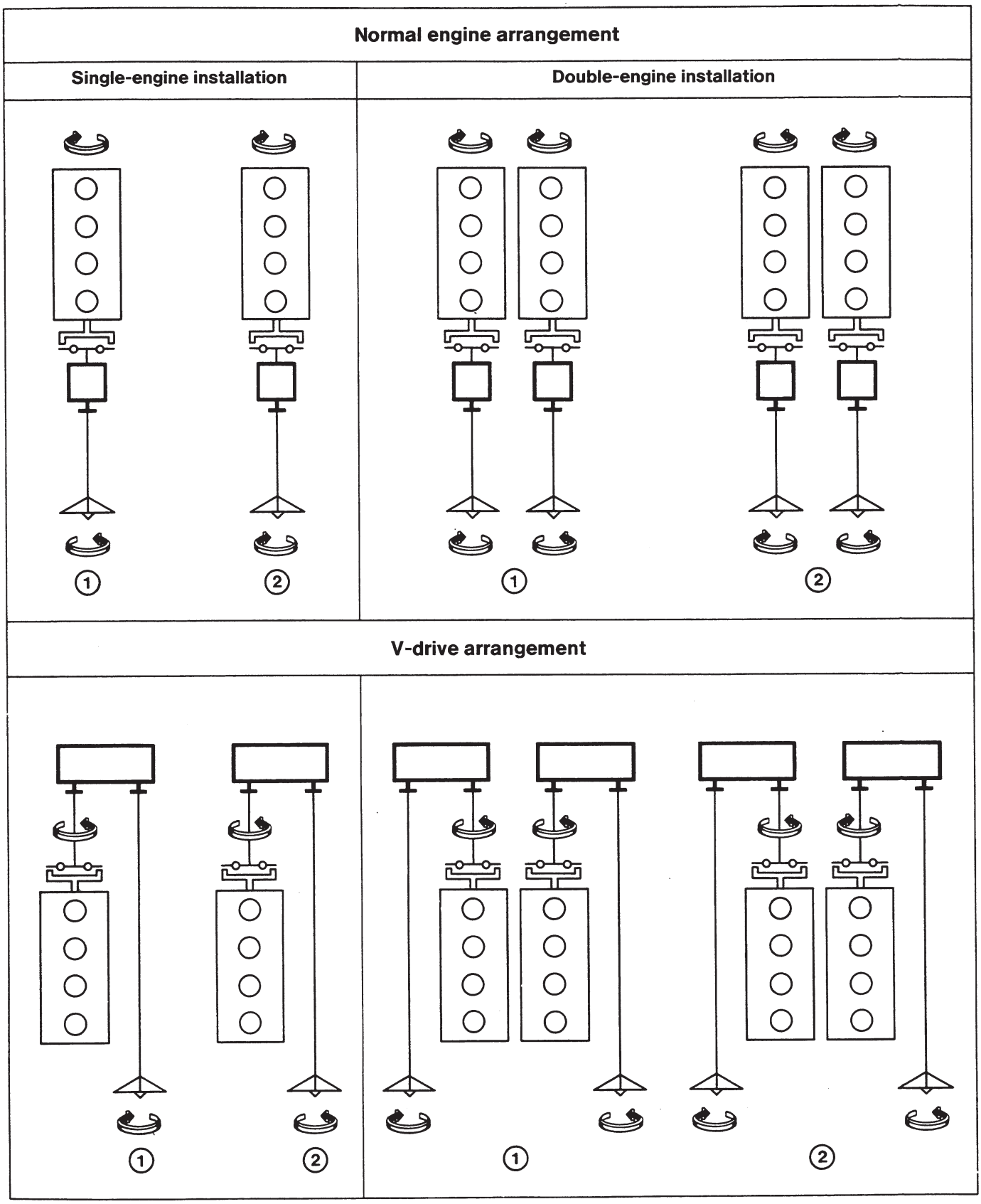
max. angular displacement "x" [mm]	max. shaft misalignment "y" [mm]	smallest bearing distance "L" [mm]
0.05	0.10	500 for d <60 1 000 for d 60 to 90 2 000 for d >90

Cooler data

■ **Max. permissible cooling water flow rate**	12 500 dm^3/ h	
■ **Min. permissible cooling water flow rate**	2 000 dm^3/ h	
■ **Pressure loss cooling water inlet/outlet**	at 12 500 dm^3/ h	0.35 bar
	at 10 000 dm^3/ h	0.20 bar
	at 7 500 dm^3/ h	0.13 bar
■ **Max. water pressure on cooling water inlet**		3 bar
■ **Max. cooling water inlet temperature**		40 °C
■ **Max. ambient temperature of gearbox**		60 °C

Oil grade	according to MIL - L - 2104 C or MIL - L - 46152; API - CC, CD, SC, SD, SE specifications.	
	Viskosity grades SAE 30 or SAE 40 for oil sump temperatures	<80 °C
	Viskosity grade SAE 40 for oil sump temperatures	>80 °C
	Multi-grade oils not permissible.	
	The relevant ZF lubricants list TE-ML 04 for ZF marine gears is applicable. This list can be obtained from any ZF service station.	
Oil capacity	approx. 20 dm^3	
Gearbox ratio	see gearbox type plate	
Gearbox mass	according to scope of supply — see gearbox type plate	

Direction of propeller rotation for forward drive



① Preferable

② Admissible

Note: for the input shaft rotation anti-clockwise – looking at the gearbox input flange – a special version is required.

I Description of basic gearbox

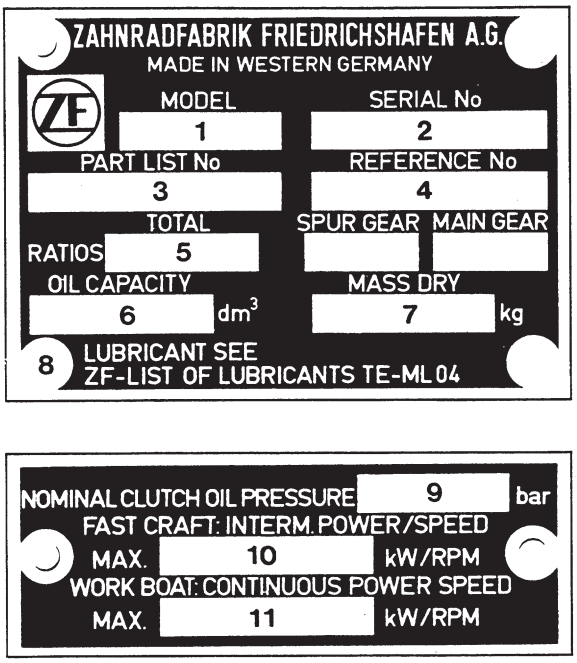
1 Power, speed, rotational direction, ratio, type plate

The ZF marine gears are designed and manufactured according to the regulations of the various Classification Societies. The input power approved by the Classification Societies depends on the input speed, the class of the craft and the differing design regulations currently in force. In most cases the maximum torques approved by ZF are also fully accepted by the Classification Societies.

Upon request, either a full test or a factory acceptance test is carried out by the Classification Society specified by the customer.

Normally the input shaft rotates clockwise (looking at the gearbox input flange). For anti-clockwise input shaft rotation a special version is required. The correct input shaft rotation direction can be noted from the rotation direction sign situated on the top of the gearbox housing.

The respective ratio is stamped on the gearbox type plate which is mounted on top of the gearbox housing.



1 Model

2 Serial No.

3 Part list No.

4 Reference No.

5 Gearbox ratios and code letter for oil pump

6 Oil capacitiy

7 Mass (dry)

8 Lubricant see ZF-List of lubricants TE-ML 04

9 nominal clutch oil pressure

10 max. power /speed ratio on intermittent operation for fast craft

11 max. power /speed ratio on continuous operation for work boats

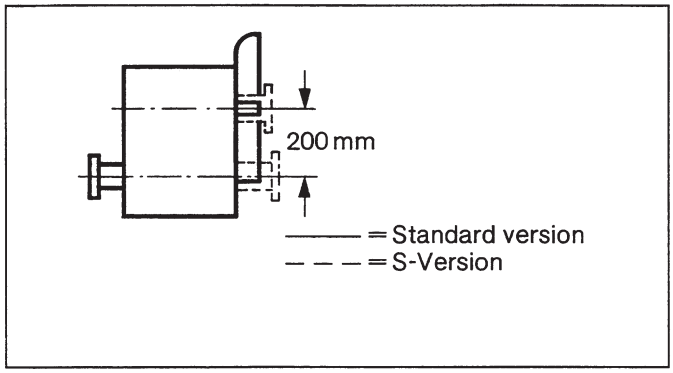
For spare parts orders and inquiries the items shown in the spaces 1, 2, 3, and 5 are necessary.

Code letter 5 after gearbox ratio in space 5 means:

Letter	Design engine speed	Engine idling speed
A	approx. 1700 to 2600	≧ 500
B	approx. 1100 to 1700	≧ 390

The oil pump A is the standard version
(speed range B for gearboxes with trolling device is not possible).

2 General design



Gearboxes of series "600" are 3-shaft reversing and reduction units with offset shafts and clutches on the input shaft and the reversing shaft. The general design is the same for all gearboxes.

The principal components exposed to wear are accessible through a cover on the gearbox casing even when the gearbox is installed.

The cast gearbox casings are of exceptional torsional rigidity and consist of a light alloy largely resistant to salt water. The machined faces and tapped holes for attaching the gearbox mountings are included.

Size 1 bell-housing (per SAE J 617) is part of basic gearbox version. Size 0 can be supplied in scope of special supply.

Covers are fitted to seal input-side openings in housing on special version (without bell-housing).
On the basic gearbox version, these covers are integrated in the bell-housing.

In order to ensure en extended working life an quiet running, all drive gears are rated for a high margin of strength, casehardened, ground and given a special finishing treatment.
The shafts run in antifriction bearings. Propeller shaft thrust bearings are incorporated into the gearbox. The reversing clutches on the input and reversing shafts are of multi-disc type, with steel/ sintered plates pressed together by oil pressure.

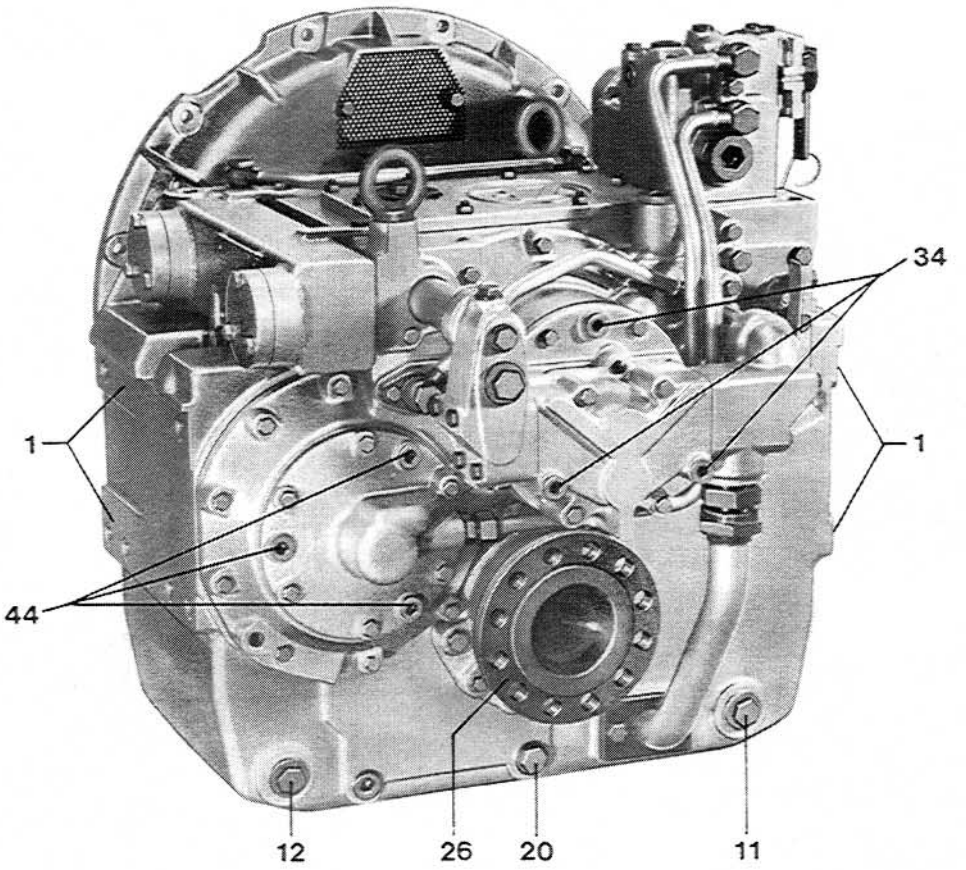
The high pump discharge rate ensures that the clutches respond rapidly when actuated. During the shift process the clutches' contact pressure is modulated to ensure a smooth shift.

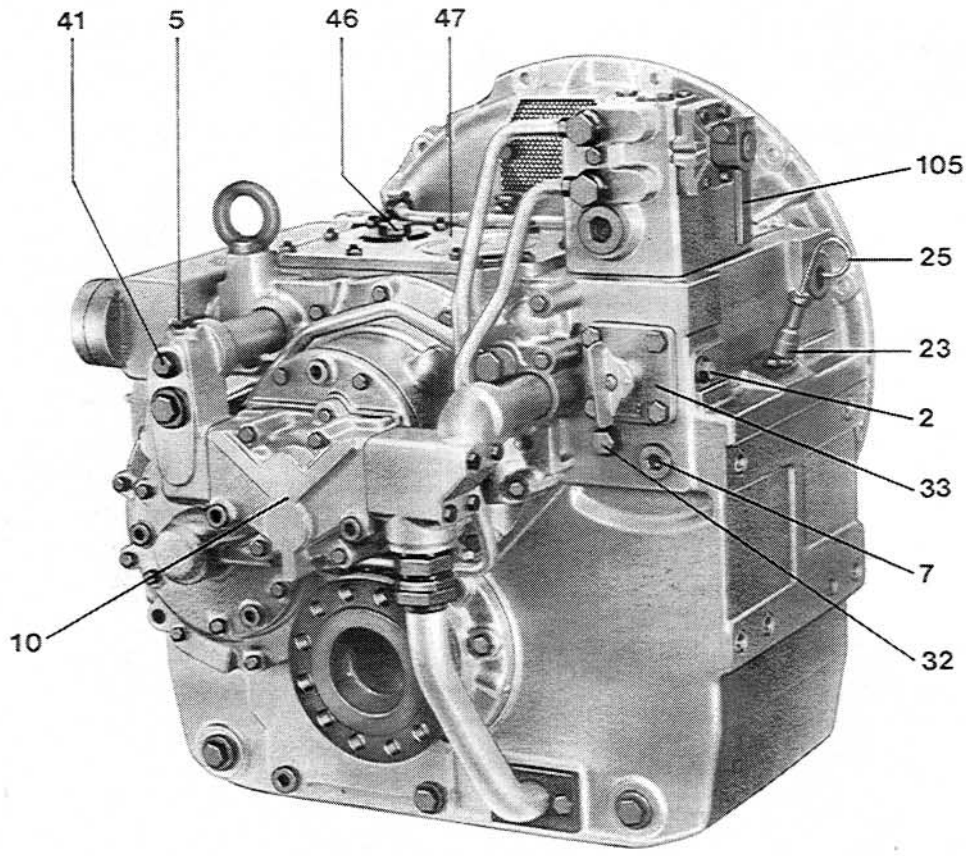
At the same time the clutch in engagement receives an increased flow of oil so that the heat generated during the shift process is rapidly dispersed and the clutches' load-bearing capacity enhanced.

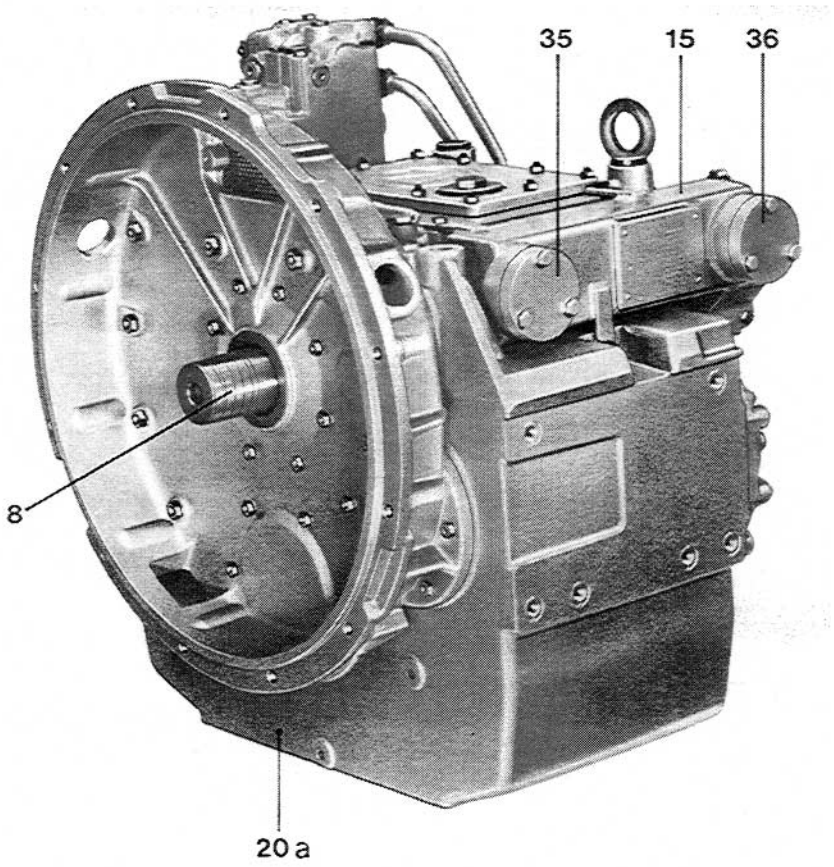
In the event of a fault in the actuating hydraulic circuit the two multi-disc clutches can be pressed together mechanically by means of 3 bolts accessible externally (but only when the gearbox is at a standstill). This emergency control method permits either enginewise or counter-enginewise rotation of the output shaft to be used.

To operate the gear shift an easily interchangeable control unit with all the necessary valves, spool valves and other control devices for the actuating and lubricating oil circuits is mounted on the gearbox casing. The unit is operated mechanically with a lever.
Pneumatic or electrical operation can also be specified.

ZF-Marine gears (basic gearbox)





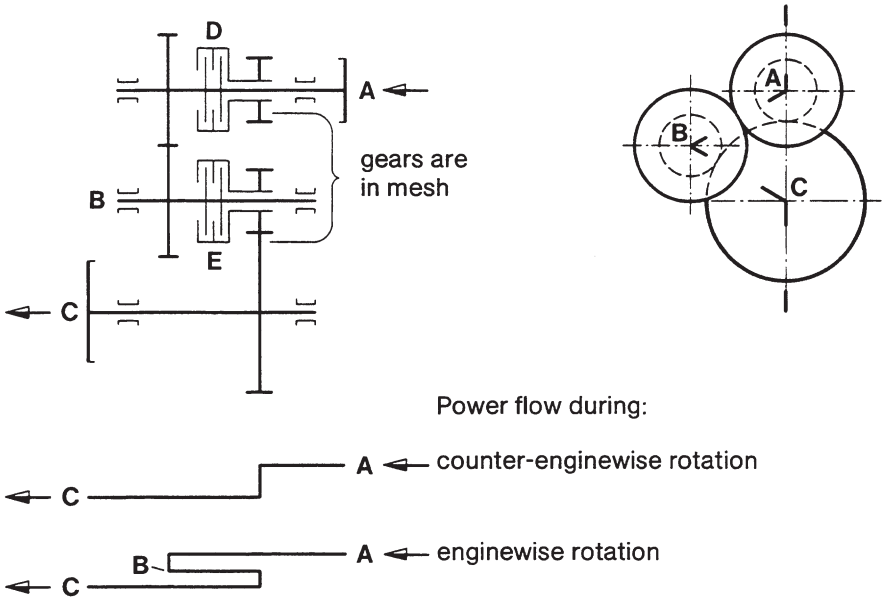


Key to drawings

1	*Mounting faces for gearbox*
2	*Pressure measuring point for clutch oil*
5	*Pressure measuring point before filter*
7	*Oil sludge drain plug*
8	*Input*
10	*Engine driven oil pump*
11 12 41	*Oil temperature measuring points*
15	*Oil cooler*
20	*Oil drain plug*
20a	*Position of oil drain plug on V-drive version*
23	*Gearbox breather*
25	*Oil dipstick*
26	*Output*
32	*Oil chamber drain plug*
33	*Oil filter*
34	*Emergency control counter-enginewise rotation*
35	*Cooling water inlet*
36	*Cooling water outlet*
44	*Emergency control enginewise rotation*
46	*Oil filling*
47	*Inspection cover gearbox housing*
105	*Control lever for mechanical auxiliary actuation*

3 Functional description

Gearbox and power flow diagram



A - Input shaft
B - Reversing shaft
C - Output shaft
D - Clutch for counter-enginewise rotation
E - Clutch for enginewise rotation

The power for "enginewise rotation" (output shaft rotation in same direction as input shaft) and for "counter-enginewise rotation" (output shaft rotating in opposite direction to input shaft) is transmitted as shown in the above diagram.

The full torque can be transmitted in both directions of rotation. Even the gearbox ratio is the same for both rotational directions of the output shaft. Identical gearboxes can therefore be used for multi-engine installations. This requires fewer spare parts and permits the use of standardized replacement assemblies.

4 Oil supply and gearbox cooling

The gearbox casings are designed as oil reservoirs. One gear pump is installed to supply oil for gearbox lubrication, cooling and engagement of the multi-disc clutches.

This pump supplies oil to the pressure oil circuit at a rate dependent on the speed of the gearbox input shaft. In order to ensure ample oil for gearbox lubrication and cooling even at a low driving speed, a high-output pump is used.

The oil pump is driven by the gearbox input shaft. Two pump versions are available to suit different engine speeds.

Gearbox oil is cooled by an oil cooler mounted on the gearbox and manufactured from salt water resistant material. After cooling, the oil passes through a slot-type filter to the control unit and then to the clutches and the gearbox lubrication points.

Connecting unions are provided as standard equipment for monitoring gearbox temperature, oil pressure ahead of the filter, and clutch oil pressure. For their locations and designations, see section II, 8.

5 Control unit and gearbox actuation

The control system is arranged as a complete unit on the gearbox housing. It comprises:

- the *control valve* for charging and draining the clutch packs
- the *control valve* for the clutch pressure level
- the *time switch* for modulating the clutch pressure.

The oil wich flows out of the control unit is used to lubricate and cool the clutch discs, meshing gears and bearings.

Different control units are used according to gearbox actuation.

When the gearbox is actuated *mechanically* the control valve (rotary valve) is moved by means of the shift lever, laterally mounted on the control unit, via a push-pull cable or a linkage. A dial shows the particular shift position engaged. The manual actuation belongs to the basic version of the gearbox.

When the gearbox is actuated *pneumatically* the same control unit as for mechanical actuation is used. The control valve is moved into the shift positions, i.e. enginewise or counter-enginewise rotation, by means of a 3-way cylinder actuating on the shift lever, and reset to neutral by spring pressure. The pneumatic gearbox actuation is a part of the scope of special supplies.

When the gearbox is actuated *electrically* the control valve acts as a spool valve. It is moved axially into the shift positions, i.e. enginewise or counter-enginewise rotation, by means of oil pressure. Resetting to the neutral position is effected by spring load or oil pressure according to version (I or II. see section II. 7.3). The necessary oil flow is taken from the control unit. The oil flow itself is controlled by solenoid valves. The electrical gearbox actuation is a part of the scope of special supplies.

6 Test run and storage

Before the ZF marine gears are delivered to our customers, they are tested under load on the test bench and during this test every function, oil pressure, temperature and noise level is checked thoroughly and recorded. After the test run the interior of the gearbox is slushed with oil as a preservation measure. The gearbox can now be stored in a dry place for up to 12 months without taking any further special measures.

Any necessary preservation measures on the exterior of the gearbox depend on storage conditions and should be undertaken by the customer. Preservation measures for long storage periods should be specified when ordering the equipment.

II Gearbox installation

When planning the power pack, care must be taken to provide sufficient free space for replacing the oil cooler, oil filter, oil pump, clutch packs and discs and for checking the dipstick. (The dimensions for these procedures are given in the gearbox installation drawings.)
It is possible to remove clutch packs and discs with gearbox still installed.

The oil drain plug should also be easily accessible. If there is not enough space available to place a pan under the oil drain opening for collecting the oil during oil changes, then it is advisable to fit a suction pipe positively to the gearbox instead of the oil drain plug to carry out oil changes by this way.

Important!

The following screw connections for which the customer is responsible must be rated according to the operating loads supplied:

- suspension brackets—gearbox (as far as not ZF-scope of supplies)
- suspension brackets—foundation
- flywheel housing—gearbox bell-housing
- flexible coupling—engine/ gearbox
- gearbox—propeller shaft

The necessary safety equipment for rotating components must be available, e. g.

- protective covers for output flange, flexible coupling or engine flywheel drive shaft.
- protective covers and guard equipment for artic shaft.

1 Permissible installation position

The installation documents applicable to the gearbox supply contract shall apply (see "Direction of propeller rotation", page 7).

2 Gearbox attachments for transportation

The lifting gear used for lifting the gearbox for transportation should only be attached to the lugs mounted on the top of the gearbox housing.

Under no circumstances may the lifting gear be attached in other places, particularly not to the input shaft, the output shaft, the covers, the oil pumps or the pipes.

3 Gearbox mountings on foundation

The sides of the gearbox housing are provided with machined pads and bolt holes. The surfaces of the mounting brackets which face the gearbox must be finished with surface machining.

If required, dowels may be used in those points indicated in the installation drawing.

The gearbox can be mounted in the foundation separately, or can be mounted together with the engine (on versions where the units are flanged) either rigidly or elastically.

In the case of a flexibly mounted gearbox the natural frequency of the resilient supports chosen must also be calculated. This may, on no account, coincide with the exciting frequency of the engine unit. If the propeller thrust is taken up by the gearbox (propeller thrust bearings for ahead and astern thrust are incorporated in the gearbox) the supports must also be suitable for taking up the propeller thrust.

To align the gearbox on the foundation (see connection to propeller shaft) very strong supports must be used. Individual supports — only around the individual foundation bolts — are not permissible. The mounting brackets supplied by ZF are provided with aligning screws. These screws must be removed again after the support have been placed in position.

We recommend the use of fitted bolts to secure the mounting brackets to the foundation. If through bolts are used, solid stops should be fitted with, at least in the direction "ahead propeller thrust".
The size of the mounting bolts (No., diameter, grade) depends on the operating loads, and is to be specified by the shipyard.

4 Connection to engine

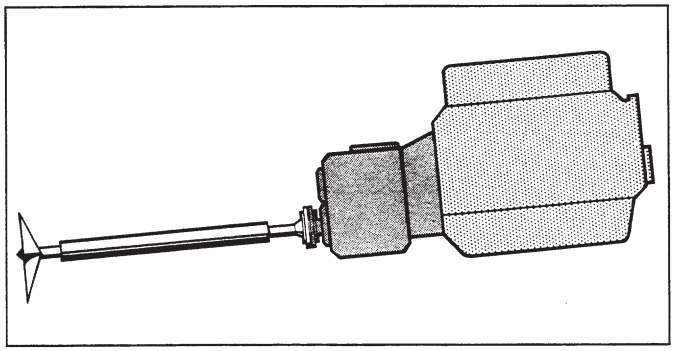
If a rigid connection between engine and gearbox is not possible due to the vibration calculation, the engine torque must be transmitted to the gearbox by means of a flexible coupling. This is to prevent any detrimental vibration resonances within the operating speed range by controlling the natural frequency of the engine, gearbox and propeller. If, in special cases, a critical speed within the operating speed range is inevitable, a limiting range must be specified for certain speeds. This is dependent on the value of the calculated vibration amplitude.

The flexible coupling to be used is generally selected by the engine manufacturer with the aid of a torsional vibration calculation. The gearbox data necessary for this calculation can be taken from our "Data for torsional vibration calculation" sheet.

If a flexible coupling is supplied by ZF according to the selection of the engine manufacturer or as stipulated by the shipyard, ZF can in no way be held responsible for the suitability or durability of the flexible coupling.

The assembly and disassembly of the clutch hub or the input flange i.e. the part of the flexible coupling on the input side facing the gearbox side has to be carried out according to the workshop manual of this gearbox range.

4.1 "Normal" engine arrangement



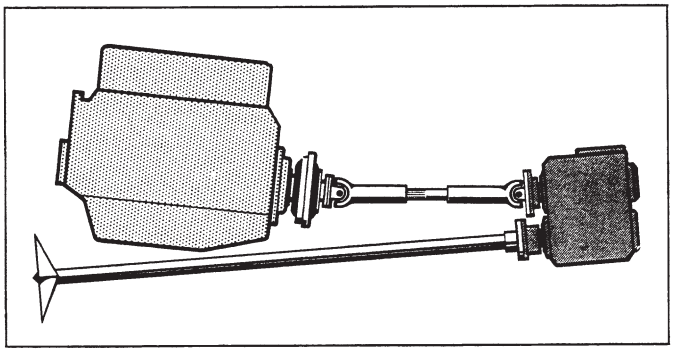
Normally the gearbox is flanged to the engine. In this case, the two units are properly centered. In addition, the torsionally flexible connection is not required to absorb any additional forces created by shaft misalignment.

The engine/ gearbox assembly can be mounted either rigidly or elastically in the foundation. If it is mounted elastically, care must be taken that the conditions laid down in section 5 are fully complied with.

If the gearbox is installed separately, the foundation mounting will be either rigid or elastic. Normally the engine is mounted elastically. The torsionally flexible input connection must also be capable of absorbing misalignments of the engine axis to the gearbox axis.

The elasticity of the engine mounting, as well as the aligning accuracy between the engine and the gearbox must, related to the gearbox, be selected so that the axial and radial forces bearing on the gearbox due to the retroactive forces of the flexible coupling do not exceed the permissible limit (see page 6).

4.2 V-drive arrangement



Gearboxes with both the input and output flanges at the same end of the gearbox are used for the V-drive engine arrangement (.. 160 S, .. 165 S, .. 165 SP, .. 165 SP1).

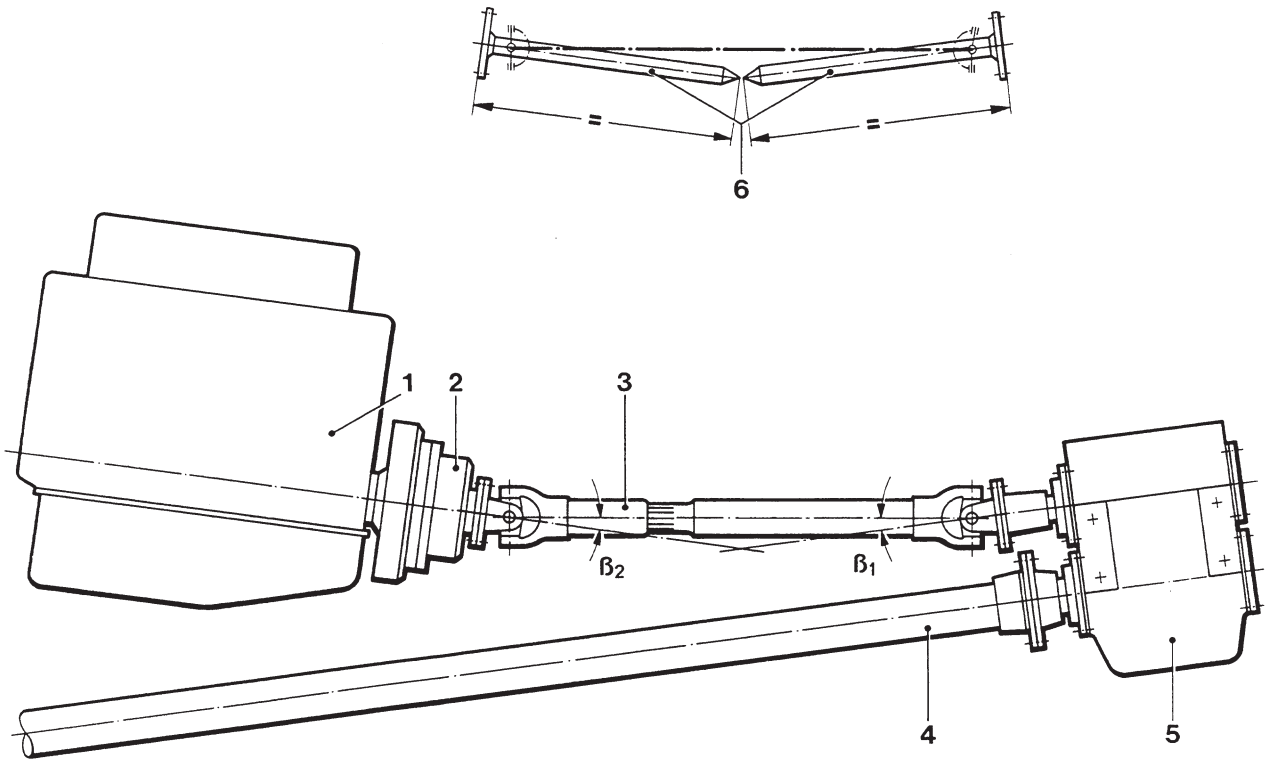
The same conditions as in section 4.1 apply to the connection between the engine and the gearbox, but an additional, variable-length drive shaft is used between the torsionally flexible connection and the gearbox input flange. The joints of the drive shaft create radial forces and flexural torque. In addition, the changes in the distance between the engine and gearbox cause such axial forces to occur, as can be transmitted by the joints in the additional drive shaft. The total value of all these forces and bending moments depends on the torque transmitted, the length of the drive shaft and the size of the joint angle.

These forces and bending moments are absorbed by the foundation at the gearbox end by the gearbox input shaft, gearbox housing and mounting bracket, and at the engine end by the torsionally flexible connection, crankshaft and engine housing. For this reason, the torsionally flexible connection must be fitted with additional suspension elements between the primary and secondary sides. If the torsionally flexible connection or the engine crankshaft are not capable of absorbing the forces and bending moments created by the drive shaft, an additional bearing must be installed between the drive shaft and the torsionally flexible connection. This bearing can be supported by a flange on the engine, or else an intermediate shaft can be installed and mounted in the foundation. This latter solution can also be applied in cases where an elastic engine mounting is not capable of absorbing the additional forces which occur. The forces and bending moments created by the drive shaft occur periodically at twice the engine speed of rotation. The mounting brackets for the engine, or for the intermediate shaft and gearbox, must be of adequate dimensions to prevent and impermissible distorsions, which would cause vibration and noise. If necessary, the foundation must be strengthened.

The size of the drive shaft is dependent on engine output, the size of the joint angle and the desired life of the drive shaft. The drive shaft-manufacturer will normally make recommendations in accordance with the actual operating conditions to be encountered. In order that the drive shaft can operate at the optimum kinematics, the joint angles must be of the same size at both ends and the joint forks in the same plan. Efforts should be made to ensure that the joint angles are as small as possible (max. approx 7^{o} to 8^{o}) and that the middle section of the drive shaft has as small a dynamic rotating mass as possible. The technical information supplied by the drive-shaft manufacturer will give details.

To check the joint angles when aligning the engine, two alignment shafts of equal length can be installed in place of the drive shaft. The engine will be properly alignet (and the joint angles of equal size) when the ends of the two alignment shafts meet — see installation diagram.

V-drive arrangement installation diagram



1 *Power unit*

2 *Self-centering torsional flexible connection. Specified according to engine output and torsional vibration calculation.*

3 *Variable-lenght drive shaft Selected in accordance with manufacturer's recommendations. Comply with installation instructions ($\beta_1 = \beta_2$, joint forks mounted in the same plane)*

4 *Propeller shaft*

5 *Marine gearbox with input and output at the same end*

6 *Installation to help in the correct alignment of the engine and gearbox, i.e. to achieve equal joint angles β_1 and β_2. Install two alignment shafts in place of the drive shaft. The shafts must be of equal length. Align the two units so that the ends of the shafts meet. Finally remove the alignment shafts and install the drive shaft.*

5 Connection to propeller shaft

The rating of the propeller shaft mounting is dependent on the operating loads and must be specified by the shipyard.

The output flange of the gearbox is so designed that the maximum permissible torque for the gearbox can be transmitted frictionally. For this purpose, all bolt holes and bolts M 16 of material quaility 8.8 (minimum tensile strength 800 N/mm^2) must be used.

If body-fit bolts are used, the bores of the propeller-shaft flange together with those of the gearbox-output flange (material strength 750 to 900 N/mm^2) may be opened out by drilling and reaming.

5.1 Aligning the gearbox

If the gearbox mounting is extremely flexible the connection between the gearbox output flange and the propeller shaft must normally be capable of absorbing relative movements (e.g. joint coupling or flexible coupling). This does not apply if the propeller shaft is also extremely flexible.

If the propeller shaft is connected rigidly to the output flange of the gearbox, the gearbox must be aligned with the propeller shaft. To do this, the vessel must be fully fitted-out and afloat. If necessary, the alignment procedure must be repeated before the vessel goes into service.

x [mm]	max. 0.05
y [mm]	max. 0.1
L [mm]	min. 500 for d <60 mm min. 1000 for d 60 to 90 mm min. 2000 for d >90 mm

Fig. A

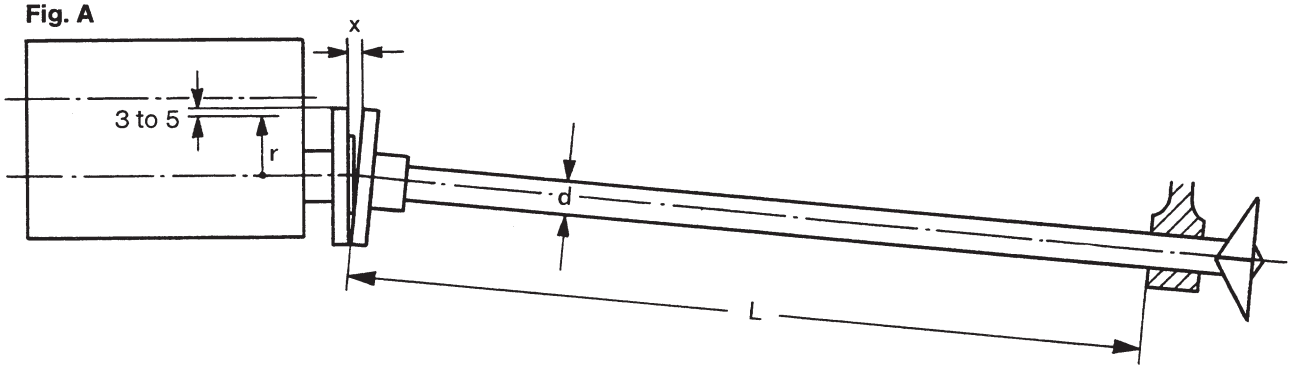
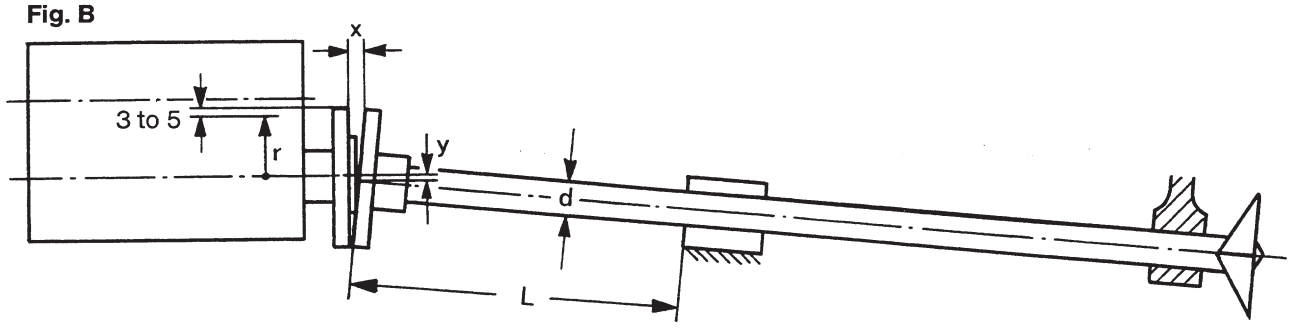


Fig. B



Shafts with only one propeller-shaft bearing (Fig A)

It must be possible to move the propeller shaft axially and radially so that the propeller-shaft flange can be fitted in the centering of the gearbox output flange. The gearbox must be so aligned — see also section 3 — that the permissible angle error "x", referred to measuring radius "r", does not exceed the value stated in the table (value "y" is disregarded).

Shafts with two or more propeller-shaft bearings (Fig. B)

It must be possible to move the propeller shaft axially so that the propeller-shaft flange can be fitted in the centering of the gearbox output flange. The gearbox must be so aligned — see also section 3 — that the offset "y" and the angle error "x" (referred to measuring radius "r") do not exceed the values stated in the table. Both errors may be present at the same time. If the propeller shaft has a very small diameter and the distance "L" is very great, it may not be possible to measure the value "y". If the propeller shaft can be installed in the centering of the gearbox output flange with a maximum radial force not exceeding 500 N, the "y" value can be disregarded. If this is the case, the alignment instructions for shafts with only one propeller-shaft bearing apply.

Note:
The values given for "x" and "y" only apply when distance "L", between the propeller-shaft flange and the final shaft bearing, is great enough in relation to shaft diameter "d".

6 Connections for gearbox cooling and monitoring

6.1 Cooling water connection (Data applies only to coolers mounted as standard)

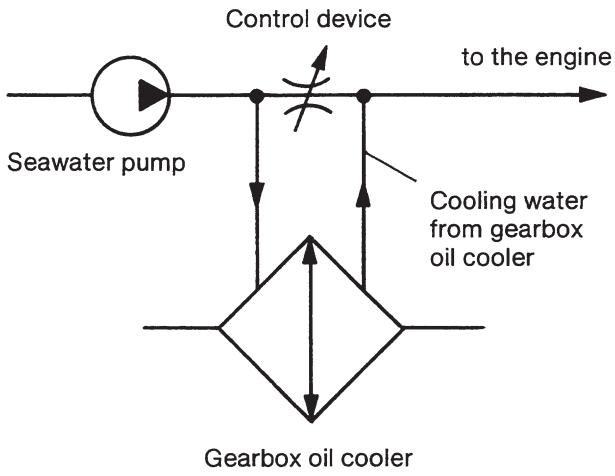
The volume of heat generated in the gearbox is removed partly by radiating from the surface of the housing and partly through the oil cooler. The oil cooler included in the basic version of the gearbox is mounted on the housing. All the necessary oil lines are securely attached and ready for operation.

The cooling water inlet and outlet parts are located on the oil cooler sides and blanked off for shipment. The blanking-off flanges can be used as welding-on flanges when installing the cooling water line. The positions of the cooling water inlet and outlet connections are shown in the gearbox installation drawings.

The direction of water flow is to be maintained i.e. water inlet and water outlet may not be interchanged.

For permissible water flow rate and pressure loss between cooling water inlet and outlet see "Summary of technical data". The specified water pressure at the cooling water inlet must not be exceeded. The cooler is designed to ensure adequate heat dissipation at a gearbox ambient temperature of 60 °C and a water inlet temperature of 40 °C — even at full gearbox load and maximum speed.

Arrangement of the gearbox oil cooler in the seawater circuit



The correct gearbox temperature is achieved by adjustment of the cooling water flow rate. A replaceable orifice, valve or similar must be included in the circuit for this purpose. For this reason, the gearbox water circuit should be arranged in a by-pass from the engine cooling water circuit.

The maximum temperature increase of the cooling water in the gearbox oil cooler is 3 °C and is of no significance to the engine oil circuit. The stated maximum cooling water flow through the gearbox oil cooler must not be exceeded, since this may lead to cavitation in the cooler. Similarly, the minimum flow rate must always be maintained or else sludge may form in the cooler after only a relatively short period of operation.

The pipes and shut-off valves for the sea water circuit must be manufactured from copper or material containing copper for operation in sea or brackish water. Galvanized steel pipes may not be used due to the risk that the zinc coating may be eroded by galvanic processes and rust debris be deposited on webs of flanged pipes of the cooler. Within a short period of time, this would lead to the cooler being damaged by corrosion.

The water pipes have to be connected to the cooler in such a way that stresses and recoil forces caused by thermal expansion will be avoided. If routing of the water pipes makes this impossible, flexible connections must be fitted and arranged as closely as possible to the cooler.

6.2 Connection of monitoring devices

The minimum monitoring facilities specified in the monitoring diagram page 4 and 5 must be provided (monitoring equipment is not included in the standard scope of supplies).
The equipment necessary should be installed in such a way that reliable instrument readings can be taken at any time even under unfavorable operating conditions. The display scales of the monitoring equipment should be selected so as to achieve the maximum possible pointer deflection in the operating range. In addition to the specified minimum monitoring facilities, further indicating or warning equipment can be connected to the points sealed by screw plugs.

7 Gearbox actuation devices

The gearbox can be actuated mechanically, pneumatically or electrically according to choice. The mechanical actuation is standard equipment. The actuation mechanism must be designed so that a gear change can only occur when the engine throttle control lever is set at idling. This can best be obtained with "single lever control" whereby engine throttle control and gearbox control are interlocked. When using "dual lever control", a locking device should be incorporated in the gearbox actuation system so that a gear change can only be carried out when the engine throttle control lever is set at idling.

A cutout device for the gearbox should also be provided for single lever control, so that the engine can be run at high speed for inspection or warming-up purposes without having to actuate the gearbox.

7.1 Mechanical gearbox actuation

The rotary valve is installed horizontally in the control housing. The selector lever is mounted on the splined shaft which emerges from the control housing and held with a clamping bolt. The bore hole in the gear selector lever is for attaching the push/pull cable or the gear shift linkage. After loosening and removing the clamping bolt, the selector lever can be pulled off and then remounted 10^{o} further round the shaft axis — a distance of 8 mm measured at the bore hole connection. The distance of the bore from the pivot and the required rotary-valve shift angles are selected so that standard remote-control devices with a shift stroke of app. 25 to 35 mm (from neutral to the forward or reverse position) can be attached directly. The control housing has two M8 bore holes for attaching a reaction bearing for the push/pull cable. The dimensions of the reaction bearing and the position of the gear shift lever are to be selected so that the push/pull cable is at an angle of app. 90^{o} to the shift lever. A notch indicates the theoretical neutral position of the rotary valve.

Checking selector positions:
From neutral, select the forward or reverse position at the shift lever on deck an check the shift angle at the gear selector lever. The indicating pin on the lever must point within the raised area designating enginewise or counter-enginewise rotation — see diagram.

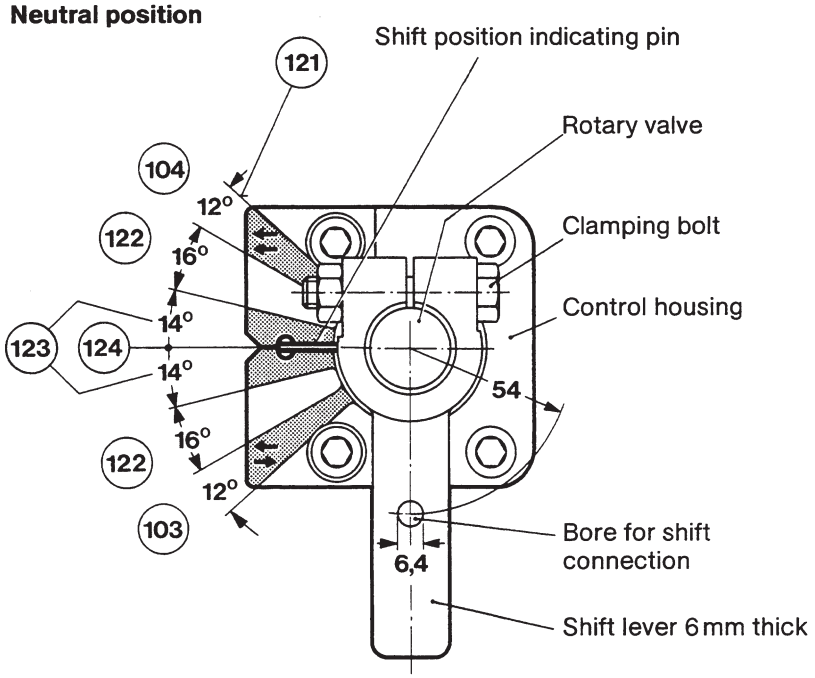
Checking neutral position:
From the forward or reverse position, select neutral at the shift lever on deck. The indicating pin on the gear selector lever must point within the raised area designating the neutral shift position.
The shift movements in the gearbox must be checked at regular intervals and after all repairs or overhauls and adjusted, if necessary.

Caution!
Clutch pressure can drop in undefined shift range. This can damage the reversing clutches by causing "clutch slip".

When the distance between actuation device and gearbox control lever is too large, it is difficult to maintain the specified control position by mechanical means. In such cases wie recommend the use of pneumatic or electric gearbox actuation devices.

Mechanical gearbox actuation

Neutral position



103 Counter-enginewise position

104 Enginewise position

121 Selector lever stop

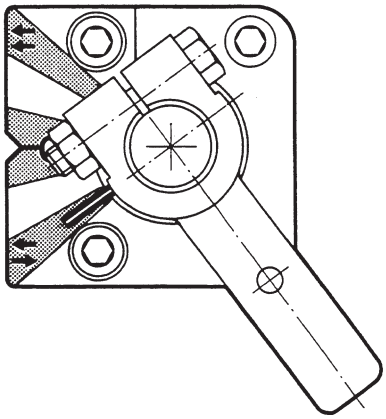
122 Undefined selector position (pass through this area quickly)

123 Reliable neutral range

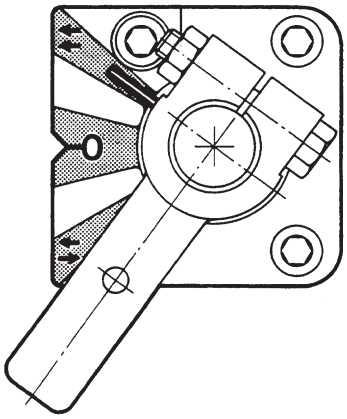
124 Neutral detent position

Actuation force = max. 50 N at radius 54 mm

Counter-enginewise position



Enginewise position

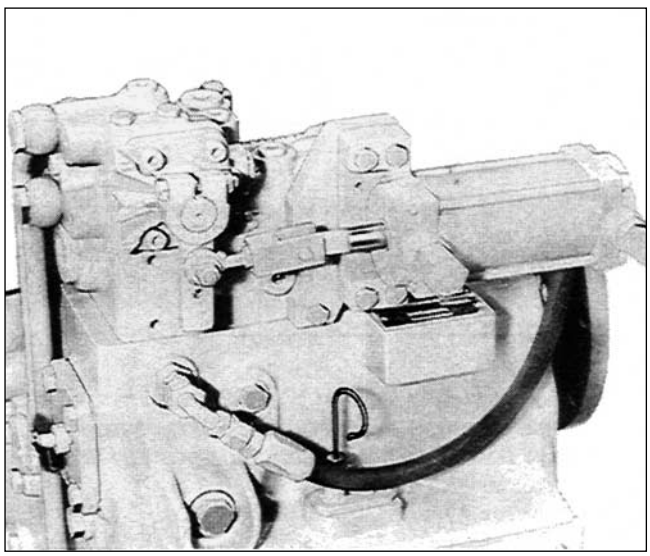


7.2 Pneumatic gearbox actuation

For pneumatic gearbox actuation the same control unit is used as for mechanical actuation. A 3-way cylinder shifts pneumatically to the enginewise or counter-enginewise position by means of the selector lever. If a failure occurs in the pneumatic system the gearbox can be actuated mechanically by the selector lever (see section III. 3.2).

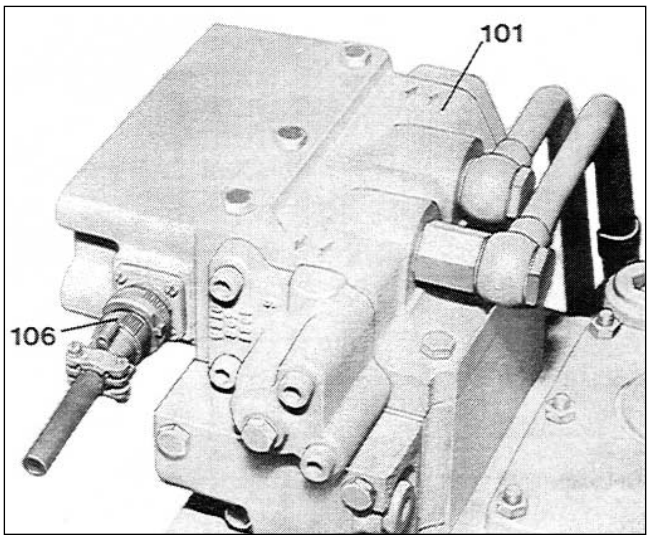
The compressed air supply must be arranged according to the pneumatic circuit diagram supplied with the equipment. Losses caused by leakage are so small in the pneumatic system that apart from the small quantities lost during the shift procedures, compressed air consumption does not have to be checked.

Warning!
If the air supply should fail, the gearbox will shift to neutral automatically.



7.3 Electric gearbox actuation

In the case or electric gearbox actuation the control valve (spool valve) is moved axially by oil pressure.



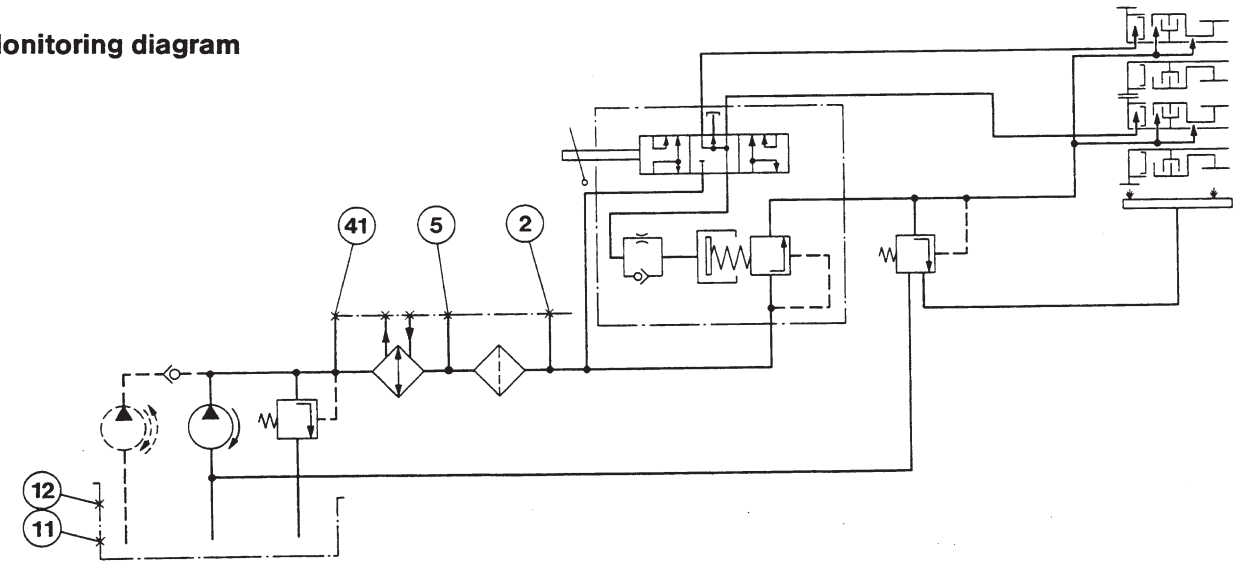
101 Electric actuation device

106 Electrical connections (plug connection included in ZF scope of supply)

The necessary data of the electric connections and the soldering procedures of the plug element are shown in the documentation supplied with the gearbox.
If there is a failure in the power supply, the gearbox can be actuated manually (see section III, 3.3).

8 Gearbox monitoring

Monitoring diagram



The monitoring facilities stated in section 8.1 are essential as a check on the operating reliability of the gearbox and must always be installed. In addition, the gearbox is provided with measuring outputs for additional monitoring equipment (see section 8.2).

8.1 Minimum gearbox monitoring facilities
(for values, see table on page 4 and 5)

Pressure reading before filter (measuring point 5)
This measuring point is intended as a means of monitoring the oil filter. At normal operating temperature and with the filter clean the pressure drop through the filter is 0.5 to 1.0 bar, so that the pressure reading ahead of the filter will be that much higher than the pressure at measuring point 2. Any additional rise in pressure indicates that filter is becoming increasingly blocked.

A pressure sensing switch must be used for monitoring. It should be set to change over when pressure rises above the preset valve, and transmit a warning signal.

Clutch oil pressure (measuring point 2)
Depending on the gearbox version and its input torque, the clutch oil pressure setting will vary. The nominal clutch oil pressure is confirmed in the technical documentation forming part of each order, and also stamped on the gearbox type plate (see section I. 1, pos. 9).

The clutch oil pressure indication applies to both the enginewise and counter-enginewise shift positions. In neutral the oil pressure at this measuring point drops to 10.0 to 7.5 bar, depending on input speed and oil temperature. To monitor clutch oil pressure, a pressure gauge must be used.

If clutch oil pressure is in accordance with the specified values and the conditions stated above apply, gearbox lubrication will be assured. For this reason, separate monitoring of lubricating oil pressure is unnecessary.

Oil temperature (measuring point 12)
A thermometer must be used to monitor gearbox oil temperature. The volume of water flow through the gearbox oil cooler must be regulated until the gearbox oil temperature remains within the recommended normal range during normal operation. The maximum gearbox oil temperature must not be exceeded during continuous operation (see section III. 2).

8.2 Additional gearbox monitoring
(for values, see table on page 4 and 5)

Additional measuring points are provided in the form of unions on the gearbox if a higher level of gearbox function monitoring is desired. The relevant values are the same as those at the measuring points for the minimum monitoring facility.

Pressure reading before filter (measuring point 5)
If monitoring is to take place by means of a pressure gauge and a warning device, a T-union can be attached at measuring point 5 for the simultaneous connection of a pressure gauge and a pressure sensing switch. It is also possible to use a pressure sensor with built-in switch contact for an alarm device if a remote reading instrument is to be provided. The oil pressure must not exceed the corresponding value at measuring point 2 by more than 4 bar, nor exceed the value at which the warning signal is transmitted.

Clutch oil pressure (measuring point 2)
An additional pressure-sensing switch with a warning device or pressure gauge can be fitted to measuring point 2 by attaching a distributor piece.

When monitoring is by way of a pressure-sensing switch, this must be adjusted so that the alarm signal is transmitted if pressure drops below the warning limit.
In the neutral setting of the gearbox, oil pressure will drop below the trip value for the pressure-sensing switch, so that the alarm would normally be given in neutral even if oil pressure were normal. To prevent this, the warning device must be interlocked with the selector lever so that it is out of action in neutral (by providing an on-off switch (ZF-special scope of supply) actuated by the gear selector or some similar device). To prevent the alarm from tripping in the period between operation of the control unit and build-up of the full clutch oil pressure (app. 1 to 2 s), a delay timer must be incorporated additionally, with a setting of min. 3 s and max. 10 s, in the line from the alarm device.

Oil temperature (measuring point 11)
An additional temperature sensor can be connected to measuring point 11 for a remote thermometer or a temperature warning switch. The temperature switch must be set to the warning value specified for the gearbox version used.

Measuring point 41
This measuring point can be used in gearbox versions equipped with a trailing oil pump.

Important!
Measuring point 41 is not located in the oil sump. It can only be used for monitoring oil temperature if the oil is being circulated (engine running or rotating propeller shaft).

9 Necessary measures before putting the gearbox into operation for the first time

9.1 Oil filling, oil level check

See section "Maintenance", for correct procedures.

9.2 Installation check

First rotate the engine by hand and then the prop shaft. Check for ease or operation.

Check that clamping bolts of mounting brackets on gearbox and foundation are tightened positively. Check that connecting bolts between propeller shaft flange and gearbox output shaft flange as well as those on the gearbox input side are tightened correctly and secured. Check connections for supervision instruments, cooling water connection and electrical connections — as far as possible.

Functional test of control mechanism

On *mechanically controlled gearboxes* the indicating pin on the gear selector lever must point to the appropriate area of the control housing for every shift position. If necessary, the shift mechanism must be adjusted.

On *pneumatically controlled gearboxes* check shifting operation (appropriate position of selector lever) when engine is at stand still.

On *electrically controlled gearboxes* check operating voltage or power consumption at an appropriate place as near as possible to the plug connection of the electrical control unit.

III Operation

During operation the gearbox does not require any attention except for the supervision of the indicating devices for the gearbox temperatures and oil pressures.

1 Change-over procedure

According to our experience the change-over procedures as described in the following sections, procedure the best operational behaviour, with regard to the shortest possible time required for changing the travel direction of the vessel and, at the same time the greatest possible protection for the gearbox reversing clutches and the entire power transmission system.
We would therefore strongly recommend that the change-over sequences specified here are maintained.

Shift procedures from neutral to ahead or astern, or vice versa, should be carried out rapidly. It is forbidden to rest in the undefined areas between shift positions.

1.1 Change-over from neutral to ahead or neutral to astern

(The propeller shaft is at rest or only rotates very slowly.)

Move engine throttle control to idling, select desired travel direction and keep lever in this position for 1 or 2 secs. before increasing the engine speed to the required operating speed.

1.2 Change-over from ahead to astern with vessel moving at low speed (not applicable to BU ...)

Move engine throttle control to idling. Change position of gearbox control lever from present travel direction to opposite direction and keep it in this position for approx. 1 or 2 secs. before increasing the engine speed to the required operation speed.

1.3 Change-over from ahead to astern with vessel moving at higher speed

Move engine throttle control to idling. Leave gearbox control lever in "ahead", in order to utilize the engine braking effect on the propeller until the engine speed has dropped to approx. 1.2 x idling speed. Now move gearbox control lever to "astern" and keep it in this position for approx. 1 or 2 secs. before increasing the engine speed to the required operating speed.

1.4 Emergency change-over in case of danger

In case of emergency, it is of course possible to carry out a change-over from "ahead" to "astern" at higher engine speeds too. However, in this case as well we would recommend that there is a time lag of approx. 1 or 2 secs. after the "astern" direction has been engaged, before increasing the engine speed.
During such manoeuvres please note that in many cases (depending on the type of vessel etc.) the time needed to bring the vessel to a stop is not shortened at all or only very slightly compared with the change-over sequence described above. Therefore, in spite of the increased load on the propulsion unit, in most cases the chances of avoiding a collision are not greatly reduced.

2 Operation with engine stationary and propeller trailing

2.1 Occasional trailing operation

It is possible to carry out occasional trailing operations with the basic gearbox version installed (without trailing oil pump).

The gearbox oil temperature has to be monitored (measuring points 11 and 12 located in oil sump). The max. oil temperature must not exceed 75 °C. If the temperature exceeds this, the ships' speed must be reduced. Should it prove necessary, the engine can be started up for a short time until the gearbox oil temperature is brought below the max. permissible value by the cooling water circulation (gearbox in forwards or neutral position). A trailing operation of max. 24 hours is permissible in emergencies.

2.2 Regular trailing operation

If regular trailing operation is necessary and if it should take more than 5 hours without interruption, a gearbox version with trailing oil pump (refer to section IV. 5.1) must be used (trailing oil pump can not be retro-fitted).

The oil temperature must be monitored and may not exceed 105 °C (the oil sump temperature is approximately equal to the clutch disc temperature). If the oil temperature is too high, it is cooled either by reducing the trailing speed of the ship or by passing water through the gearbox oil cooler.
The cooling water can either be taken, via a special valve, from the engine cooling system in operation, or it can be delivered through a separately driven water pump. With these dimensions one can count on a cooling water capacity wich corresponds to max. 25 % of the water capacity during normal operation.

If the gearbox oil temperature rises to above 90 °C, the gearbox must remain in neutral after the engine has been started until the temperature drops below 90 °C. Only then is normal operation possible as described in section 1.

3 Operation with the mechanical hand actuation

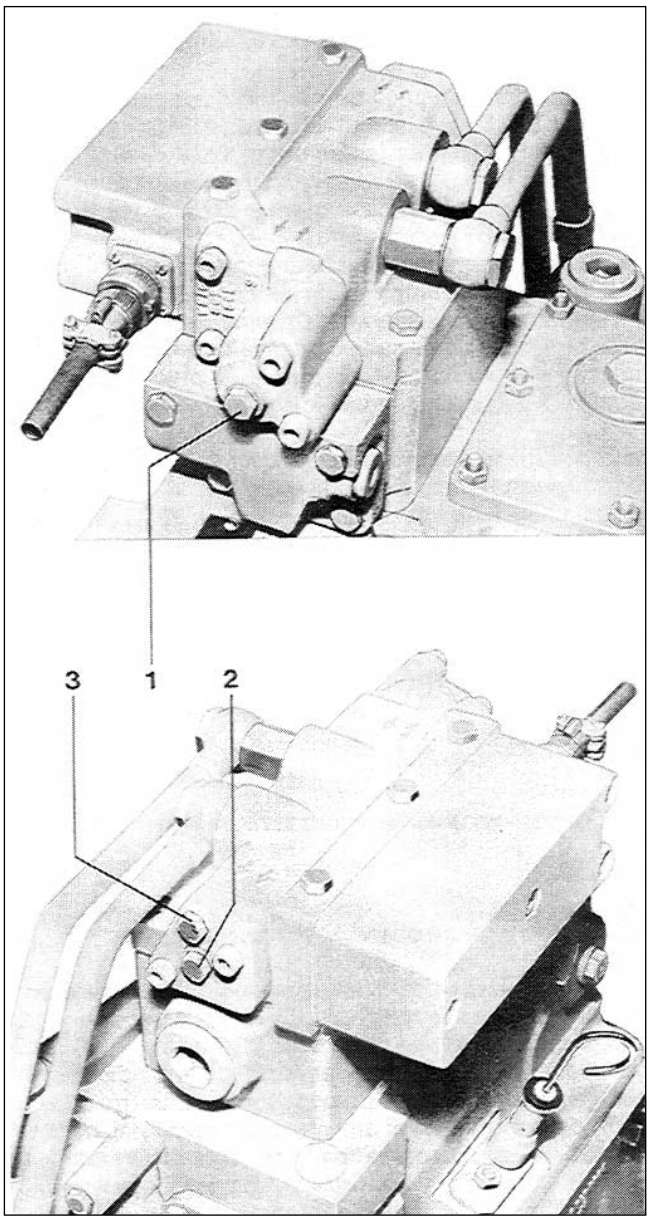
3.1 Version with mechanical gearbox actuation

If a fault should develop in the actuating system, the gearbox can be shifted at the gearbox selector lever after first detaching the push/pull cable or shift linkage.
The lever must be moved as far as the detent indicating each gear shift position. Appropriate measures must be taken to secure the lever and prevent it from jumping out of the ahead or astern position, wich might otherwise occur on account of vibrations for example. Comply with the gear shift instructions in paragraph 1.

3.2 Version with pneumatic gearbox actuation

The three-way cylinder which operates on the selector lever is designed in such a way that should the air pressure fail the gearbox is reset to neutral by spring pressure.
For manual control the selector lever must be moved against the spring load to the desired position and secured by appropriate means.

3.3 Version with electric gearbox actuation



Gear change operation

- Switch-off main switch on electric gearbox actuation
- For enginewise rotation remove screw plug 2 and replace with auxiliary screw 3
- For counter-enginewise rotation remove screw plug 1 and replace with auxiliary screw 3
- Cut-off is effected in the inverse order

Important!

- If the gear change operation is carried out whilst the engine is running the same safety precaution as for revolving engine elements are to be observed .
- Small oil leak is possible when screw plug is removed
- Auxiliary/ screw plugs to be provided with seal ring before insertion

" In case of power failure gearbox automatically reset to neutral ".

The gearbox actuation is designed to shift automatically to the neutral position in case of a power failure.
In case of a defect in the electrical actuation device or a power failure the gear can be controlled manually by moving the valve (spool valve) mechanically with an auxiliary screw into the required control position.

4 Operation with emergency control

If no power transmission occurs despite manual control (section III, 3) there is a fault in the gearbox. In such cases, the clutch discs of the shift clutches can be pressed together mechanically by the clamp bolts in the gearbox.

The clutch for counter-enginewise direction or rotation and that for enginewise direction of rotation both have three clamp bolts which are accessible from outside the gearbox, on the front end of the housing opposite the gearbox input side. The openings in the housing are sealed with screw plugs.

The emergency control can be used in compliance with the following conditions:

a) with the gearbox at operating temperature, the oil pressure at measuring point 2 must be at least 7.5 bar, in which case unrestricted operation is permissible.

b) the oil pressure at measuring point 2 is not available. In this case max. 50 % engine speed operation is permissible.

The special key required for operating the emergency control (SW 8 Allen key, length 280 mm) is available from ZF with the order number 1X56 137 055.

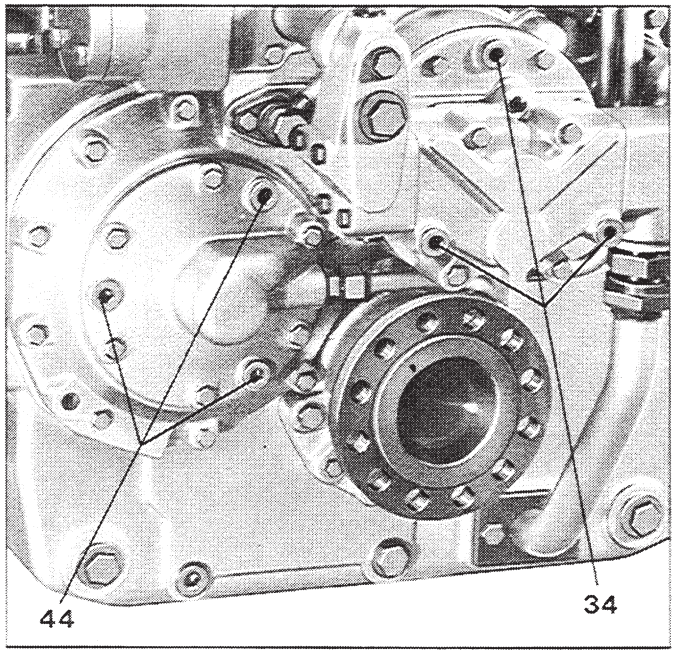
Only one shift clutch on the gearbox may be closed at any one time, otherwise power will be transmitted in both directions of rotation and the gearbox will be jammed. When the emergency control is in use the normal gearbox actuation mechanism must be rendered inoperative for the same reason, and the selector lever on the control unit (for mechanically or pneumatically actuated gearboxes) must be in neutral. For electrical gearbox actuation the control valve must be in neutral (see section III. 3.3).

The emergency control is to be operated in the following sequence:

1. Stop the engine.
2. Decide which clutch is to be used.
3. Loosen and remove the screw plugs.
4. Insert the key as far as possible in one of the three holes. Turn the engine or gearbox input shaft slowly until clamp bolt contacts Allen key. The direction of rotation is unimportant, but the required position must be reached after a maximum 120° turn. Withdraw Allen key approx. 30 mm and turn engine or gearbox input shaft very slightly (approx. 1°) until Allen key can be inserted in clamp bolt.
5. Tighten the clamp bolt right down by turning it several times in clockwise direction. Repeat this procedure with the other two clamp bolts by inserting the key in the appropriate openings; turning the input shaft will not be necessary. Then tighten all three bolts to a torque of app. 25 Nm.
6. Seal the bores in the housing with the screw plugs.

With the emergency control set up in this way, the engine can be started and the vessel taken to the nearest repair dock.

To make the emergency control inoperative, proceed as for setting it up by following points 1 to 4. Then turn clamp bolt anti-clockwise as far as the stop (a torque of approx. 10 Nm is necessary). Repeat the procedure with the other two clamp bolts. Finally seal the bores in the housing with the screw plugs.



34 Emergency control for counter-enginewise direction of rotation

44 Emergency control for enginewise direction of rotation

IV Maintenance

1 Maintenance schedule

Regular maintenance

Maintenance level	Operating hours	Max. value
A 1	every day of operation	3 months see also K 1, K 2
A 2	after 500 each	6 months
A 3	after 1000 each	1 year
A 4	after 4000 to 6000 each	5 years
A 5	during every basic overhaul of engine	operating condition of gearbox

Additional maintenance jobs on new or overhauled gearboxes, necessary only once

Maintenance level	Operating hours	Max. value
Z 1	50 to 100	12 months

Necessary measures for protection against corrosion after a long period out of use

Maintenance level	Procedure	Period out of use
K 1	every 10 to 20 days	up to 6 months
K 2	at end of operating period	9 months
K 3	at end of operating period	max. 36 months

The operating hours given in the maintenance schedule as well as the test and maintenance jobs given in the maintenance work plan are the results of *average* operating data. Therefore the data can only be guide values. Under special service conditions it may be necessary to change the time schedule and maintenance work plan.

Also, it is useful to adapt the maintenance periods given in the operating hours to the corresponding maintenance periods of the engine, as long as the operating hours given are not exceeded to a great extent. This is especially applicable for the maintenance levels A 4, A 5 and K.

The necessary protective measures against corrosion after a long period out of use for a gearbox installed in a ship are largely dependent on temperature fluctuations, atmospheric humidity and the salt content of the atmosphere in the machine room. Therefore the recommended measures and data can only be seen as rough guide values. In case of doubt we recommend implementing the protective measures on the marine gear similar to the ones on the engine.

For a period up to *3 months* out of use, in normal cases, no protective measures against corrosion are necessary.

If the period of non-use is *less than 6 months* we recommend that the measure K 1 is carried out every 10 to 20 days. Before the craft is put into operation again it may be necessary to change the oil (see Maintenance stage Z 1), according to the condition of the oil already in the gearbox.

K 2 is a preservation measure and should be implemented immediately at the end of operation if a period of more than 6 months out of use is intended. K 2 may be implemented also in the case of shorter periods out of use, instead of K 1.

K 3 is a long term preservation measure and allows for a period of non-use of the marine gear up to a max. of 36 months. The preservation can also be carried out acc. to K 2 instead of K 3. This preservation measure must, however, be repeated every 9 months.

2 Protection against corrosion. Preservation

K 1 Protection against corrosion

Start the engine and let it run at idling speed or somewhat above idling for at least 5 minutes in order to lubricate the gearbox thoroughly. The gearbox can be in neutral, or in either direction of rotation. Repeat this procedure every 10 or 20 days. Before putting marine gear into service again check the oil for condensation water (emulsion effect). This check must take place immediately after the engine has been turned off — the oil must not show any turbid aspect.

K 2 Preservation

After operation, drain the gearbox oil and top up with anti-corrosion oil to at least the low oil level mark on the dip-stick (see description of maintenance work).
Use anti-corrosion oil grades C 642 or C 644 acc. to MIL - L - 21 260.

Immediately afterwards allow the engine to run in the position "enginewise rotation" or "counter-enginewise rotation" for approx. 5 to 10 minutes with increased engine speed (max. 50 % of the nominal operating speed). Shut off the engine. Protect exterior steel parts against corrosion.

Extension of preservation period for another 9 months

Allow engine to run for approx. 5 minutes. Then drain off the preservation oil and fill the gearbox with the correct grade and amount of oil specified for operation.

Start the engine again and allow to run for at least 15 minutes. During this period the gearbox selector clutches must be actuated several times. Then repeat "K 2 preservation" procedure.

Putting into operation after the K 2 preservation procedure

Start the engine and allow to run for approx. 5 minutes so that any condensation water which may have collected in the gearbox is mixed with the anti-corrosion oil.
Drain off the anti-corrosion oil and fill gearbox with the specified oil grade (see "Maintenance work 141").

K 3 Long term preservation

Drain off the oil in the gearbox after operation and fill with anti-corrosion oil up to the low oil level mark on the dip-stick (see description of maintenance work). Use anti-corrosion oil C 642 or C 644 acc. to MIL - L - 21 260.

Immediately afterwards allow gearbox to run in the position "enginewise rotation" or "counter-enginewise rotation" for approx. 5 to 10 minutes at increased engine speed (max. 50 % of the nominal operating speed). Shut off the engine, then *completely* fill the gearbox with anti-corrosion oil. Protect the exterior steel parts against corrosion.

Putting into operation after the K 3 long term preservation procedure

Drain off anti-corrosion oil down to usual oil level and allow the engine to run for approx. 5 minutes. Then drain off the anti-corrosion oil completely and fill the gearbox with the specified oil grade (see "Maintenance work 141").

3 Maintenance work plan

Maintenance level							Maintenance jobs		Tools required
regularly					once				
A 5	A 4	A 3	A 2	A 1	Z 1				
						101	Oil level check	none
						102	Turning of oil filter handle	none
						103	Visual check	none
						104	Draining of water separator of compressed air system	none
						121	Cleaning outside of gearbox	none
						122	Re-tightening of all bolt connections accessible from the outside	tool kit
						123	Check shift position adjustment	none
						124	Lubrication of external moving parts	none
						141	Oil change	tool kit
						142	Cleaning of oil filter	tool kit
						161	Flexible coupling; visual check	none
						162	Flexible mountings of engine and gearbox; visual check	none
						163	Clutch discs; visual check	tool kit
						164	Gearings; visual check	tool kit
						165*	Check of oil pump	W 1
						166*	Check of control unit	W 1
						168	Re-adjust indicator devices	—
						169*	Cleaning of oil cooler	—
						200*	Basic overhaul of gearbox	W 2
T 1 + T 2 + NB	T 1 + T 2	T 1	—	—	T 1		Spare parts required	

*See workshop manual for instructions

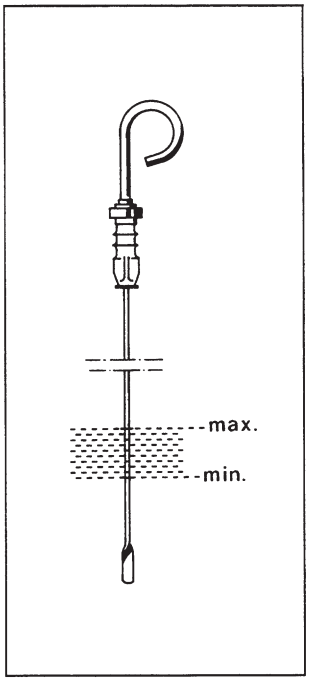
NB = Spare parts according to requirements
T 1, T 2 = Part sets — see spare parts list
W 1, W 2 = Tool sets — see workshop manual

4 Description of maintenance work

Maintenance job 101 – Oil level check

The oil level must only be checked with the engine at a standstill and at least 2 minutes after switching off the engine.

The control oil level lies between the top and bottom marks on the oil dipstick.



When the gearbox is filled with oil for the first time after repair or cleaning the oil filters, please note that some of the oil stays in the oil cooler, the oil pipes and in the oil filter chambers and that it does not flow back into the gearbox housing.
Therefore the oil level must be checked again after a brief period of operation and a delay of app. 2 minutes after switching off the engine. If necessary fill up with oil through the opening for the dipstick.

Only pull the dipstick when the engine is at rest, otherwise there is the danger of getting scorched if any hot oil splashes out.

Maintenance job 102 – Turning of oil filter handle

Slowly turn the handle of the slot type filter one or two revolutions in a clockwise direction.

Maintenance job 103 – Visual check

Check the input and output shaft locations at the gearbox housing, and the oil-pipe, monitoring-device and cooling-water connections for leaks (visual check).

Maintenance job 104 – Draining of water separator of compressed air system

Only on gearboxes with pneumatic actuation. To be carried out according to the instructions of water separator manufacturer.

Maintenance job 121 – Cleaning outside of gearbox

Clean the outside of the gearbox with a cold cleaning agent, diesel oil or a similar cleaning agent to make the visual check easier (see 103).

Important!
Do not allow the rubber components, hose pipes or shaft sealing rings to come into contact with the cleaning agent.

Maintenance job 122 – Re-tighten of all bolt connections accessible from the outside

Re-tighten all accessible bolt connections, particularly the following:

- Engine/ flexible coupling
- Flywheel housing/ gearbox bell housing
- Gearbox output flange/ propeller shaft flange
- Mounting bracket/ gearbox
- Mounting bracket/ foundation

The connections "to" and "from" the oil cooler and of the monitoring devices also have to be examined and re-tightened if necessary.

In order for the tightening torques (see workshop manual) to be maintained these jobs should be done when the gearbox is cold (approx. 20 °C).

Maintenance job 123 – Check shift position adjustment

Only necessary on gearbox version with "mechanical actuation".

Loosen the mechanical connection between the gearbox control lever and the actuating linkage or the push-pull cable. Put control unit and gearbox control lever into "neutral" (rest position). Hole on gearbox control lever and control linkage or fork head of push-pull cable should be in alignment. Engage "ahead" position on control unit and move gearbox control lever to "enginewise" or "counter-enginewise" position until stop. The hole on the gearbox control lever must align with the hole on the linkage or on the fork head. Check "astern" position in the same way.

The specified control positions must be reached positively. The actuating linkage may be re-adjusted if necessary. On no account should the control lever get stuck in the intermediate range between "neutral" and "ahead" or "neutral" and "astern".

Maintenance job 124 – Lubrication of external moving parts

Only necessary on gearbox version with "mechanical or pneumatic actuation".

Lubricate the moving parts of the gearbox actuation (fork head on gearbox control lever, linkage connections and connection to control unit) lightly with lithium-saponified multi-purpose grease.

Maintenance job 141 – Oil change

(These jobs should be carried out, as far as possible, together with the maintenance job 142.)

Remove dipstick, unscrew oil drain plug and drain off the oil.
Put a new sealing ring on the oil drain plug. Screw the plug back in and tighten it.

If an oil suction unit has been attached to the gearbox, suck off the oil and then close the suction unit again.

For filling in oil remove oil filler plug or inspection cover. Fill in new oil.
Use new sealings on filler plug or inspection cover and tighten bolts. Then check oil level acc. to maintenance job 101.

Oil grade

(See "Summary of technical data")

Oils in the current "ZF list of lubricants TE-ML 04 for ZF marine gears" are permitted. A current list of lubricants is supplied together with the gearbox. It can be obtained from any ZF service station.

Maintenance job 142 – Cleaning of oil filter

(This job should be done, as far as possible, together with maintenance job 141.)

Turn handle of oil filter while gearbox is stationary as described under maintenance job 102.

Unscrew oil chamber drain plug by approx. 20 to 25 mm (this allows most of the oil from the filter chamber to flow back into the gearbox housing).
Then unscrew sludge drain plug and empty the filter sediment bowl); use a pan to catch the oil running out (approx. 0.5 to 1.0 dm^3).

After the four hexagon bolts have been removed from the filter head the filter element can be pulled out. Care must be taken that no dirt gets into the clean oil space in the filter housing.
Clean the oil filter with diesel oil or paraffine; turn the handle several times during this process.
Only use brushes for cleaning purposes, never fibrous cloths, mechanical devices, screw drivers or scrapers.

Use a new filter gasket and sealing rings for the installation of the filter, the oil chamber drain plug and the sludge drain plug. Install filter according to previous description.

Maintenance job 161 – Flexible coupling/visual check

Check the rubber components of the flexible coupling for cracks, embrittlement and signs of overheating.

Maintenance job 162 – Flexible mountings of engine and gearbox/visual check

Check the rubber bonded metal supports of engine and gearbox for perfect condition. Rubber components should not show any signs of cracks, embrittlement or other damage.

Maintenance job 163 – Clutch discs/visual check

(This job should be carried out, as far as possible, at the same time as the oil change – see maintenance job 141).

Remove inspection cover and check the clutch packs. The discs should not show any signs of overheating and must be able to move axially.

Maintenance job 164 – Gearings/visual check

(This job should be carried out, as far as possible, at the same time as the oil change — see maintenance job 141)

Remove the inspection cover and check gears on the input shaft, the reversing shaft and the output shaft. The gears should not show any signs of pittings or other defects.

Maintenance jobs 165 and 166

See workshop manual for instructions

Maintenance job 168 – Re-adjust indicator devices

Check that the indicators for the oil pressure and oil temperature give the correct values.

1st alternative:
Operate standardazied indicator devices alongside and compare the values indicated. The indicator should not deviate by more than 10 % in the range used.

2nd alternative:
Dismantle indicator devices and have them re-adjusted, or use new indicator devices.

Maintenance jobs 169 and 200

See workshop manual for instructions.

5 Special versions/Special scope of supply

Should there be differences in the operation and maintenance of special versions or special supply ranges wich are not dealt within the following sections the data can be obtained from the appropriate specifications.

5.1 Special scope of supply – Gearboxes with trailing oil pump

This oil pump is mounted on the gearbox housing at the opposite gearbox end to the input end. It is driven by a layshaft from the gearbox ouput shaft. The pump delivers oil to the oil circuit in a constant direction, regardless of the direction of rotation of the output shaft (see diagram section II. 8).
During operation with engine stationary and propeller trailing, the pump is responsible for supplying lubricating oil to the gearbox. It is thus permissible to operate in this mode for an unlimited periode of time.

Additional operating requirements (see section III. 2)

During operation with engine stationary and propeller trailing, the selector lever on the control unit must be in neutral. For electrical actuation the control valve must be in neutral (see section III. 3.3).

Additional monitoring

Oil pressure need not be monitored when the engine is stationary. The gearbox oil temperature must be monitored, according to data in section III. 2.
There is another measuring point (41) for oil temperature monitoring available (see section II, 8.2).

Additional note for maintenance

The Maintenance jobs 101 and 102 are also to be carried out daily during operation with stationary engine and with rotating propeller (see section IV. 3).

5.2 Special scope of supply – Gearboxes with trolling device

See separate leaflet for trolling device.

6 Trouble shooting

If defects occur in the drive system the gearbox is very often assumed to be the cause. But in many cases faults may arise from external influences acting on the gearbox.

The trouble shooting table below lists the principle faults which may occur, their possible causes and remedies. If it proves impossible to rectify a fault using this information you aure advised to contact the nearest ZF service station for marine gears. If you wish to repair faults or perform repairs to the gearbox yourself, you should request a copy of the workshop manual and the gearbox spare parts list from the service department of our Friedrichshafen Works.

Fault	Possible causes	Remedies
Excessive gear oil temperature (measuring points 11*, 12* and 41*)	Insufficient water flow through cooler	Increase water flow
	Sludge in oil cooler	Clean water side of cooler, see workshop manual
	Gear ratio not properly engaged, clutch slipping	Adjust shift mechanism
Insufficient gear oil temperature	Excessive water flow through cooler	Decrease water flow
Pressure before filter too high (measuring point 5*)	Clogged filter	Clean filter and drain off oil sludge
No operating oil pressure (measuring point 2*)	No oil in gearbox	Add oil
	Wrong direction of rotation at gearbox input	Use special gearbox version
	Defective indicator	Repair fault
Insufficient operating oil pressure (measuring point 2*)	Oil viscosity too low	Use a recommended oil grade (see list of lubricants)
	Incorrect oil pump version (speed range B for gearboxes with trolling device not possible)	Select oil pump in accordance with engine operating speed range
	Defective oil pump	Renew
	Overpressure valve leaking	Repair fault
	Time switch for pressure modulation defective	See remedy for clutch slipping
If the fault cannot be rectified, the lubricating oil supply to the gearbox is also at risk. Proceed at reduced engine speed until repairs can be carried out.		

* See monitoring diagram section II, 8

Fault	Possible causes	Remedies
Excessive operating oil pressure (measuring point 2*)	Oil viscosity too high	Use a recommended oil grade (see list of lubricants)
	Incorrect oil pump version (Speed range B for gearboxes with trolling device not possible)	Select oil pump in accordance with engine operating speed range
Drive interrupted between gearbox input and output; clutch not transmitting torque	For mechanical gearbox actuation Shifting angles incorrect	Adjust (see section II. 7.1)
	For pneumatic gearbox actuation Compressed air system defective (Shift lever not moved)	Repair
	Shifting angles incorrect	Adjust (see section II. 7.1)
	For electric gearbox actuation Electrical system defective	Repair
	Defective solenoid valve	Renew solenoid valve
	Spool valve blocked	Repair
	No operating oil pressure	See remedy for no or insufficient operating oil pressure
Drive between gearbox input and output cannot be interrupted; clutch does not open	For possible causes and remedies refer to "clutch not transmitting torque"	
Clutch slips at high engine speeds	Insufficent operating oil pressure (measuring point 2*)	See remedy for insufficent operating oil pressure. If the fault cannot be rectified on board, proceed with reduced engine speed — so that the clutch does not slip — until repairs can be carried out. Avoid changes in direction, but if unavoidable the ship's propeller should be almost at a standstill and the engine idle speed as low as possible

* See monitoring diagram section II. 8

Fault	Possible causes	Remedies
Oil level sinks rapidly (as indicated by the dipstick); see section IV.4 — oil level check	Leaks at housing joints, oil pipes or shaft sealing rings	Repair faults
	Oil cooler leaking into cooling water system	Repair fault, renew cooler if necessary
Oil level increases (see section IV.4 — oil level check)	Water entering the oil circuit from the cooling system	Repair fault
Gearbox operates too loud in certain speed ranges	Torsional vibration resonance of drive unit in engine speed range	Avoid critical speed range. Install a more suitable torsionally flexible coupling (see section II. 4)
Gearbox operates too loud in engine idle speed range	Torsional vibration resonance of drive unit in engine idle speed range	Increase engine idle speed
Engine stalls during rapid change from "ahead" to "astern"	Engine idle speed too low	Increase engine idle speed
	Change in direction effected too quickly or with travel speed to high	Changes in direction should be carried out as recommended in section III. 1.3

7 Customer service stations, Spare parts

If a gearbox fault cannot be rectified using the remedies in section 6 "Trouble shooting", please contact the nearest ZF service station, for marine gears.

When carrying out repairs, use only original ZF spare parts.

Please give the following information when ordering spare parts and in inquiries.

- Model
- Serial number
- Parts list number
- Gearbox ratio

This information is stamped on the gearbox type plate.

In the case of marine gears with classification, note that spare parts without classification are always supplied under the item numbers stated. If a version with classification is required, the desired type of test must be stated in addition to the item number. This is also necessary if the gearbox parts list is quoted when ordering, and when requesting exchange gearbox units.

V Trolling device

Supplement for gearbox with trolling device

Additional information relating to description, installation, operation and maintenance of gearbox version with trolling device.

1 Applications and operating range

The trolling device makes it possible to operate the propeller at speeds which are less than are possible with *non-trolling* operation.

Typical applications are:

- if the speed at which the vessel moves at minimum permissible engine speed is still too high,
- if a PTO driven by the engine is operated at a constant speed and the speed of the vessel should nevertheless be reduced.

Trolling can be used both for ahead and astern travel. However, the engine should not be turning at more than 0.5 x maximum permissible operating speed, and not in excess of 1000 rpm. Propeller speed during trolling can be reduced to approximately 0.3 to 0.7 x propeller speed for *non-trolling* operation.

2 Description of operation

Reducing propeller speed at a given engine speed is achieved by a defined slip of the clutch discs. During trolling the clutch oil pressure (which presses the clutch discs against each other) is lowered far enough to maintain a specific slip operation. Additionally, during trolling, a greatly increased quantity of oil passes through the clutch discs to lubricate the parts and to dissipate the friction heat. The valves for controlling this increased quantity of lubricating oil have a fixed setting and are installed in the gearbox. *The trolling valve* for varying the clutch oil pressure is attached to the side of the gearbox control unit and is operated mechanically by a shift lever.

3 Operating equipment for trolling

We recommend operating the trolling valve with a suitable lever — *the trolling drive lever* — connected to a push-pull cable.

The push-pull cable and the trolling drive lever should permit a shift stroke of at least 70 mm. The operating force — measured at the bore of the shift lever on the trolling valve — is approximately 100 N when moving out of the detent of normal position C (see dwg.). The force required for shifting from position A to position C is approx. 50 N. In addition there exists a resetting force of approx. 20 N toward position A over the entire adjustment range. The trolling drive lever should be equipped with a braking device and be capable of holding this resetting force.

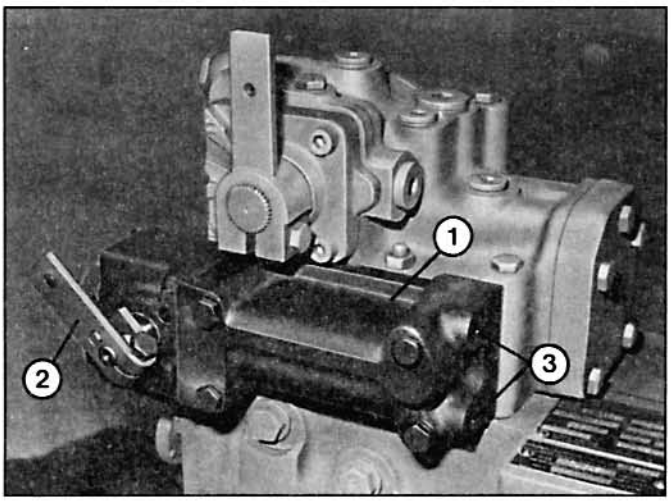
We recommend connecting the push-pull cable to the trolling drive lever in such a way that the shift movement from trolling position A to the *non-trolling position C* is performed in the same direction as the shift movement of the deck controller when increasing the speed of the engine (in the case of single-lever controllers the same as increasing speed when travelling ahead).

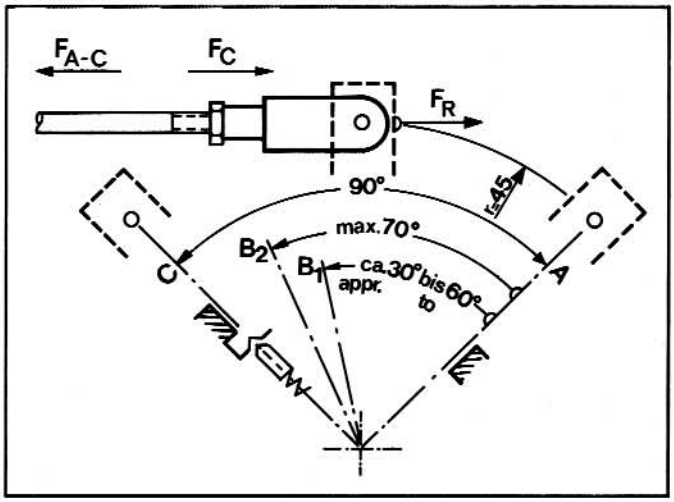
The shift lever of the trolling valve can be turned into any desired angle position on the selector shaft and clamped in position with a clamping bolt. The push-pull cable should be so arranged as to be approximately vertical relative to the shift lever in the middle position between A and C. Two tapped holes are provided for fixing the thrust bearing to the trolling valve.

The sign supplied with the operating instructions for trolling should be affixed in an unobstructed position as close as possible to the trolling drive lever, and should also be clearly legible when the ship is being operated.

Setting the operating equipment

Position the trolling valve in the detent position C by moving the shift lever counter-clockwise. Move trolling drive lever in non-trolling position. Slacken clamping bolt on the shift lever of the trolling valve, attach fork head and tighten clamping bolt (tighten with approx. 25 Nm torque). Following this, check shift setting.





1 *Trolling valve*

2 *Shift lever*

3 *Surfaces for thrust bearings, M8 thread, 15 mm depth*

C	*Non-trolling position, detent position*	
B_2	*max. trolling position at maximum permissible engine speed*	*approx. 70 % drag*
B_1	*max. trolling position at low engine speed*	
A	*Position of lowest trolling speed*	*approx. 30 % drag*
F_R	*Resetting force of shift lever in direction A*	*approx. 20 N*
F_{A-C}	*Force for shifting from A to C*	*approx. 50 N*
F_C	*Force for moving out of detent in C*	*approx. 100 N*

Checking shift setting

- Move trolling drive lever from *non-trolling position* to position of *lowest trolling speed*. Check whether trolling valve has reached position A (detaching fork head for this purpose)
- Move trolling lever from position of *lowest trolling speed* to *non-trolling position*. Check whether trolling valve has engaged in *non-trolling position C* (detaching fork head for this purpose).

Adjust shift setting if necessary and re-check.

4 Operation

The trolling device may be used for travelling ahead and astern without any restrictions in terms of time provided the specified levels for engine speed and for lubricating oil temperature are not exceeded.

Maximum permissible engine speed for trolling

- for engines with a maximum operating speed up to 2000 rpm: 0.5 x maximum operating speed
- for engines with a maximum operating speed in excess of 2000 rpm: 1000 rpm

Maximum permissible lubricating oil temperature: 90 °C

Caution!
A reversing operation during trolling is technically feasible. Depending on the size of the vessel, the speed at which it is travelling and the trolling range set, however, the time for the clutch to reverse and the stopping distance of the vessel are uncontrollably long. For reasons of safety, therefore, it is not permitted to perform a reversing operation when trolling.

The operator is responsible for ensuring that the trolling valve is engaged in the *non-trolling position C* when performing reversing manoeuvres and at engine speeds in excess of the permissible engine speed for trolling.

The gearbox supplier cannot accept any liability for damage to property or injury to persons arising from a failure to observe this operating instruction.

Setting propeller speed for trolling

Switch on ahead or astern clutch with the deck controller and set the minimum engine speed for continuous operation. Move trolling drive lever to position for minimum trolling speed (Position A on trolling valve).

Increasing propeller speed

The load acting on the clutch discs and the friction forces are lowest when the engine is turning at its slowest speed. For this reason, the propeller speed should initially be increased only at the trolling drive lever. The trolling limit (position B_1) is indicated by severe vibration noises.

Caution!
It is not permitted to operate the equipment in the vibrating range. This would damage the gearbox.
If the propeller speed is still too low, the engine speed can be increased. Due to raising the revs, the propeller absorbs an increased output. This causes greater slip at the clutch discs, with the result that the speed of the propeller does not increase in proportion to the speed of the engine. For this reason, the propeller speed can be increased further at the trolling drive lever (limit is indicated by vibrations).

The control range of the trolling valve has been set so that the maximum possible propeller speed during trolling is higher than the propeller speed in *non-trolling operation* and at the minimum engine speed.

The most satisfactory gearbox oil temperature for trolling is approx. 60 to 80 °C.If the propeller speed is set when the oil is too cold, the propeller speed will increase during trolling if the oil temperature rises. The speed of the propeller can be reduced in such cases by reducing the engine speed (if this is possible) or by moving the trolling drive lever. If the lower engine speed or the increase in engine oil temperature results in the trolling operation moving into the vibrating range above B_1 / B_2, it is then essential to select a lower propeller speed at the trolling shift lever.

Switching over to "non-trolling operation":

Move trolling shift lever to *non-trolling*. Trolling valve must be locked in position C for *non-trolling* — refer to para 4.

5 Supplement for monitoring gearbox

During trolling operation the clutch oil pressure ranges from approx. 2 to 7 bar — depending on the trolling speed set. The clutch oil pressure (measuring point 2) does not require to be monitored. If a clutch pressure warning device is fitted, it should be disconnected.

Sequence of operations for retrofitting

- Clean off any paint on flange face of control unit and check that surface is in good condition. Treat any damage (Fig. a).
- Unscrew 3 screw plugs and clean sealing face completely, ensuring that no dirt gets into the oil transfer points of the control unit (Fig. b).
- Attach the trolling valve incl. flat gasket to the control unit with four M8 bolts (note different lengths of bolts) and tighten bolts to torque of approx. 25 Nm (Fig. c).
- On gearboxes which have already been installed it may be necessary to re-lay the push-pull cable of the mechanical gearbox actuation because it may conflict with the operation of the shift lever of the trolling valve.
- Connect actuating equipment as described in para. 3.

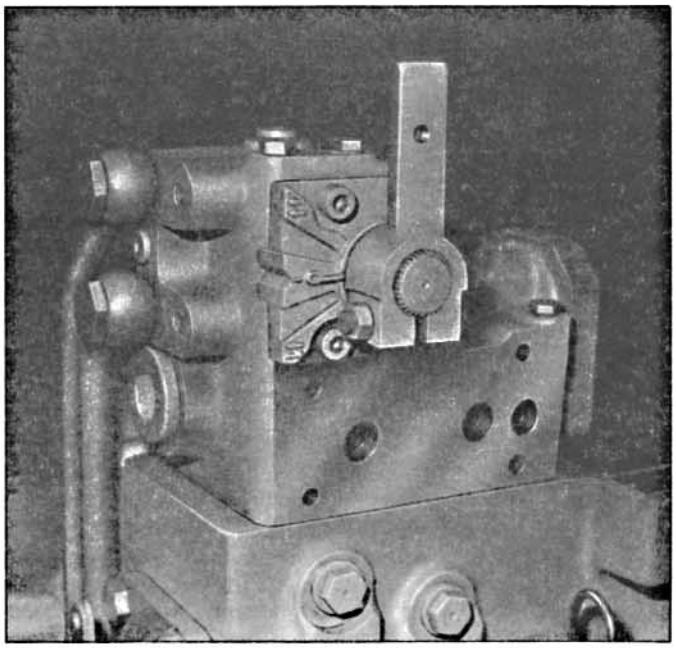


Fig. b

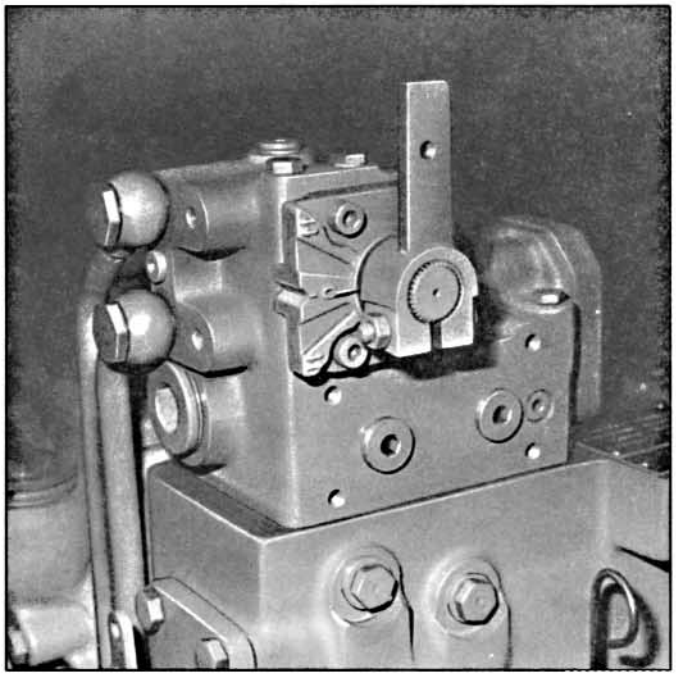


Fig. a

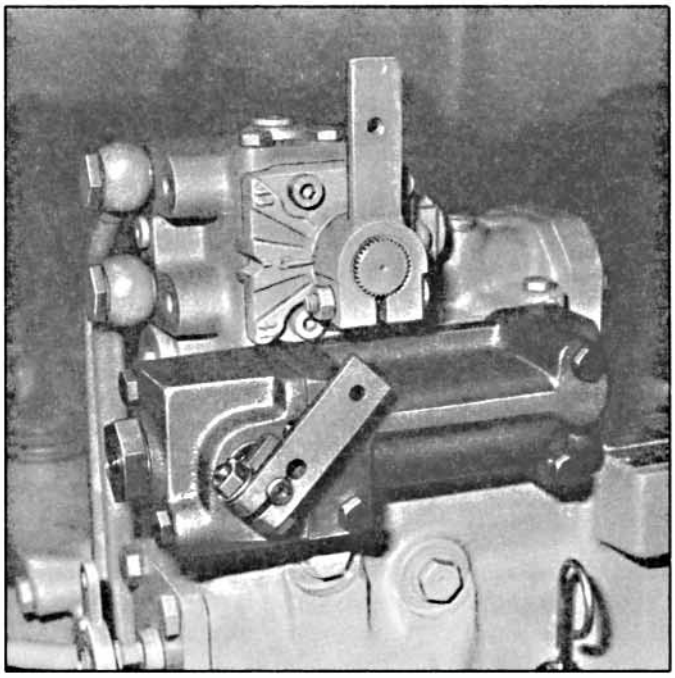


Fig. c