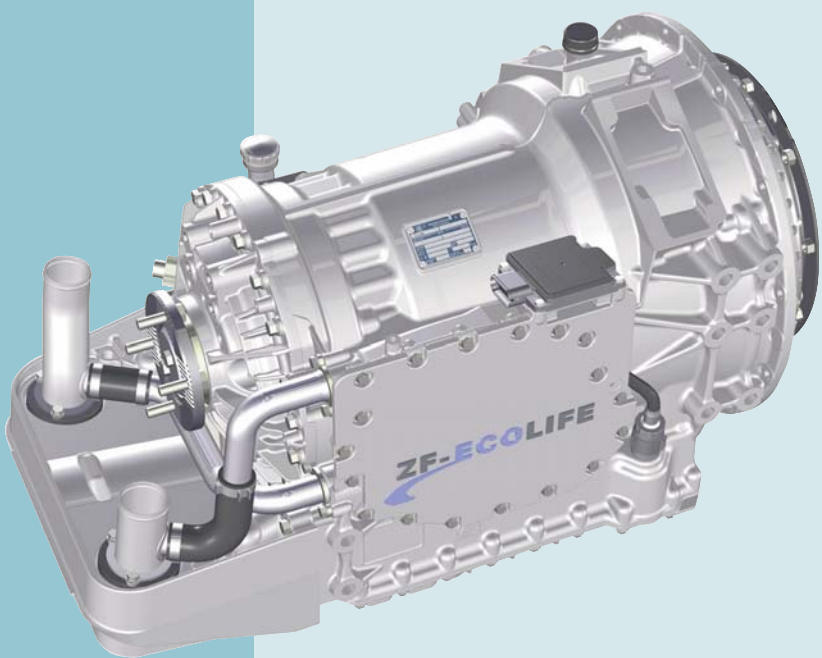
Technical Manual

for City Buses, Intercity Buses, and Coaches



ZF-ECOLIFE

Bus

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4181 765 101b

Important information

This EcoLife technical manual serves as a technical guide for the EcoLife system to be used by both vehicle and body manufacturers as well as ZF staff.
This manual contains answers to questions ranging from specifications to installation inspection and start-up.

This manual provides the basis for the transmission and peripheral units specifications.

Optimal measures before production delivery:
- For specifications of the transmission, electronic automatic control unit, and peripherals, refer to the “Questionnaire for Parts List Preparation” by the OEM and ZF
- Documentation by ZF
- Initial installation
- Initial installation check by ZF staff
- Initial operation by ZF staff
- Release document by ZF
- Revision according to release document

ZF can only be held accountable for initial installation faults, when acceptance was done by authorized ZF staff and all defects detected by ZF have been removed by the OEM or body manufacturer. The vehicle and/or body manufacturer will be exclusively liable for damage caused by defects which the vehicle or body manufacturer is to be held accountable for and which were not detected during initial acceptance by ZF staff.

For installation and installation inspection, we have created the “Installation Guidelines” manual in addition to the EcoLife Technical Manual. These installation guidelines are to be observed by all means during the installation.
If you have any questions, suggestions or ideas for improvement, please approach our “Sales and Application” department.

Safety Instructions

This manual uses the following Safety Instructions:

NOTE
Refers to special working procedures, methods, information, use of auxiliary equipment, etc.

CAUTION
Is used when nonconforming and unprofessional working methods may result in damage to the product.

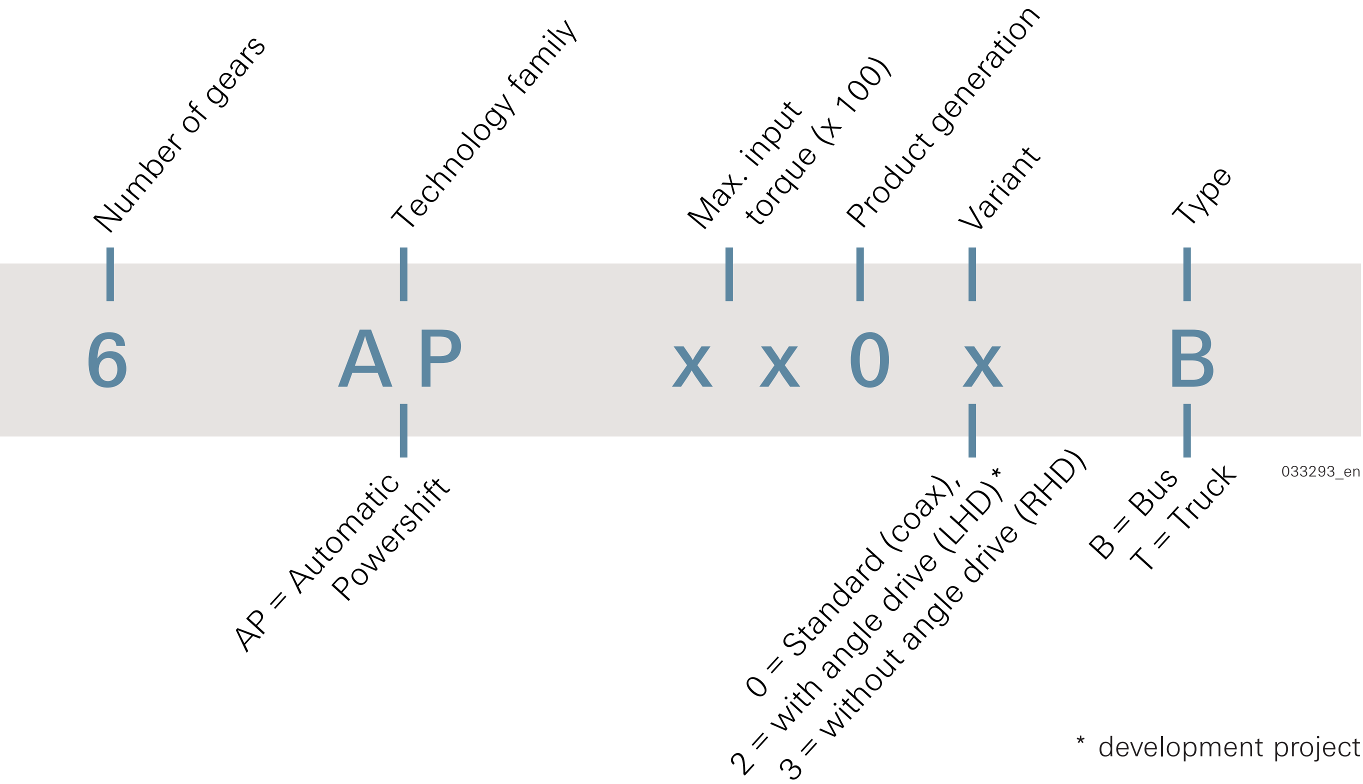
⚠ **DANGER**
Is used when lack of care may lead to personal injury or danger to life.

⚠ **THREATS to the environment!**
Lubricants, consumables, and cleaning agents must not be allowed to enter the soil, ground water, or sewage system.
- **Ask your local environmental protection agency for safety information on the relevant products and adhere to their requirements.**
- **Collect used oil in a suitably large container.**
- **Dispose of used oil, dirty filters, lubricants, and cleaning agents in accordance with environmental protection guidelines.**
- **When working with lubricants and cleaning agents always refer to the manufacturer’s instructions.**

ZF-EcoLife - Product designation

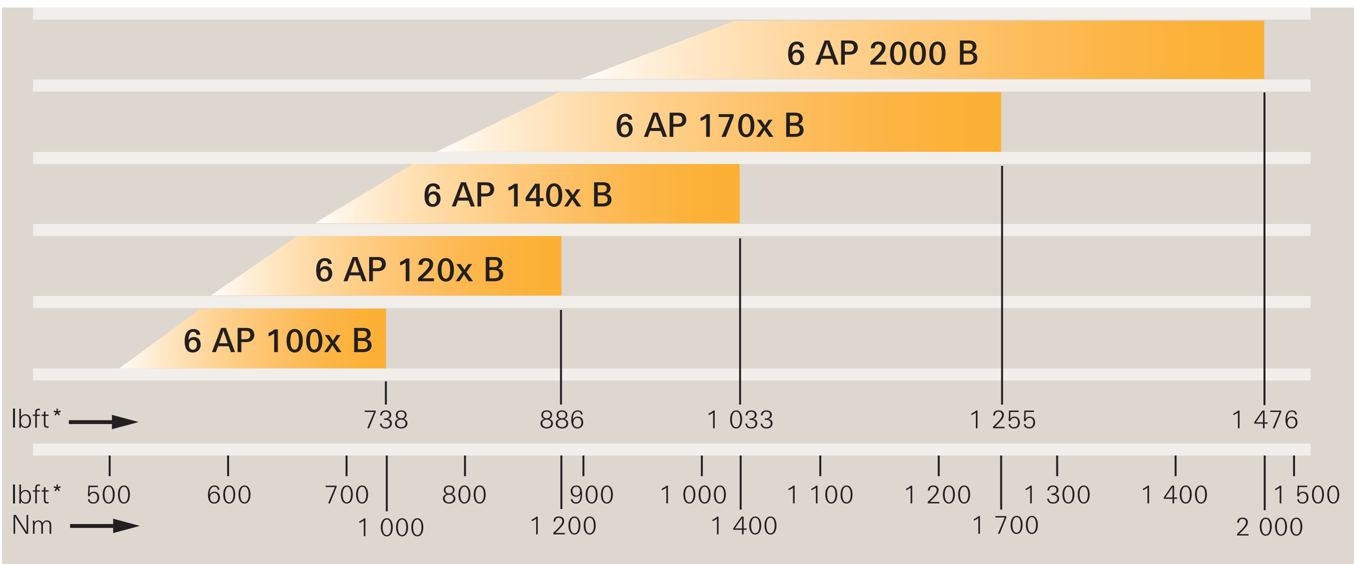
The entire ZF-EcoLife transmission family at a glance.

The new nomenclature:
- Transparent and standardized for all ZF model ranges.



* development project

Transmission Types



* 1 Nm ≅ 0.738 lbft
The installation conditions and connection points of all transmission types are identical.

1 System Design

2 Transmission Description and Technical Data

3 Transmission Specification

4 Application, Documentation, Document Overview

5 EcoLife Arrangement in Vehicle

6 Suspension, Installation, Ambient Temperatures

7 Guidelines for Propshaft Installation

8 Engine Connection

9 Torque Converter

10 Retarder

11 Hydraulics (Reference to Document Overview)

12 Cooling System

13 Peripherals

14 EcoLife ECU Control Unit, E-Module 2, and Wiring

15 AIS – Automatic Idle Shift

16 TopoDyn Life

17 Diagnosis

18 Transmission Warehousing, Oil-Related Topics

19 Formulary and Conversion Tables

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a	2009-08	14.5 14.9	BVA2 dept.	Connection charts, schemes, wiring/routing examples with LM1 dimensions
b	2011-05	all	BVA2 dept., BPE1 dept.	Complete revision

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1 System Design

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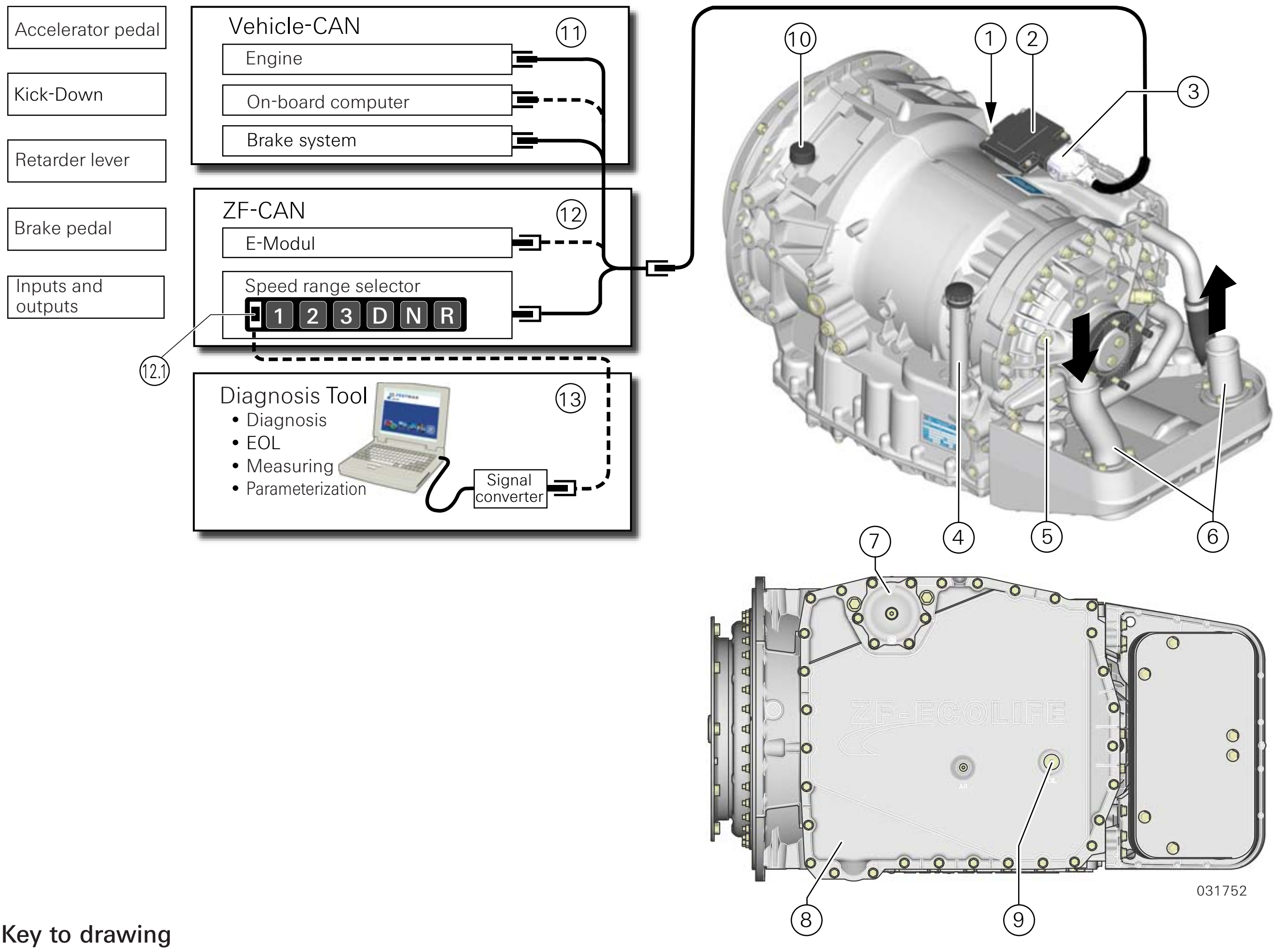
1 System Design

1.1 Example



Key to drawing

1 Cable connection between EcoLife ECU and transmission
2 EcoLife ECU
3 EcoLife ECU connector
4 Oil filler tube with dipstick
5 Impulse sensor for speedometer (optional at 10 o'clock / 2 o'clock)
6 Cooling water connections
7 Pressure filter
8 Oil pan
9 Oil drain plug
10 Breather

11 Vehicle CAN
- Engine/ on-board computer / brake system
  - Accelerator pedal
  - Kickdown, retarder lever, step plate

12 ZF-CAN
- E-Module 2 (optional)
  - Inputs
    - Kickdown, retarder lever, step plate
  - Outputs
- Speed range selector (pushbutton range selector)
  - Inputs
    - Kickdown, retarder lever, step plate
  - Outputs
  - ZF diagnostic access (12.1)

13 Diagnostic tool, ZF-Testman
- Diagnosis
- EOL
- Measuring
- Parameterization

1.2 Brief description

The system diagram shows possible system solutions for the ZF-EcoLife with all required individual components.

The ZF-EcoLife transmission is connected with the vehicle electrical system via the vehicle CAN and with the speed range selector, the E module 2, and the diagnosis tool via ZF CAN.

The EcoLife ECU controls and monitors the EcoLife transmission and features all standard diagnostic protocols. The control system records vehicle and transmission input variables communicated via CAN and converts them into signals to control the transmission's hydraulic control elements.

The driver can actively intervene in the EcoLife control system:

- Speed range selector (pushbutton range selector)
- Kickdown
- Accelerator pedal
- Brake pedal
- Switch for retarder actuation

- The speed range selector can be used to preselect the driving range.
  The pressed pushbutton will light up (continuous illumination).

- The kickdown function can be used to move shift points towards higher engine speeds, so the transmission remains in each gear longer during acceleration and shifts to a lower gear earlier.

- For retarder control variants, refer to Chapter 10.5.

2 Transmission Description and Technical Data

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2 Transmission Description and Technical Data

2.1 Brief description of transmission

Due to their versatility ZF-EcoLife transmissions are suitable for all kinds of buses, but also for trucks and special vehicles. The 6-speed transmission can cover all city, suburban, and long-distance traffic applications. Numerous additional functions are made available for the universal applicability of EcoLife transmissions. They live up to today's highest traffic safety requirements.

The ZF-EcoLife transmissions offer the following advantages:

- Smooth starting without wear on mechanical components, also under toughest conditions
- Preservation of the entire driveline, from the engine to the transmission, from the shaft to the axle to the tires, thanks to an optimally adjusted drive program with smooth gear shifts.
- Increased driving dynamics at highest traffic safety thanks to the integrated hydrodynamic retarder. As a result, the service life of the brake pads is multiplied. Thus, the retarder contributes to significant cost savings and reduced environmental pollution.
- Due to the fine gear stages, the engine always operates in the most fuel-efficient speed range. Converter operation is limited to the starting range. These features lead to a significantly improved fuel economy.
- Simple operation means a relief of the driver which increases both his performance and traffic safety.
- By using the transmission oil Ecofluid Life (filling ex works) oil change intervals are considerably extended and operating and maintenance costs are significantly reduced.
- Faults/Malfunctions in the transmission system or the connected electronic systems in the vehicle can be identified early by means of a diagnosis system with a statistics memory. Thus, major secondary damage can be prevented.

The EcoLife transmissions of the aforementioned types consist of a hydrodynamic torque converter with lock-up clutch and a downstream 6-speed planetary transmission.

Torque Converter

The hydrodynamic torque converter, which uses the Trilok principle, is a wear-free starting element equipped with a stator freewheel and an integrated lockup clutch. The torque converter operates only during the starting process and is automatically bypassed when the clutch closes. As a result, losses occurring in the torque converter are eliminated.

Torsional vibration damper

All torque converter types are equipped with a torsional-vibration damper which allows not only for better riding/driving comfort but also for fuel consumption reduction by lowering shifting speeds.

Retarder

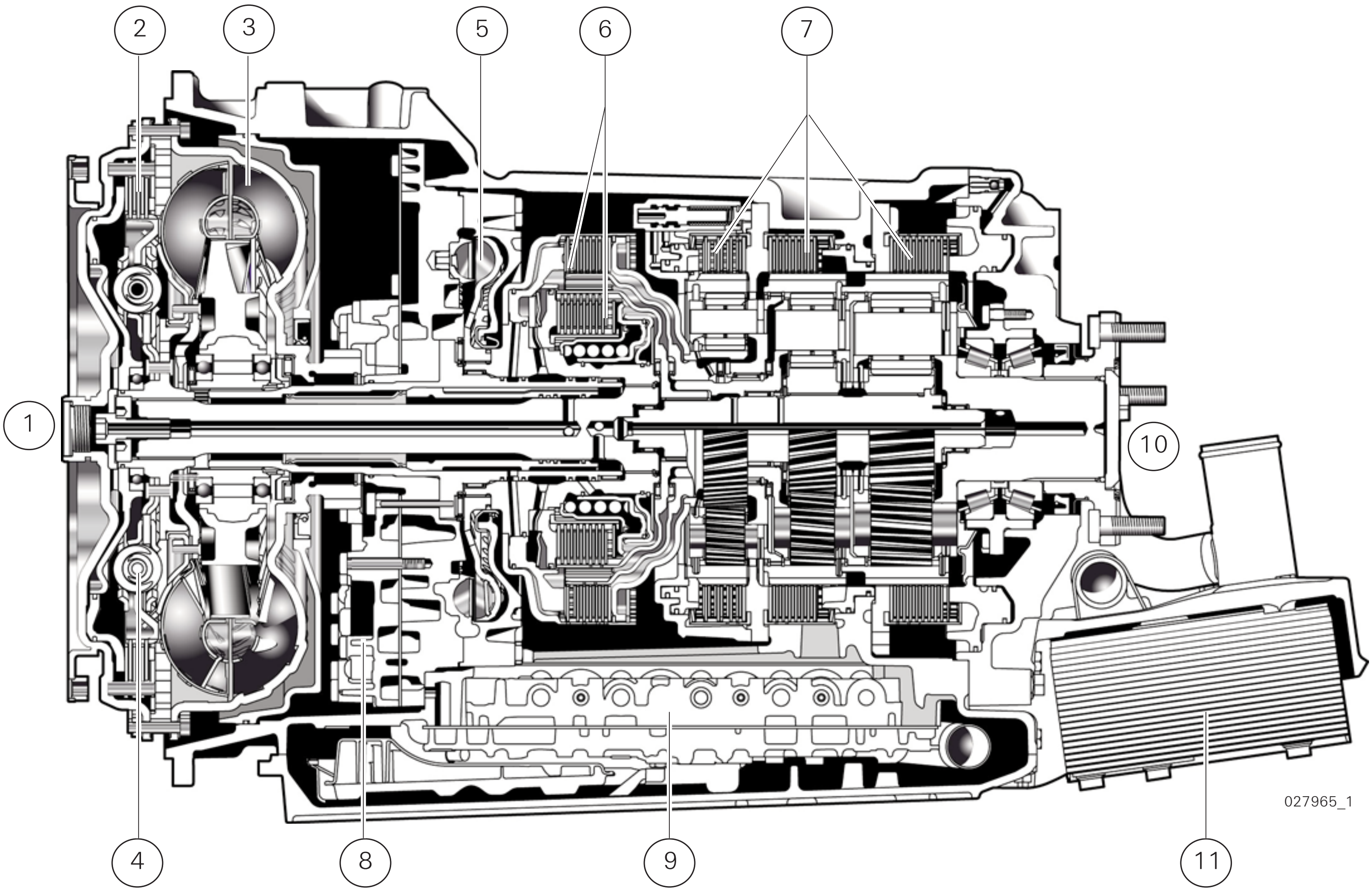
Retarder equipment is standard for all transmission versions. In the basic transmission, the integrated hydrodynamic retarder is fitted between the torque converter and the planetary transmission. Due to the location of the retarder at the transmission input (so-called primary retarder), the brake torque on the output is increased by the respective transmission ratio. As a result, a high retarder brake torque is available in the lower gears, and can be used until vehicle is almost at standstill. As long as permissible values are observed, this torque can be parameterized at will, which permits adaptation to individual applications or customer requests. Retarder control is normally managed through actuation of the brake pedal. The EcoLife ECU converts the brake signal is into a braking torque, either in steps or in a continuously variable manner.

Via CAN, the retarder can be combined with other systems at any time. When this is done, the maximum permissible sum of brake torques is to be taken into account; see Section 2.4, paragraph on brake torques.
Optionally, or in combination with the brake pedal, the retarder can also be operated via a manual lever.

Planetary gears
The planetary gearset, downstream of the torque converter, is designed as a 6-speed transmission. It is a linked system of simple planetary gearsets (not a group-type design). The gears in the planetary gearsets are selected automatically and without any interruption of traction.

The EcoLife ECU provides the signals for individual gearshifts. Depending on various operating variables of engine, vehicle, brake system etc., the corresponding multidisk clutches or brakes are controlled via the electrohydraulic control unit.

Electrohydraulic shift control
The transmissions are equipped with an electrohydraulic control unit. This unit receives shifting commands from the EcoLife ECU. Proportional solenoid valves are used to modulate closing of the clutch and brake elements in accordance with the engine load.



Key to drawing

1 Input
2 Torque converter lock-up clutch (LuC)
3 Torque converter
4 Torsional damper
5 Retarder
6 Clutches A, B
7 Brakes D, E, F
8 Oil pump
9 Hydraulic shift control unit
10 Output
11 Retarder heat exchanger

2.2 Transmission configuration and add-on parts

Based on the basic transmission with the integrated control unit, the EcoLife ECU, the following variants can be created:

- **Coaxial transmission version with directly attached heat exchangers.**
  In case of the coaxial standard transmission, the retarder heat exchanger is mounted at the output end, and the transmission heat exchanger is side-mounted.

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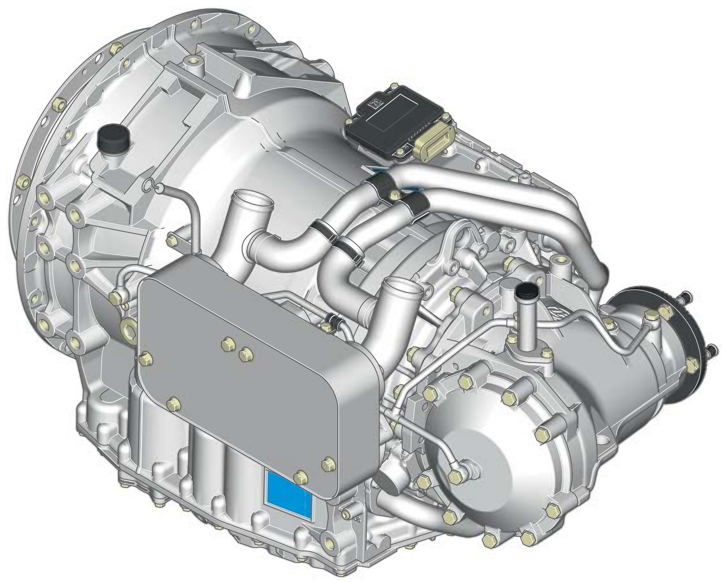
- **Transmissions with flange-mounted angle drives of 80° (RHD) and directly attached heat exchangers.**
  An angle drive of 80°, RHD, can be flange-mounted to the basic transmission. Special retarder heat exchanger arrangements are made available for this purpose.



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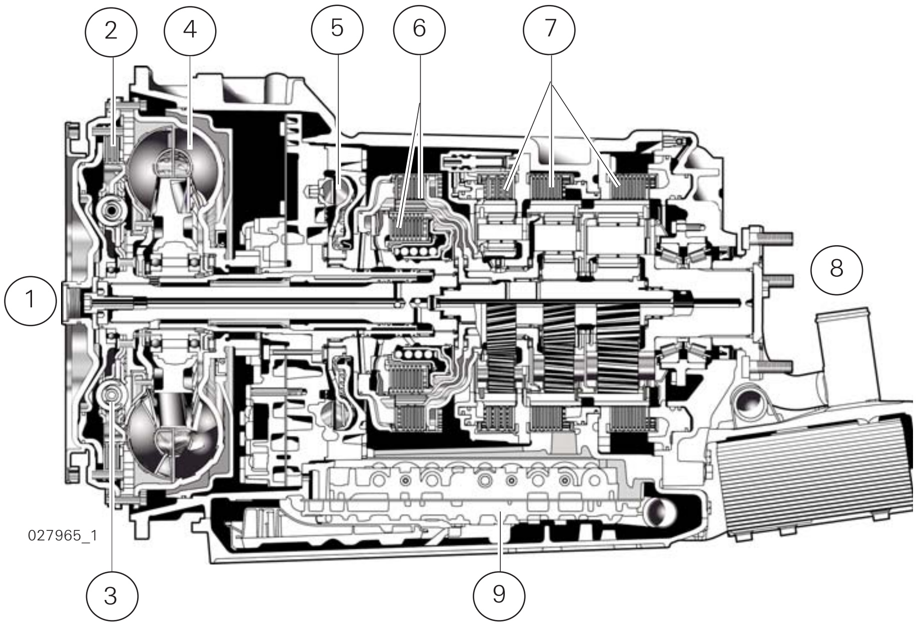
2.3 Transmission ratio and force distribution diagram

Gear ratios:

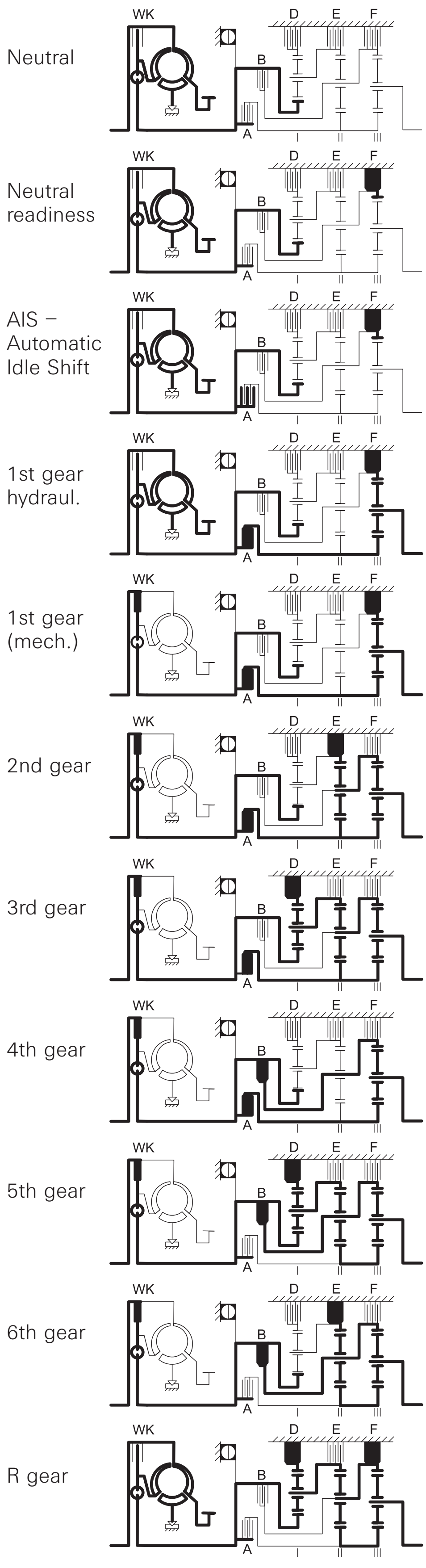
The table shows the mechanical transmission ratios in the individual gears (without torque converter).

Transmission ratios								
Transmission version	1st gear	2nd gear	3rd gear	4th gear	5th gear	6th gear	R gear	Total
coaxial 6 AP xx00 B	3.364	1.909	1.421	1.00	0.72	0.615	4.235	5.469
with angle drive 6 AP xx0x B i_{WTR} = 0.971	3.265	1.853	1.38	0.971	0.699	0.597	4.112	5.469



1 Drive
2 Torque converter lock-up clutch (WK)
3 Torsional vibration damper
4 Torque converter
5 Retarder
6 Clutches (A, B)
7 Brakes (D, E, F)
8 Output
9 Hydraulic control unit with proportional pressure control

Force distribution



2.4 Torque/Vehicle weight correlation *

Transmission types	Permissible input torque [Nm]		Permissible turbine torque [Nm] [3]		Max. vehicle weight [kg]	Permissible engine output [kW] [5]
	1st – 6th gear [1]	Reverse gear [2]	1st and 2nd gear	Reverse gear [2]		
6 AP 100x B	1000	790	1350	1000	19000	170
6 AP 120x B	1200	950	1350	1000	28000	230
6 AP 140x B	1400	1110	1790	1350	28000	260
6 AP 170x B	1700	1350	2230	1670	32000 [4]	300
6 AP 2000 B	2000	1590	2230	1670	32000 [4]	340

1) The transmission types can be used for applications with several engine types with different specified torques up to the max. permissible input torque.
2) Reverse gear limitation
3) Engine torque limits according to permissible turbine torques are to be ensured when torque converter lock-up clutch is open.
4) Special version up to 42 000 kg upon request
5) Maximum nominal engine torque at transmission input (torque converter)

***** For up-to-date data, refer to Chapter 2.4.1 Application instructions

Permissible transmissions - input speeds

Transmission type			6 AP 1000 B 6 AP 1200 B 6 AP 1400 B	6 AP 1700 B 6 AP 2000 B	6 AP xx0x B Angle drive 80° RHD
Speeds					
Minimum idling speed	n_{min}	[rpm]	400	400	400
Maximum input speed	n_{max}	[rpm]	2800 (1st – 5th gear)	2600 (1st – 5th gear)	2400 (1st – 5th gear)
			2100 (6th gear)	2100 (6th gear)	2100 (6th gear)

Brake torques*

6 AP xxxx B transmission type				100x B	120x B	140x B	170x B	2000 B
Max. rotor torque (primary retarder)	1st/2nd gear	T_{Rotmax}	[Nm]	1100	1100	1400	1900	1900
	3rd/6th gear	T_{Rotmax}	[Nm]	1100	1400	1400	1900	1900
Max. brake torque (primary retarder and engine brake)	1st/2nd gear	T_{brake}	[Nm]	1300	1300	1600	2100	2100
	3rd/6th gear	T_{brake}	[Nm]	1300	1600	1900	2250	2650

***** For up-to-date data, refer to Chapter 2.4.1 Application instructions

2.4.1 Application instructions

Application instructions **4181 701 107** apply to the standard versions of all transmission types which belong to the EcoLife model range for bus applications.

NOTE
The standard version is generally to be preferred according to the application instructions at hand.

2.5 Torsional vibrations in driveline, mass moments of inertia, vibration simulation model

CAUTION
Usually it is not a single component which causes torsional vibrations. The natural frequencies are determined by the distribution of mass moments of inertia and torsional stiffness of the entire driveline.
The OEM is to ensure that no impermissibly high loads caused by vibrations in the entire driveline act on the transmission.

Threshold values for the angular acceleration amplitude at the output flange:
ε_{max} = ± 2 000 rad/sec^2.

Limit value for the amplitude of the turbine shaft torque:
± 30 % of the rated engine torque,
zero transition points of torque are not permissible.

For mathematical analyses of the torsional vibrations, the transmission is represented by four or five rotating masses respectively, which are connected by (zero-mass) torsion springs:

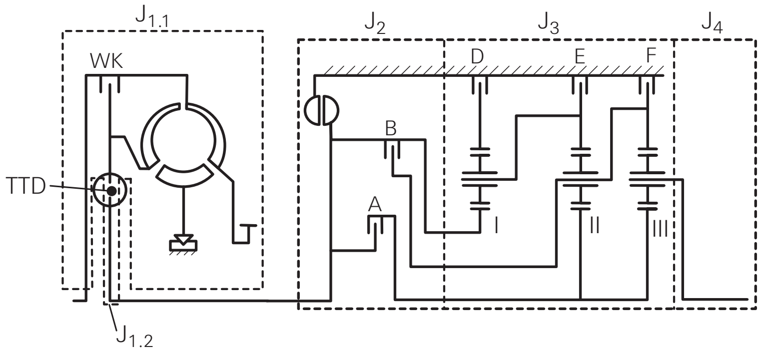
- Mass J_1: Torque converter without engine flywheel and connecting parts, split in primary mass J1.1 and secondary mass J1.2
- Mass J_2: Clutch carrier A, B
- Mass J_3: Manual transmission
- Mass J_4: Angle drive (if available), output flange
- Stiffness C_{TTD}: Turbine torsional damper
- Stiffness C_1: Turbine shaft
- Stiffness C_2: Input and/or hollow shafts
- Stiffness C_3: Output shaft

The shafts' mass moments of inertia are added to the neighboring masses at 50% each.

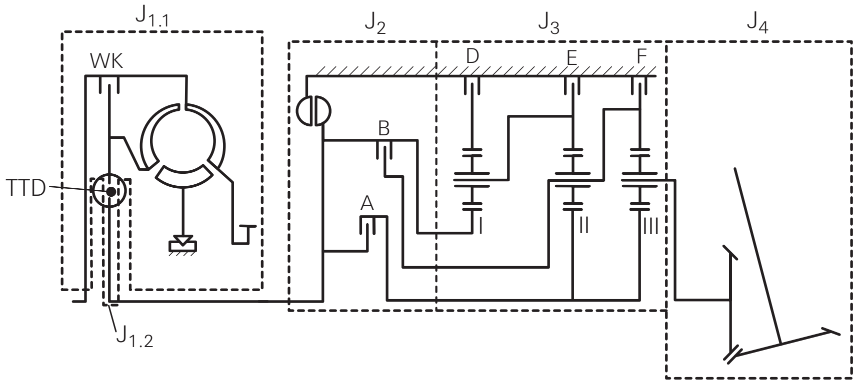
The corresponding data (mass moments of inertia and torsional stiffness) for the individual transmission variants are summarized in the following tables.

2.5.1 EcoLife vibration simulation model

2.5.1.1 Torque converter lock-up clutch (LuC) closed, 1st to 6th gear



Coaxial transmission version



Transmission version with angle drive

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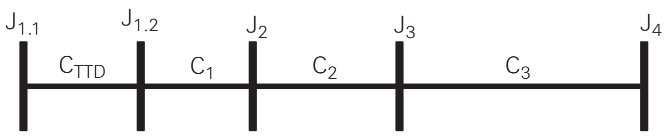


Torque converter type (LuC closed)	$J_{1.1}$ [kgm^2]	C_{TTD} [Nm/rad]	$J_{1.2}$ [kgm^2]	$\alpha_{max, TTD}$ * [°]
W370	1.517	$1.78 \cdot 10^4$	0.046	± 8.9
W410	2.287	$1.78 \cdot 10^4$	0.048	± 8.9

Values for $J_{1.1}$ apply with oil fill included.

* $\alpha_{max, TTD}$: Torsion angle of turbine torsional damper from zero position until stops

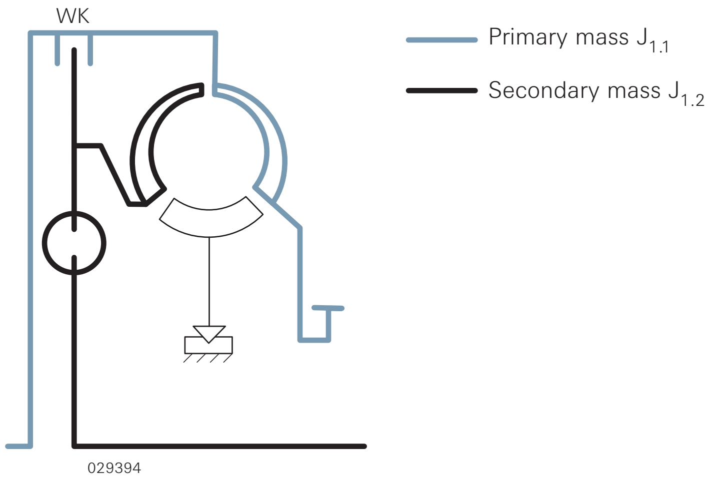
Coaxial transmission version

Transmission type	Gear	C_1 [Nm/rad]	J_2 [kgm^2]	C_2 [Nm/rad]	J_3 [kgm^2]	C_3 [Nm/rad]	J_4 [kgm^2]
6 AP 1000 B	1	$3.1 \cdot 10^4$	0.462	$4.9 \cdot 10^5$	0.0125	$3.5 \cdot 10^5$	0.0014
	2		0.3488	$4.9 \cdot 10^5$	0.0455	$1.1 \cdot 10^6$	0.0044
	3		0.3461	$4.9 \cdot 10^5$	0.1036	$2.0 \cdot 10^6$	0.0079
	4		0.551	$5.6 \cdot 10^6$	0.2203	$4.0 \cdot 10^6$	0.0160
	5		0.365	$5.1 \cdot 10^6$	0.4343	$7.7 \cdot 10^6$	0.0308
	6		0.3677	$5.1 \cdot 10^6$	0.6083	$1.1 \cdot 10^7$	0.0422
6 AP 1200 B	1	$4.1 \cdot 10^4$	0.4772	$4.9 \cdot 10^5$	0.0125	$3.5 \cdot 10^5$	0.0014
	2		0.3551	$4.9 \cdot 10^5$	0.0461	$1.1 \cdot 10^6$	0.0044
	3		0.3502	$4.9 \cdot 10^5$	0.1056	$2.0 \cdot 10^6$	0.0079
	4		0.5669	$5.6 \cdot 10^6$	0.2203	$4.0 \cdot 10^6$	0.0160
	5		0.375	$5.1 \cdot 10^6$	0.4343	$7.7 \cdot 10^6$	0.0308
	6		0.3798	$5.1 \cdot 10^6$	0.6083	$1.1 \cdot 10^7$	0.0422
6 AP 1400 B	1	$4.1 \cdot 10^4$	0.4908	$4.9 \cdot 10^5$	0.0125	$3.5 \cdot 10^5$	0.0014
	2		0.3585	$4.9 \cdot 10^5$	0.0467	$1.1 \cdot 10^6$	0.0044
	3		0.3523	$4.9 \cdot 10^5$	0.1076	$2.0 \cdot 10^6$	0.0079
	4		0.5799	$5.6 \cdot 10^6$	0.2262	$4.0 \cdot 10^6$	0.0160
	5		0.3754	$5.1 \cdot 10^6$	0.4489	$7.7 \cdot 10^6$	0.0308
	6		0.3816	$5.1 \cdot 10^6$	0.6298	$1.1 \cdot 10^7$	0.0422
6 AP 1700 B	1	$5.8 \cdot 10^4$	0.4983	$4.9 \cdot 10^5$	0.0133	$3.5 \cdot 10^5$	0.0014
	2		0.3635	$4.9 \cdot 10^5$	0.0512	$1.1 \cdot 10^6$	0.0044
	3		0.3589	$4.9 \cdot 10^5$	0.1184	$2.0 \cdot 10^6$	0.0079
	4		0.6018	$5.6 \cdot 10^6$	0.2482	$4.0 \cdot 10^6$	0.0160
	5		0.3863	$5.1 \cdot 10^6$	0.4882	$7.7 \cdot 10^6$	0.0308
	6		0.391	$5.1 \cdot 10^6$	0.6828	$1.1 \cdot 10^7$	0.0422
6 AP 2000 B	1	$5.8 \cdot 10^4$	0.5105	$4.9 \cdot 10^5$	0.0133	$3.5 \cdot 10^5$	0.0014
	2		0.3657	$4.9 \cdot 10^5$	0.0512	$1.1 \cdot 10^6$	0.0044
	3		0.3597	$4.9 \cdot 10^5$	0.1184	$2.0 \cdot 10^6$	0.0079
	4		0.6134	$5.6 \cdot 10^6$	0.2482	$4.0 \cdot 10^6$	0.0160
	5		0.3871	$5.1 \cdot 10^6$	0.4882	$7.7 \cdot 10^6$	0.0308
	6		0.3931	$5.1 \cdot 10^6$	0.6828	$1.1 \cdot 10^7$	0.0422

Transmission version with angle drive

Transmission type	Gear	C_1 [Nm/rad]	J_2 [kgm^2]	C_2 [Nm/rad]	J_3 [kgm^2]	C_3 [Nm/rad]	J_4 [kgm^2]
6 AP 1203 B Angle drive 80° RHD	1	$4.1 \cdot 10^4$	0.4772	$4.9 \cdot 10^5$	0.0123	$3.5 \cdot 10^5$	0.0539
	2		0.3551	$4.9 \cdot 10^5$	0.0454	$1.1 \cdot 10^6$	0.1679
	3		0.3502	$4.9 \cdot 10^5$	0.1042	$2.0 \cdot 10^6$	0.3027
	4		0.5669	$5.6 \cdot 10^6$	0.2177	$4.0 \cdot 10^6$	0.6110
	5		00.375	$5.1 \cdot 10^6$	0.4293	$7.7 \cdot 10^6$	1.1793
	6		0.3798	$5.1 \cdot 10^6$	0.6015	$1.1 \cdot 10^7$	1.6138
6 AP 1403 B Angle drive 80° RHD	1	$4.1 \cdot 10^4$	0.4908	$4.9 \cdot 10^5$	0.0123	$3.5 \cdot 10^5$	0.0539
	2		0.3585	$4.9 \cdot 10^5$	0.0460	$1.1 \cdot 10^6$	0.1679
	3		0.3523	$4.9 \cdot 10^5$	0.1063	$2.0 \cdot 10^6$	0.3027
	4		0.5799	$5.6 \cdot 10^6$	0.2236	$4.0 \cdot 10^6$	0.611
	5		0.3754	$5.1 \cdot 10^6$	0.4439	$7.7 \cdot 10^6$	1.1793
	6		0.3816	$5.1 \cdot 10^6$	0.623	$1.1 \cdot 10^7$	1.6138

2.5.1.2 Torque converter lock-up clutch (LuC) open, transmission in neutral position



Torque converter type (LuC open)	$J_{1.1}$ [kgm^2]	$J_{1.2}$ [kgm^2]	Transmission types
W370	1.20	0.68	6 AP 100x B, 6 AP 120x B, 6 AP 140x B
W410	1.80	0.84	6 AP 170x B, 6 AP 2000 B

These mass moments of inertia apply given the following conditions:

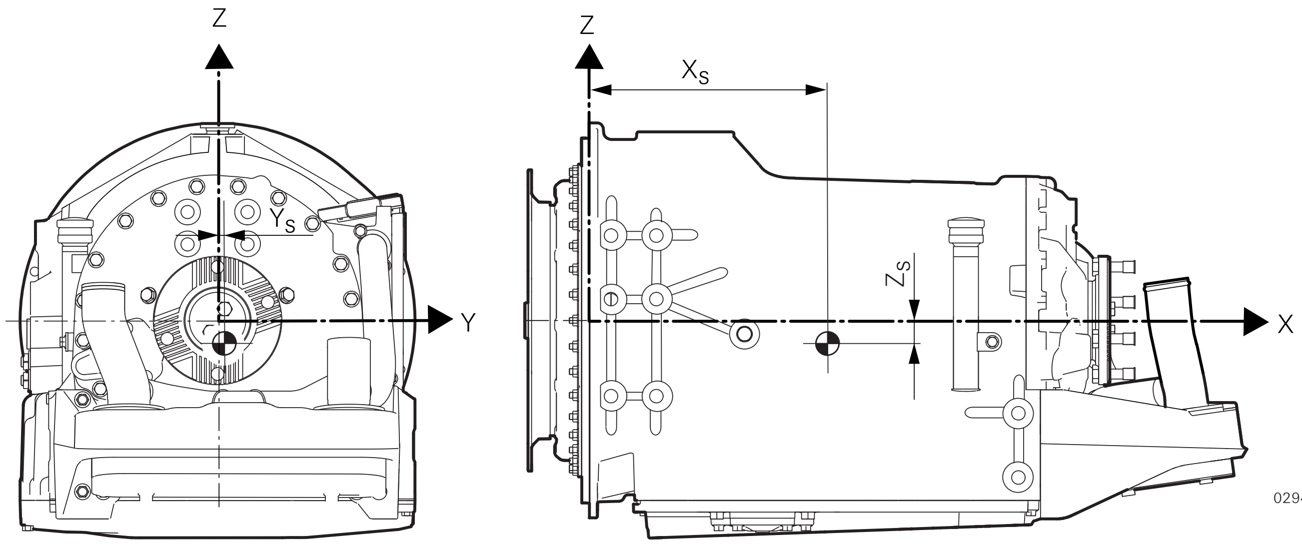
- The torque converter lock-up clutch (WK), clutches A and B as well as brakes D, E, F are open.
- The primary mass $J_{1.1}$ of the torque converter (circuit cover, impeller, torque converter lock-up clutch (WK)) is hydrodynamically coupled with the secondary mass $J_{1.2}$ (turbine wheel, turbine torsional damper (TTD), clutch carrier A/B, sun gear of the 1st planetary gear set) via the torque converter oil filling. However, in terms of vibrations, the two masses are considered as decoupled.
- The values for $J_{1.1\ \text{und}\ J}1.2$ each contain one half of the torque converter oil filling's moment of inertia.
- The values for the secondary mass $J_{1.2}$ contain a share which considers the rotating masses in the transmission driven by the rigidly coupled sun gear.
- The stiffness of turbine shaft and turbine torsional damper (TTD) is not considered.

2.6 Weights and moments of inertia

2.6.1 Weights and mass moments of inertia - EcoLife, coaxial

Transmission type	Position of center of gravity incl. oil S [mm]			Total mass incl. oil	Mass moments of inertia incl. oil J_S [kgm²]		
	X_S	Y_S	Z_S	m [kg]	J_X	J_Y	J_Z
6 AP 1000 B	342	7	-48	379	11.1	31.6	29.9
6 AP 1200 B	342	7	-48	381	11.2	31.8	30.1
6 AP 1400 B	342	7	-48	384	11.3	32.1	30.3
6 AP 1700 B	339	8	-44	409	12.8	35.9	33.7
6 AP 2000 B	339	8	-44	412	12.9	36.2	34.0

The J_x, J_y, and J_z mass moments of inertia relate to the coordinate axes.
All values refer to the transmission with the die-cast housing.



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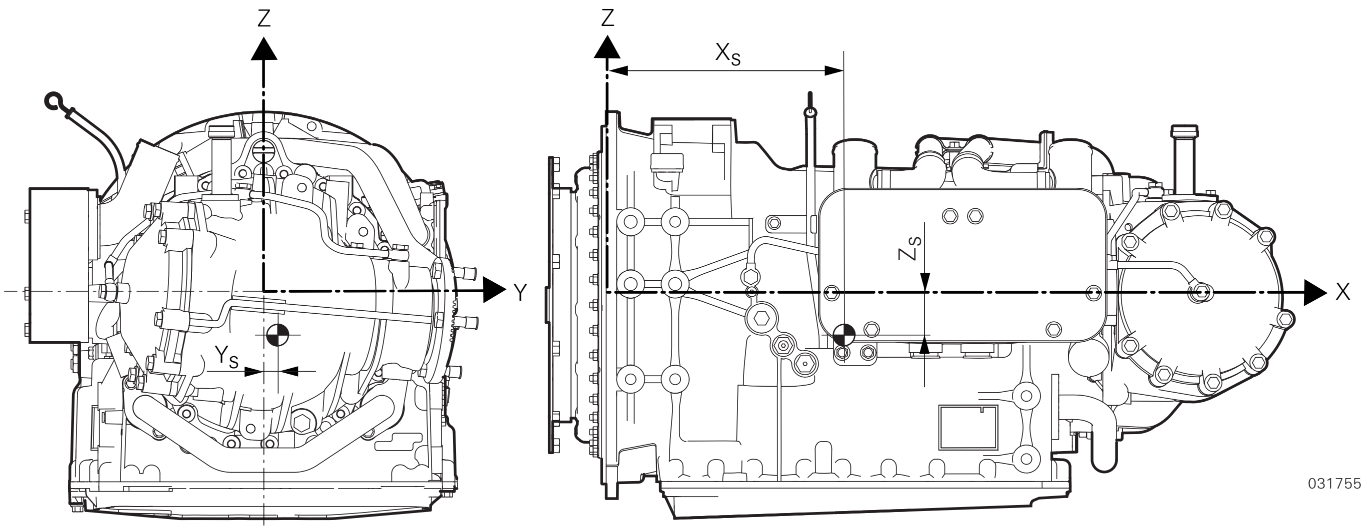
2.6.2 Weights and mass moments of inertia – EcoLife with angle drive of 80°

Transmission type	Position of center of gravity incl. oil S [mm]			Total mass incl. oil	Mass moments of inertia incl. oil J_S [kgm^2]		
	X_S	Y_S	Z_S	m [kg]	J_X	J_Y	J_Z
6 AP 1203 B	422	-9	-27	491	14.8	44.7	45.4
6 AP 1403 B	422	-9	-27	494	14.9	45.0	45.7

The J_x, J_y, and J_z mass moments of inertia relate to the coordinate axes.
All values refer to the transmission with the die-cast housing.



2.7 Shift elements - combinations

The table shows the combinations of shifting elements.

Clutch/Brake combinations / ratios					
Gear	A	B	D	E	F
1st	●				●
2nd	●			●	
3rd	●		●		
4th	●	●			
5th		●	●		
6th		●		●	
AIS 1st					●
R			●		●
AIS 2nd*				●	
AIS R *					●

*AIS special versions

3 Transmission Specification

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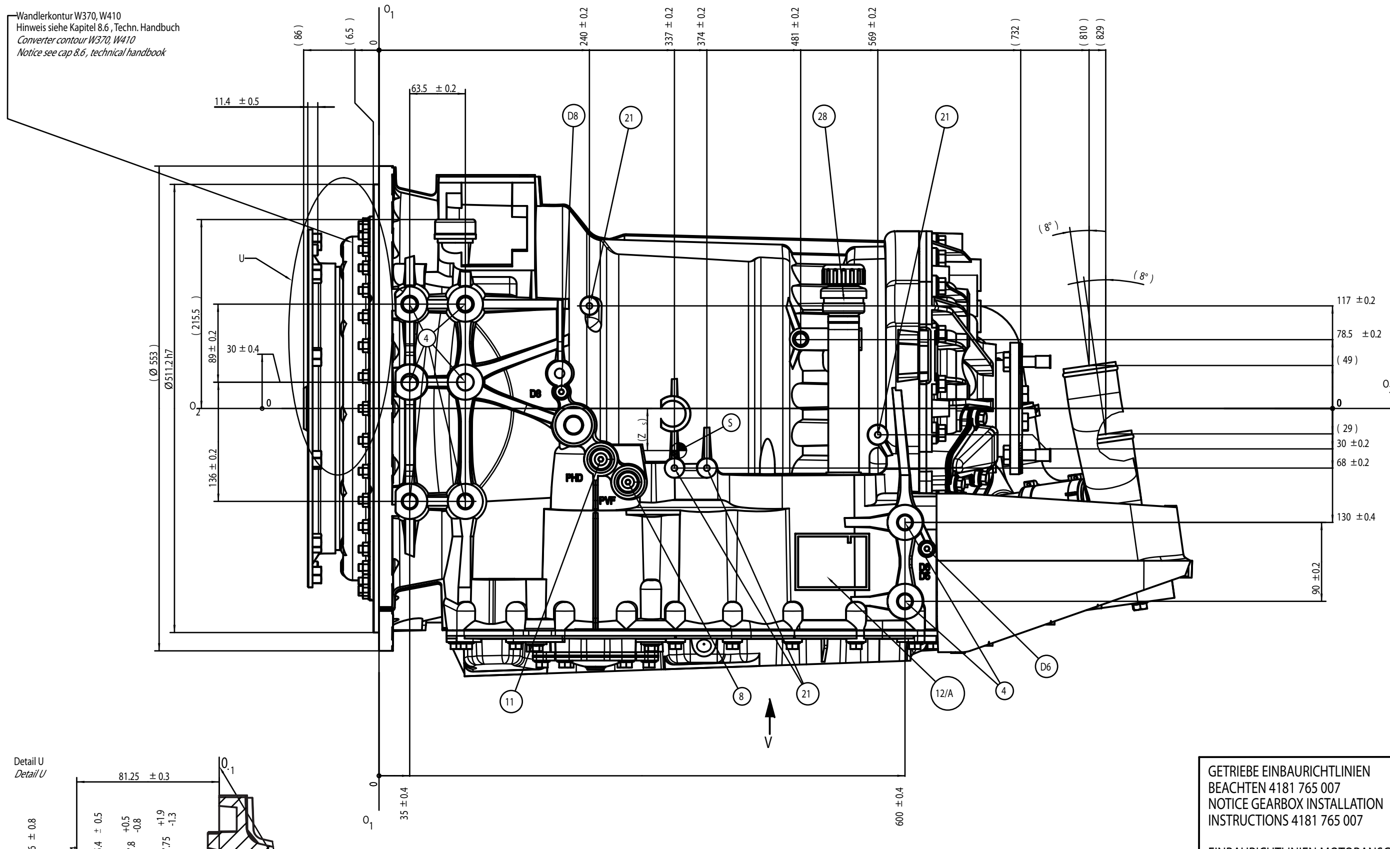
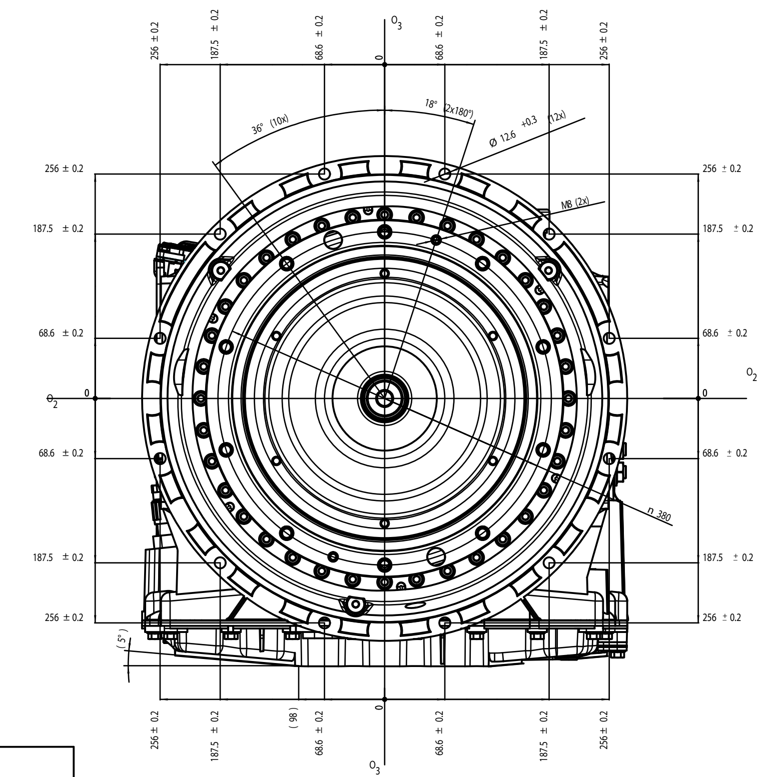
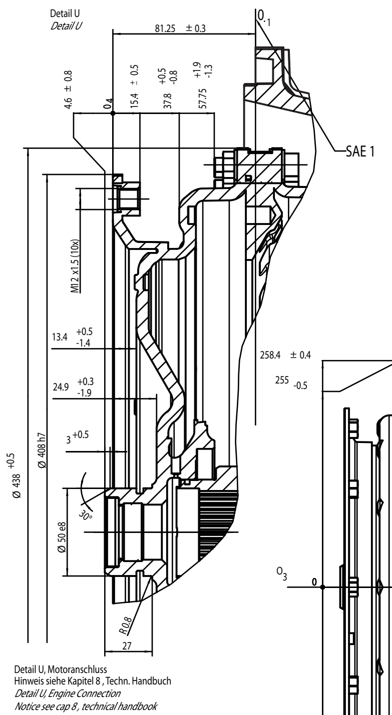
3.1 Transmission version

3.1.1 Coaxial transmission version

From drawing no. 4181 602 022b-1

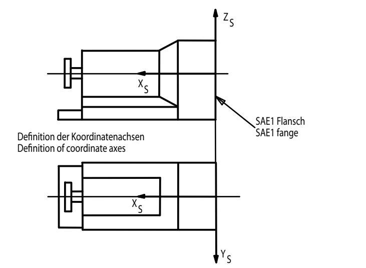


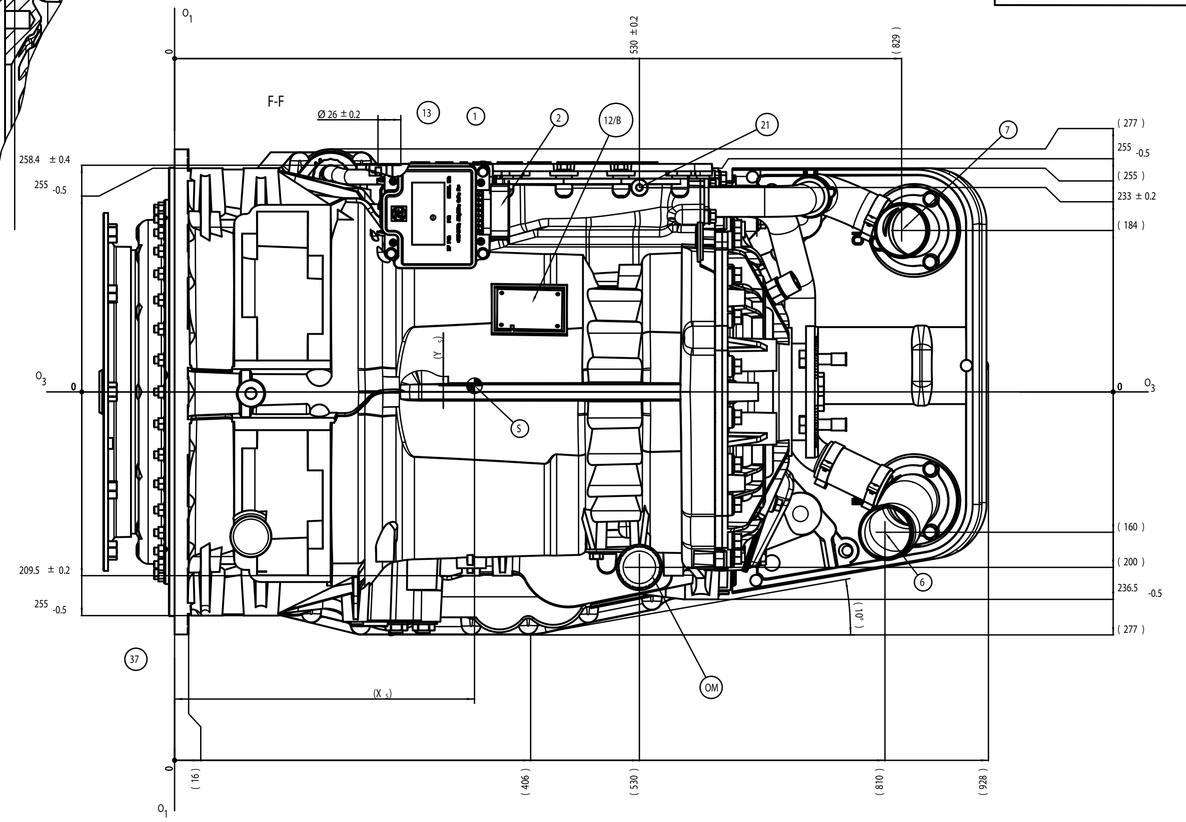




GETRIEBE EINBAURICHTLINIEN
BEACHTEN 4181 765 007
NOTICE GEARBOX INSTALLATION
INSTRUCTIONS 4181 765 007

EINBAURICHTLINIEN MOTORANSCHLUSS
NACH ZF TECHNISCHEN HANDBUCH
4181 765 001 KAPITEL 8
INSTALLATION INSTRUCTIONS ENGINE
CONNECTION ACC. TO ZF TECHNICAL MANUAL
4181 765 001 CAPITEL 8





1	STEUERGERAET ELEKTRISCHE ANSCHLUESSE NACH SPEZIFIKATION 6070 703 002 ZULAESSIGE UMGEBUNGSLUFTTEMPERATUR: 100°C ZULAESSIGE OBERFLAECHENTEMPERATUR:105°C SCHUTZART -MIT AUFGESTECKTEM KABEL: IP69K -OHNE KABEL: TBD (VOR VERSCHMUTZUNG SCHUETZEN) *CONTROL UNIT* *ELECTRICAL TERMINALS ACC. TO SPECIFICATION 6070 703 002* *PERMITTED AMBIENT AIR TEMPERATURE: 100°C* *PERMITTED SURFACE TEMPERATURE: 105°C* *PROTECTION CLASS* *-WITH CABLE PLUGGED IN: IP69K* *-WITHOUT CABLE: TBD (PROTECT AGAINST FOULING)*
2	KABELANSCHLUSS. FUER TRANSPORT MIT SCHUTZKAPPE VERSEHEN *CABLE CONNECTION: FOR TRANSPORT EQUIPPED WITH PROTECTIVE COVER*
4	GETRIEBEAUFHAENGUNG M16x1.5; 24 MIN TIEF ANZUGSDREHMOMENT 225Nm MAX *GEARBOX SUSPENSION M16x1.5; 24 MIN DEEP* *TIGHTENING TORQUE 225 Nm MAX*
5	GETRIEBEAUFHAENGUNG M16x1.5; 24 MIN TIEF ANZUGSDREHMOMENT 225Nm MAX NUR NACH ABSTIMMUNG MIT ZF GESTATTET *GEARBOX SUSPENSION M16x1.5; 24 MIN DEEP* *TIGHTENING TORQUE 225 Nm MAX* *PERMITTED ONLY AFTER CONSULTION WITH ZF*
6	KUEHLMITTELANSCHLUSS ZUM OELKUEHLER STUTZEN DIN 3021 - B 60 *COOLANT CONNECTION TO OIL COOLER* *SPIGOT DIN 3012 - B 60* FUER TRANSPORT MIT KUNSTSTOFF-STOPFEN VERSCHLOSSEN *FOR TRANSPORT CLOSED WITH PLASTIC PLUGS*
7	KUEHLMITTELANSCHLUSS VOM OELKUEHLER STUTZEN DIN 3021 - B 60 *COOLANT CONNECTION FROM OIL COOLER* *SPIGOT DIN 3021 - B 60* FUER TRANSPORT MIT KUNSTSTOFF-STOPFEN VERSCHLOSSEN *FOR TRANSPORT CLOSED WITH PLASTIC PLUGS*
8	DRUCKMESSSTELLE PVF (VOR FILTER) M10x1; 12 MIN TIEF *PRESSURE MEASURING POINT PVF (AHEAD OF FILTER)* *M10x1; 12 MIN DEEP*

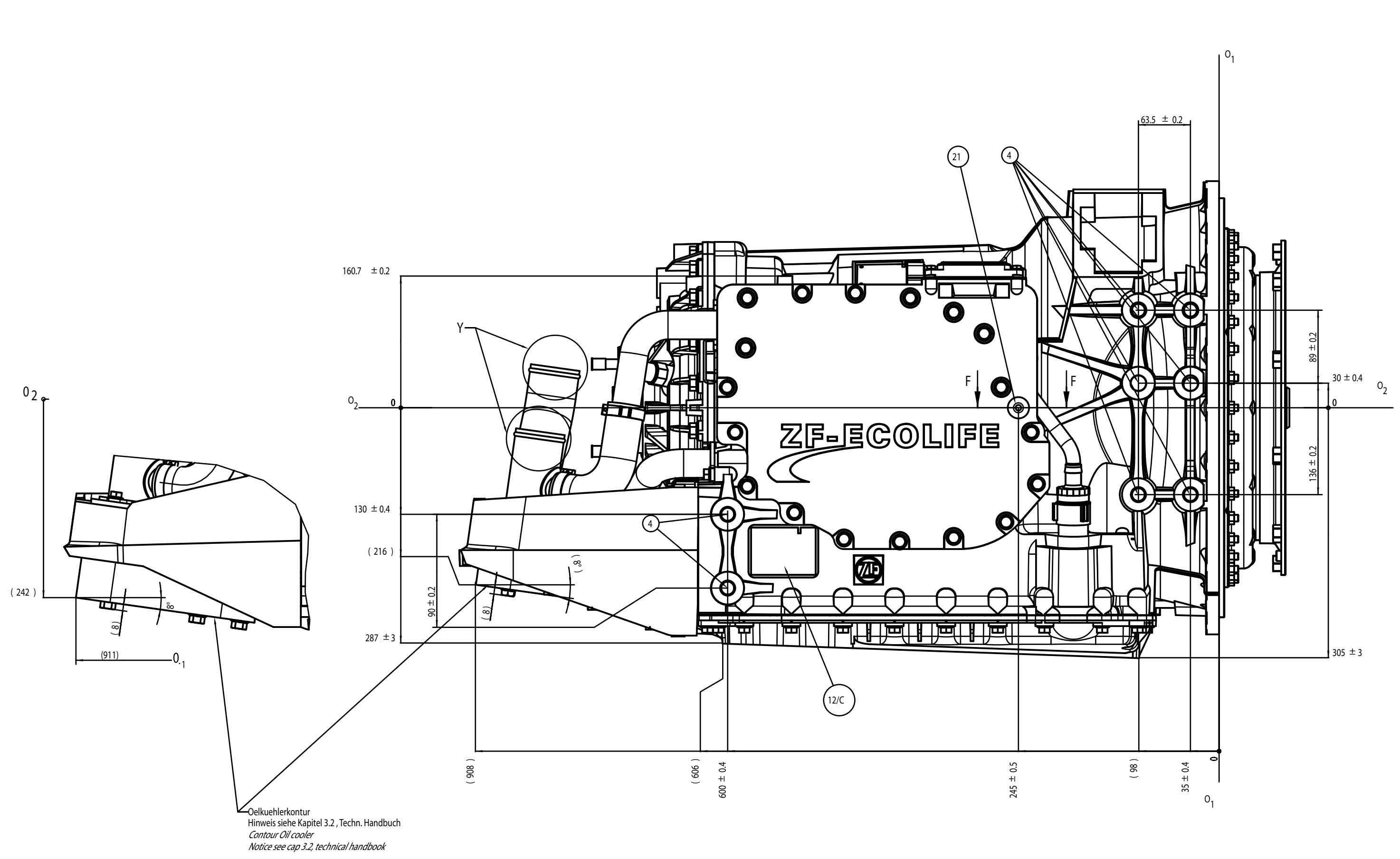
11	MESSSTELLE PHD (HAUPTDRUCK) M10x1; 12 MIN TIEF *MEASURING POINT PHD (PRIMARY PRESSURE)* *M10x1; 12 MIN DEEP*
12	TYPENSCHILD GETRIEBE; POSITION WAHLWEISE A/B/C DATEN: GETRIEBETYP,STUECKLISTEN-NR.,SERIAL-NR., KUNDEN-BESTELLNR.,UEBERSETZUNGSBEREICH, TACHO-METERUEBERSETZUNG (IMPULS/UMDREHUNG), OELMENGE, ZF-SCHMIERSTOFFBEZEICHNUNG *TYPE PLATE GEARBOX; ALTERNATIV POSITION A/B/C* *DATA: GEARBOX TYPE,PARTS LIST NO.,SERIAL NO.* *CUSTOMER ORDER NO.,RATIO RANGE, SPEEDOMETER RATIO (PULSE/REV.); OIL QUANTITY, ZF LIST OF LUBRICANTS DESIGNATION*
13	TYPENSCHILD STEUERGERAET DATEN: SACHNUMMER, SERIALNUMMER, KUNDEN-BESTELLNUMMER, BETRIEBSSPANNUNG, E1-NUMMER *TYPE PLATE CONTROL UNIT* *DATA: MATERIAL NO.,SERIAL NO.,CUSTOMER ORDER NO.,* *RATED VOLTAGE, E1-NUMBER*
14	BOHRUNG FUER PLOMBENDRAHT TACHOANSCHLUSS AN IMPULSGEBER *HOLE FOR LEAD SEAL WIRE SPEEDO CONNECTION TO PULSE SENSOR*
20	OELABLASSCHRAUBE SW6 (INNENSECHSKANT) (Ta=25 Nm) *OIL DRAIN PLUG, WIDTH ACROSS FLATS 6 (INTERNAL HEXAGON)*
21	M8 22 MIN TIEF ANZUGSMOMENT 20 NM BEFESTIGUNG VON ANBAUTEILEN NUR BEI 21 GESTATTET *M8 22 MIN DEEP TIGHTENING TORQUE 20 NM* *FIXING OF ADD-ON PARTS ONLY ALLOWED* *AT 21*
22	M8 19 MIN TIEF ANZUGSMOMENT 20 NM BEFESTIGUNG VON ANBAUTEILEN NUR NACH ABSTIMMUNG MIT ZF GESTATTET *M8 19 MIN DEEP TIGHTENING TORQUE 20 NM* *FIXING OF ADD-ON PARTS PERMITTED ONLY* *AFTER CONSULTION WITH ZF*
28	OELEINFUELLROHR BEFESTIGUNG VON ANBAUTEILEN NUR BEI 21 GESTATTET *OIL FILLER TUBE* FIXING OF ADD-ON PARTS ONLY ALLOWED AT 21
29	DREHRICHTUNG DES ABTRIEBSFLANSCHES BEI VORWAERTSFAHRT *SENSE OF ROTATION OF OUTPUT FLANGE DRIVING FORWARD*

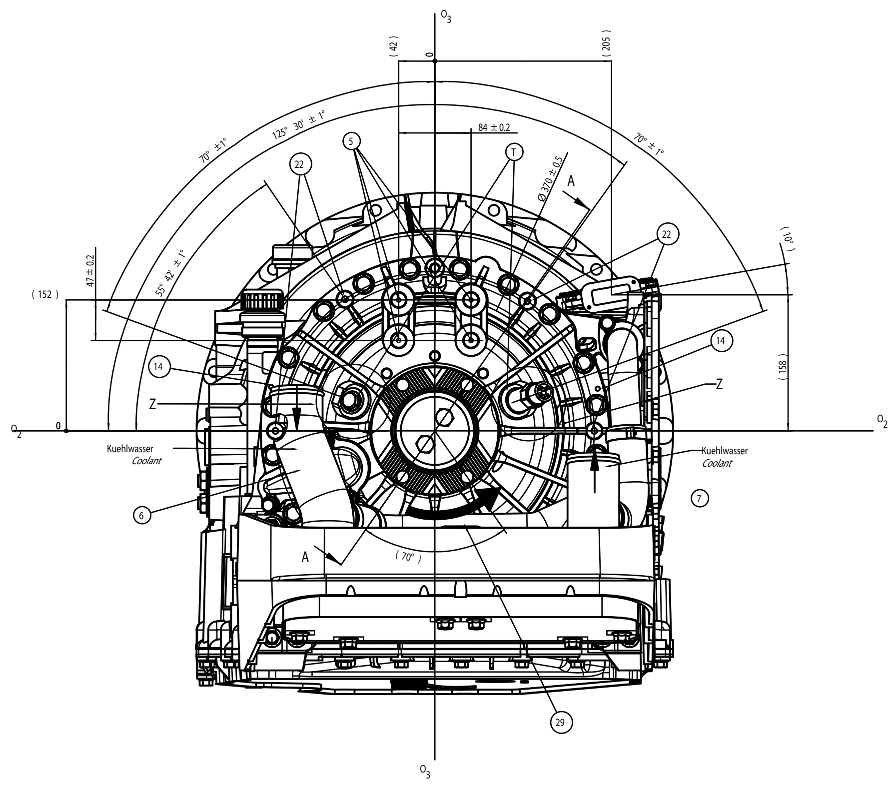
30	AUSBAURAUM FUER OELMESSSTAB (OELMESSSTAB IST FLEXIBEL) *REMOVING SPACE FOR OIL DIPSTICK* *(DIPSTICK IS FLEXIBLE)*
33	AUSBAURAUM FUER OELFILTER *REMOVING SPACE FOR OIL FILTER*
35	AUSBAUHOEHE FUER OELWANNE *REMOVING SPACE FOR OIL SUMP*
37	ENTLUEFTER *BREATHER*
A8	DRUCKMESSSTELLE A8 (WANDLER-GEGENDRUCK) M10x1; 12 MIN TIEF *PRESSURE MEASURING POINT A8 (TORQUE CONVERTER BACK PRESSURE)* *M10x1; 12 MIN DEEP*
D6	DRUCKMESSSTELLE D6 (NACH RETARDER-OELKUEHLER) M10x1; 12 MIN TIEF *PRESSURE MEASURING POINT D6 (DOWNSTREAM OF RETARDER OIL COOLER)* *M10x1; 12 MIN DEEP*
D8	DRUCKMESSSTELLE D8 (SCHMIERDRUCK) M10x1; 12 MIN TIEF *PRESSURE MEASURING POINT D8 (LUBRICATING PRESSURE)* *M10x1; 12 MIN DEEP*
OM	OELMESSSTAB *OIL DIPSTICK*
S	SCHWERPUNKT (MIT OEL) *CENTER OF GRAVITY (WITH OIL)*
T	GEWINDEBOHRUNG FUER IMPULSGEBER M18x1.5, ANZUGSMOMENT 45 NM. FUER TRANSPORT MIT VERSCHLUSSSCHRAUBE VERSCHLOSSEN *THREADED BORE FOR PULSE SENSOR M18x1.5,* *TIGHTENING TORQUE 45 NM. FOR TRANSPORT CLOSED WITH THREADED PLUG*
	GETRIEBE IST MIT OEL BEFUELLT *GEARBOX IS FILLED WITH OIL* OELSORTE: ZF ECOFLUID LIFE OELMENGE: 42 L *OILTYPE: ZF ECOFLUID LIFE OIL VOLUME: 42 L*

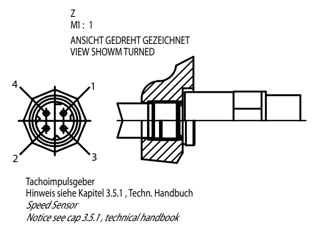
( ) MASSE NUR ZUR INFORMATION
( ) DIMENSION FOR INFORMATION ONLY

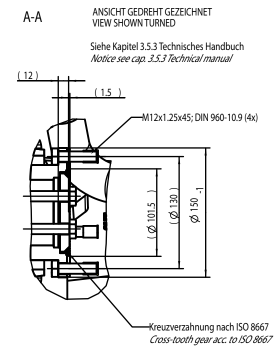
ROHKONTUR OHNE GUSSTOLERANZ
CASTING CONTURE WITHOUT CASTING TOLERANCE

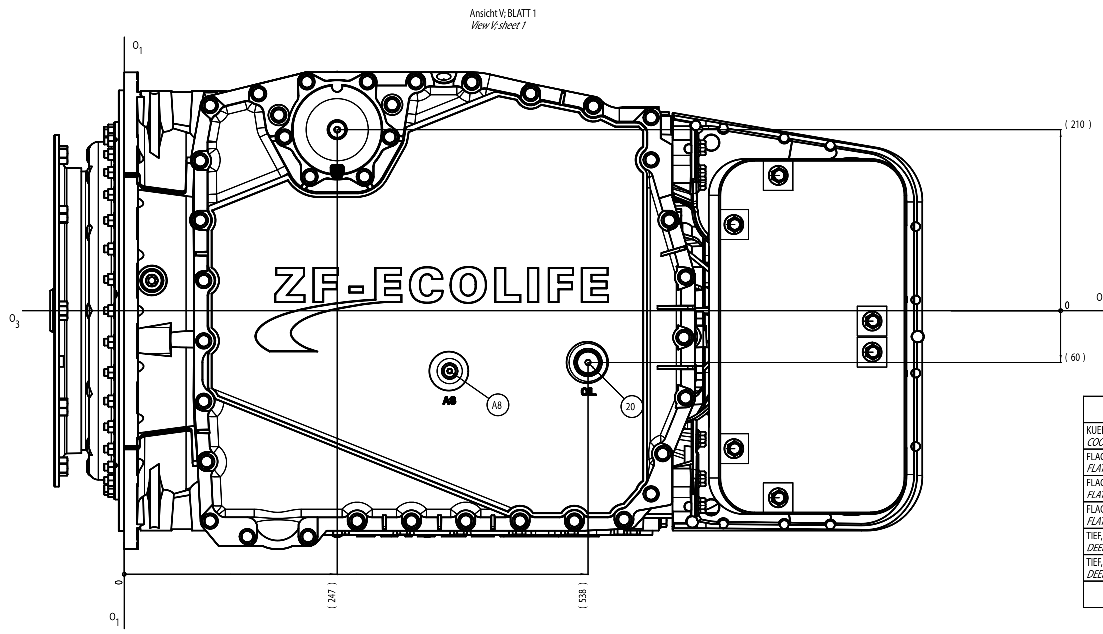
From drawing no. 4181 602 022b-2

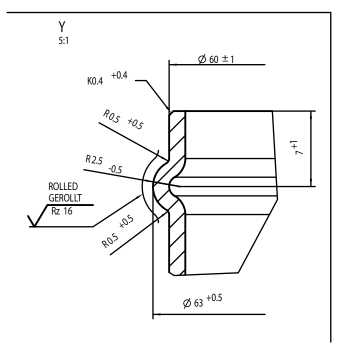










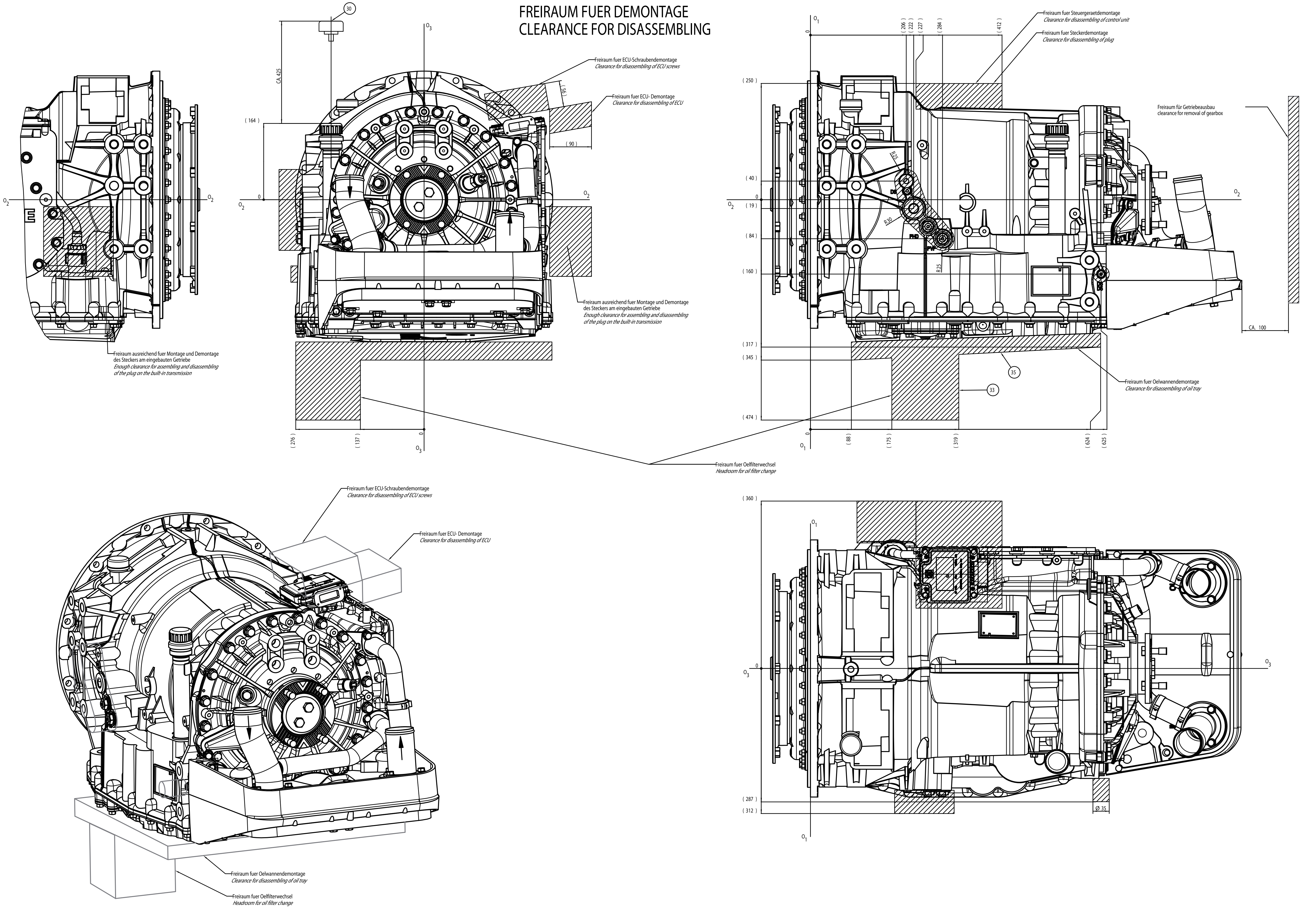


SCHWERPUNKT UND MASSENTRAEGHEITSMOMENTE MIT OELBEFUELLUNG
CENTRE OF GRAVITY AND INERTIA MATRIX WITH OIL FILLING

ALLE ABMESSUNGEN BEZIEHEN SICH AUF DIE MOTORANSCHLUSSFLAECHE
ALL DIMENSIONS ARE BASED ON ENGINE CONNECTION INTERFACE

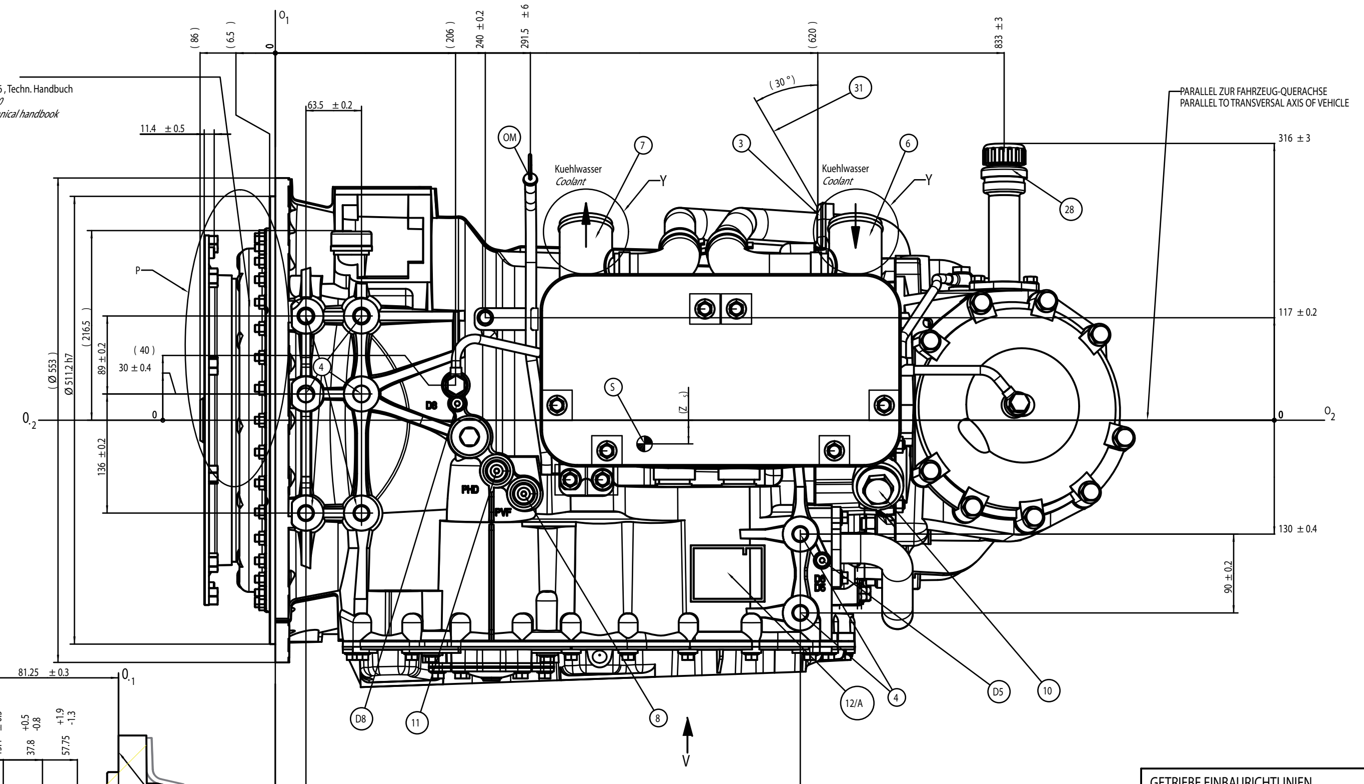
		GETRIEBE *GEARBOX*	UEBERSETZUNGEN *MECHANICAL RATIOS*							GETRIEBETYP *GEAR BOX TYPE* MIT OELKUEHLER *WITH OIL COOLER*	GESAMTGEWICHT TOTAL WEIGHT MIT OEL *WITH OIL*	SCHWERPUNKT *CENTRE OF GRAVITY* s (mm)			MASSENTRAEGHEITSMOMENT *INERTIA MATRIX* J (kgm²)		
KUEHLER ROC *COOLER ROC*	WANDLER *CONVERTER*	TYP *TYPE*	1.Gg.	2.Gg.	3.Gg.	4.Gg.	5.Gg.	6.Gg.	R.Gg.	UND OELBEFUELLUNG *AND OIL FILLING*	m(kg)	X_s	Y_s	Z_s	J_x	J_y	J_z
FLACH, MASS 216 *FLAT*	W 370	6 AP 1000 B	3.364	1.909	1.421	1.000	0.720	0.615	4.235	6 AP 1000 B	379	342	7	-48	11.1	31.6	29.9
FLACH, MASS 216 *FLAT*	W 370	6 AP 1200 B	3.364	1.909	1.421	1.000	0.720	0.615	4.235	6 AP 1200 B	381	342	7	-48	11.2	31.8	30.1
FLACH, MASS 216 *FLAT*	W 370	6 AP 1400 B	3.364	1.909	1.421	1.000	0.720	0.615	4.235	6 AP 1400 B	384	342	7	-48	11.3	32.1	30.3
TIEF, MASS 242 *DEEP*	W 410	6 AP 1700 B	3.364	1.909	1.421	1.000	0.720	0.615	4.235	6 AP 1700 B	409	339	8	-44	12.8	35.9	33.7
TIEF, MASS 242 *DEEP*	W 410	6 AP 2000 B	3.364	1.909	1.421	1.000	0.720	0.615	4.235	6 AP 2000 B	412	339	8	-44	12.9	36.2	34.0

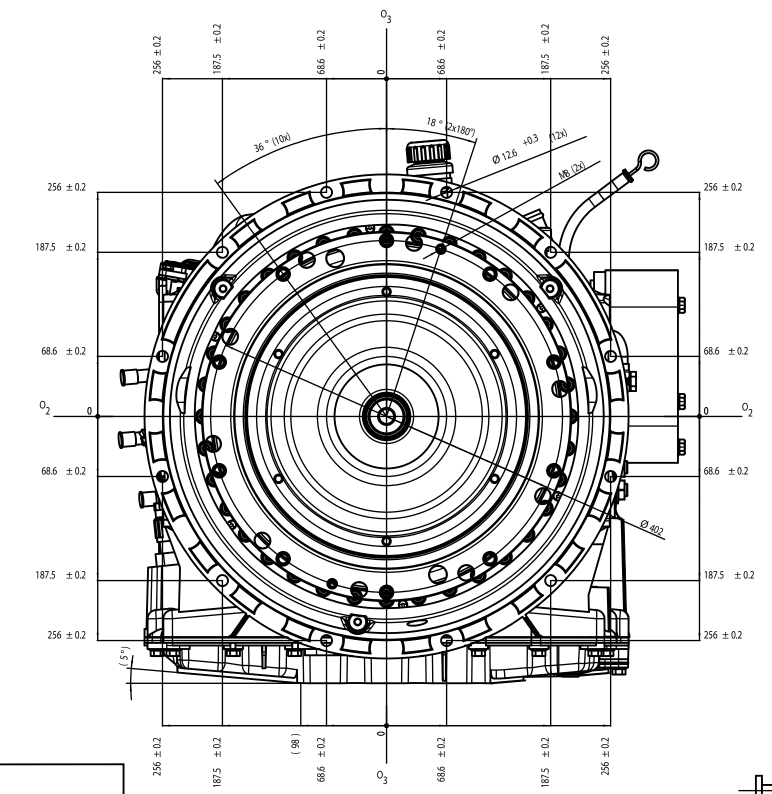
From drawing no. 4181 602 022b-3

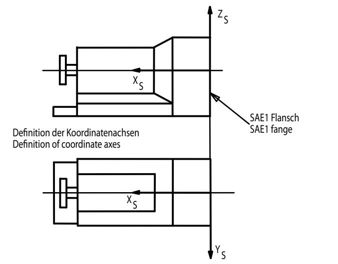


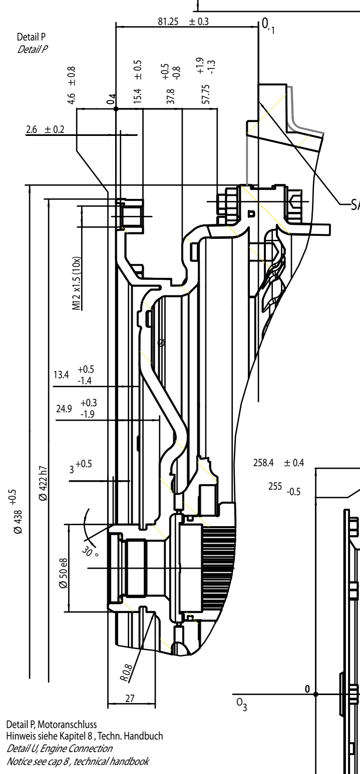
3.1.2 Transmission version with angle drive of 80 ° RHD

From drawing no. 4181 602 035b-1



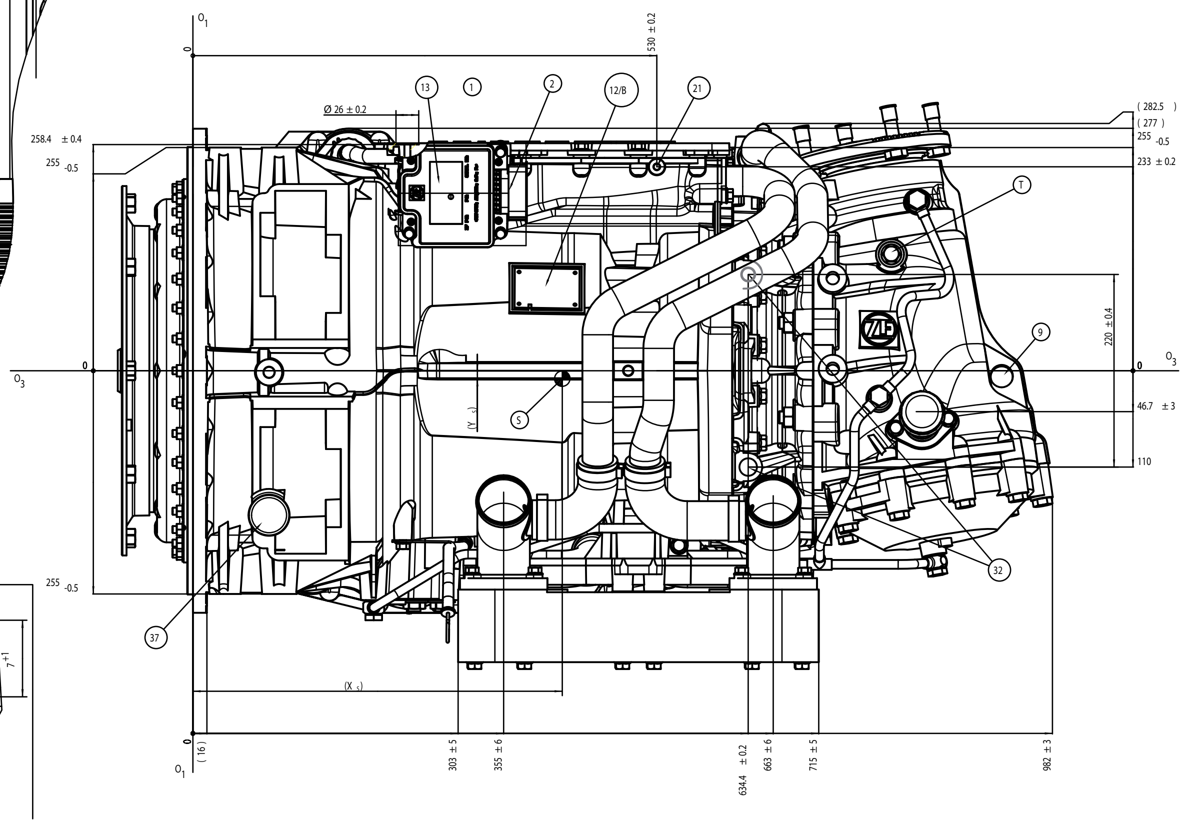


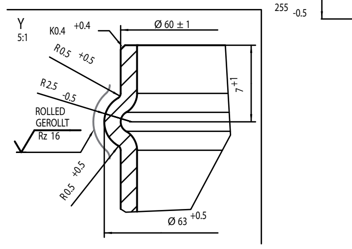




GETRIEBE EINBAURICHTLINIEN
BEACHTEN 4181 765 007
NOTICE GEARBOX INSTALLATION
INSTRUCTIONS 4181 765 007

EINBAURICHTLINIEN MOTORANSCHLUSS
NACH ZF TECHNISCHEN HANDBUCH
4181 765 002 KAPITEL 8
INSTALLATION INSTRUCTIONS ENGINE
CONNECTION ACC. TO ZF TECHNICAL MANUAL
4181 765 002 CAPITEL 8



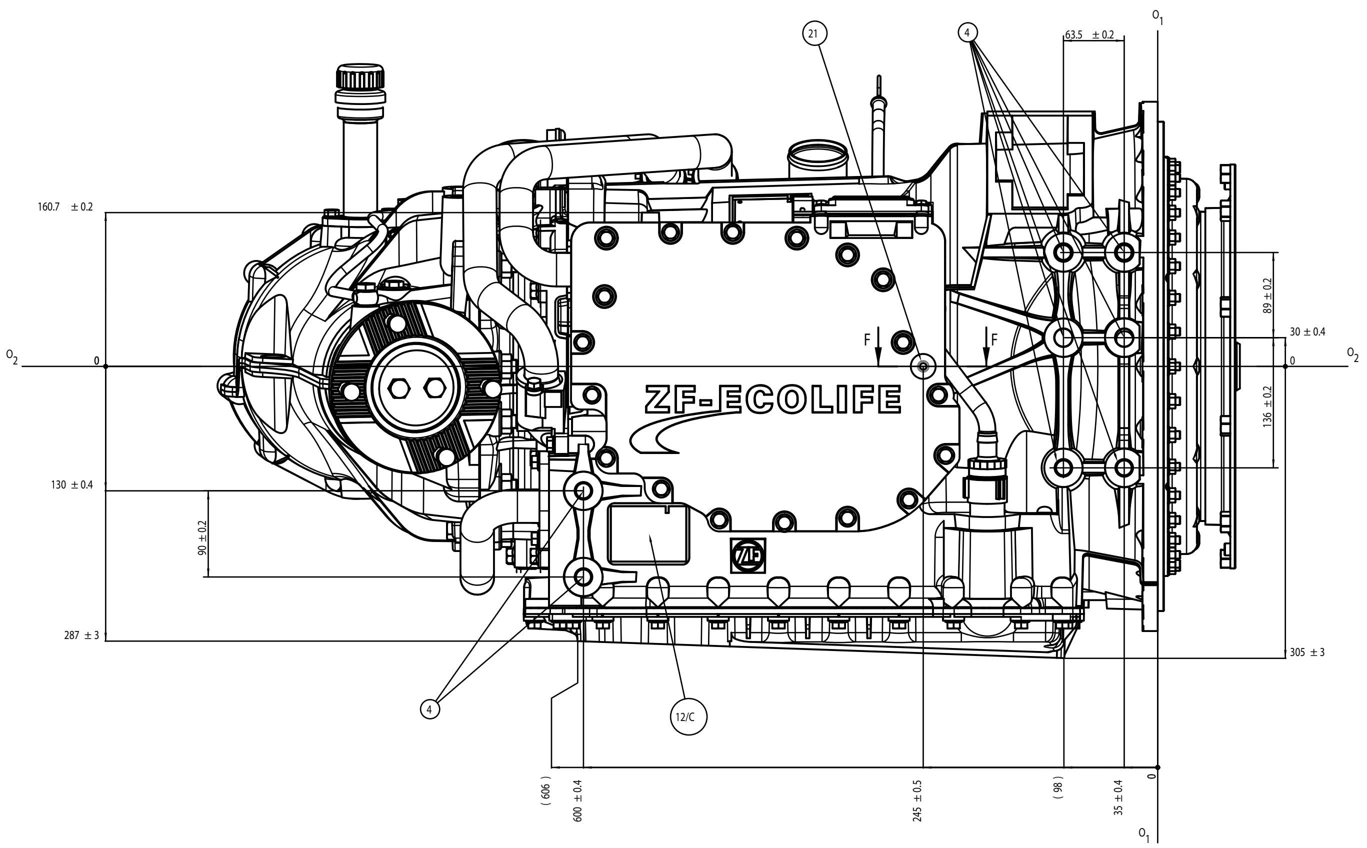


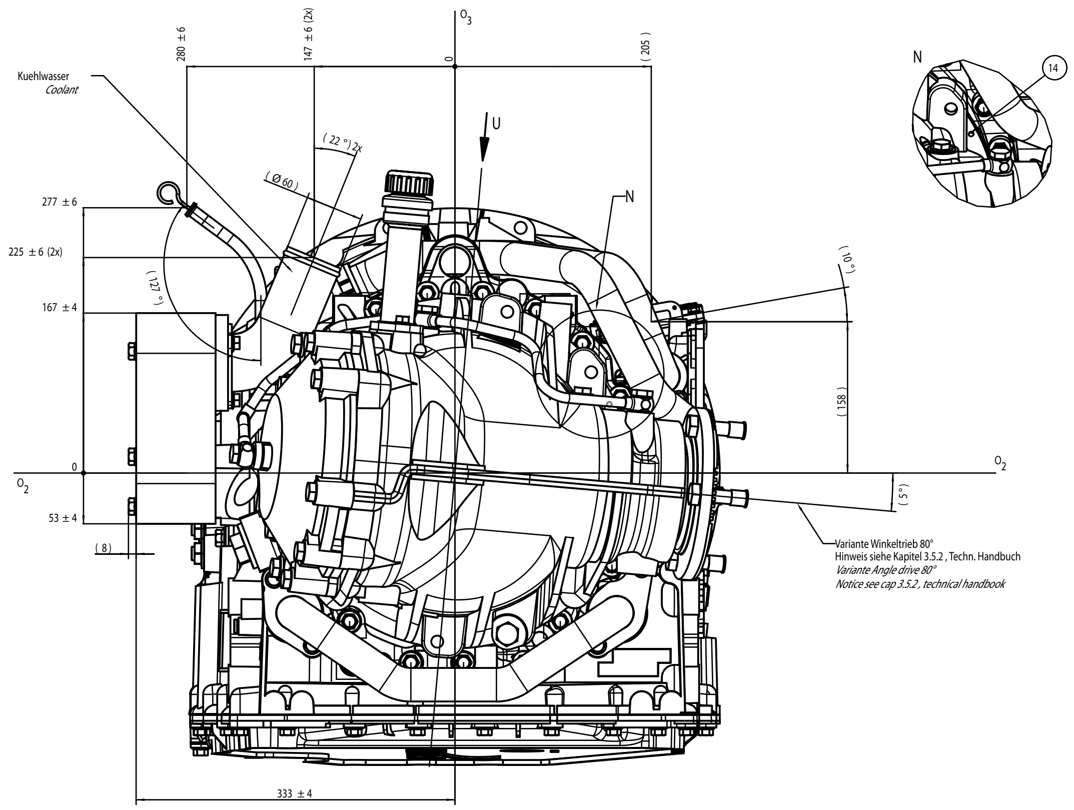
1	STEUERGERAET ELEKTRISCHE ANSCHLUESSE NACH SPEZIFIKATION 6070 703 002 ZULAESSIGE UMGEBUNGSLUFTTEMPERATUR: 100°C ZULAESSIGE OBERFLAECHENTEMPERATUR:105°C SCHUTZART -MIT AUFGESTECKTEM KABEL: IP69K -OHNE KABEL: TBD (VOR VERSCHMUTZUNG SCHUETZEN) *CONTROL UNIT* *ELECTRICAL TERMINALS ACC. TO SPECIFICATION 6070 703 002* *PERMITTED AMBIENT AIR TEMPERATURE: 100°C* *PERMITTED SURFACE TEMPERATURE: 105°C* *PROTECTION CLASS* *-WITH CABLE PLUGGED IN: IP69K* *-WITHOUT CABLE: TBD (PROTECT AGAINST FOULING)*
2	KABELANSCHLUSS. FUER TRANSPORT MIT SCHUTZKAPPE VERSEHEN *CABLE CONNECTION: FOR TRANSPORT EQUIPPED WITH PROTECTIVE COVER*
3	TRANSPORTAUFHAENGUNG *HANDLING SUPPORT*
4	GETRIEBEAUFHAENGUNG M16x1.5; 24 MIN TIEF ANZUGSDREHMOMENT 225Nm MAX *GEARBOX SUSPENSION M16x1.5; 24 MIN DEEP* *TIGHTENING TORQUE 225 Nm MAX*
6	KUEHLMITTELANSCHLUSS ZUM OELKUEHLER STUTZEN DIN 3021 - B 60 *COOLANT CONNECTION TO OIL COOLER* *SPIGOT DIN 3012 - B 60* FUER TRANSPORT MIT KUNSTSTOFF-STOPFEN VERSCHLOSSEN *FOR TRANSPORT CLOSED WITH PLASTIC PLUGS*
7	KUEHLMITTELANSCHLUSS VOM OELKUEHLER STUTZEN DIN 3021 - B 60 *COOLANT CONNECTION FROM OIL COOLER* *SPIGOT DIN 3021 - B 60* FUER TRANSPORT MIT KUNSTSTOFF-STOPFEN VERSCHLOSSEN *FOR TRANSPORT CLOSED WITH PLASTIC PLUGS*
8	DRUCKMESSSTELLE PVF (VOR FILTER) M10x1; 12 MIN TIEF *PRESSURE MEASURING POINT PVF (AHEAD OF FILTER)* *M10x1; 12 MIN DEEP*
9	HIER AUFHAENGEN NICHT GESTATTET *HERE NOT PERMITTED TO SUSPEND GEARBOX*
10	VERSCHLUSSSCHRAUBE M42x1.5 ZUGANG NUR NACH ABSTIMMUNG MIT ZF GESTATTET *SCREW PLUG M42x1.5* *ACCESS PERMITTED ONLY AFTER CONSULTION WITH ZF*
11	MESSSTELLE PHD (HAUPTDRUCK) M10x1; 12 MIN TIEF *MEASURING POINT PHD (PRIMARY PRESSURE)* *M10x1; 12 MIN DEEP*
12	TYPENSCHILD GETRIEBE; POSITION WAHLWEISE A/B/C DATEN: GETRIEBETYP,STUECKLISTEN-NR.,SERIAL-NR., KUNDEN-BESTELLNR.,UEBERSETZUNGSBEREICH, TACHO- METERUEBERSETZUNG (IMPULS/UMDREHUNG), OELMENGE, ZF-SCHMIERSTOFFBEZEICHNUNG *TYPE PLATE GEARBOX; ALTERNATIV POSITION A/B/C* *DATA: GEARBOX TYPE,PARTS LIST NO.,SERIAL NO.* *CUSTOMER ORDER NO.,RATIO RANGE, SPEEDOMETER RATIO* *(PULSE/REV.); OIL QUANTITY, ZF LIST OF LUBRICANTS* *DESIGNATION*
13	TYPENSCHILD STEUERGERAET DATEN: SACHNUMMER, SERIALNUMMER, KUNDEN-BESTELLNUMMER, BETRIEBSSPANNUNG, E1-NUMMER *TYPE PLATE CONTROL UNIT* *DATA: MATERIAL NO.,SERIAL NO.,CUSTOMER ORDER NO.,* *RATED VOLTAGE, E1-NUMBER*
14	BOHRUNG FUER PLOMBENDRAHT TACHOANSCHLUSS AN IMPULSGEBER *HOLE FOR LEAD SEAL WIRE SPEEDO CONNECTION TO PULSE SENSOR*
20	OELABLASSCHRAUBE SW6 (INNENSECHSKANT) (Ta=25 Nm) *OIL DRAIN PLUG, WIDTH ACROSS FLATS 6 (INTERNAL HEXAGON)*
21	M8 22 MIN TIEF ANZUGSMOMENT 20 NM BEFESTIGUNG VON ANBAUTEILEN NUR BEI 21 GESTATTET *M8 22 MIN DEEP TIGHTENING TORQUE 20 NM* *FIXING OF ADD-ON PARTS ONLY ALLOWED* *AT 21*
28	OELEINFUELLROHR BEFESTIGUNG VON ANBAUTEILEN NUR BEI 21 GESTATTET *OIL FILLER TUBE* FIXING OF ADD-ON PARTS ONLY ALLOWED AT 21
29	DREHRICHTUNG DES ABTRIEBSFLANSCHES BEI VORWAERTSFAHRT *SENSE OF ROTATION OF OUTPUT FLANGE DRIVING FORWARD*
30	AUSBAURAUM FUER OELMESSSTAB (OELMESSSTAB IST FLEXIBEL) *REMOVING SPACE FOR OIL DIPSTICK* *(DIPSTICK IS FLEXIBLE)*
31	ZULAESSIGER WINKELBEREICH FUER LASTANGRIFFSRICHTUNG; GETRIEBE MUSS WAAGERECHT HAENGEN *PERMITTED ANGULAR RANGE FOR LOAD DIRECTION;* *GEARBOX MUST BE SUSPENDED HORIZONTALLY*
32	M16x1.5 24 MIN TIEF, ANZUGSMOMENT 225 Nm *M16x1.5 24 MIN DEEP, TIGHTENING TORQUE 225 Nm*
33	AUSBAURAUM FUER OELFILTER *REMOVING SPACE FOR OIL FILTER*
35	AUSBAUHOEHE FUER OELWANNE *REMOVING SPACE FOR OIL SUMP*
37	ENTLUEFTER *BREATHER*
A8	DRUCKMESSSTELLE A8 (WANDLER-GEGENDRUCK) M10x1; 12 MIN TIEF *PRESSURE MEASURING POINT A8 (TORQUE CONVERTER BACK PRESSURE)* *M10x1; 12 MIN DEEP*
D5	DRUCKMESSSTELLE D5 (VOR RETARDER-OELKUEHLER) M10x1; 12 MIN TIEF *PRESSURE MEASURING POINT D5 (UPSTREAM OF RETARDER OIL COOLER)* *M10x1; 12 MIN DEEP*
D8	DRUCKMESSSTELLE D8 (SCHMIERDRUCK) M10x1; 12 MIN TIEF *PRESSURE MEASURING POINT D8 (LUBRICATING PRESSURE)* *M10x1; 12 MIN DEEP*
OM	OELMESSSTAB *OIL DIPSTICK*
S	SCHWERPUNKT (MIT OEL) *CENTER OF GRAVITY (WITH OIL)*
T	GEWINDEBOHRUNG FUER IMPULSGEBER M18x1.5, ANZUGSMOMENT 45 NM. FUER TRANSPORT MIT VERSCHLUSSSCHRAUBE VERSCHLOSSEN *THREADED BORE FOR PULSE SENSOR M18x1.5,* *TIGHTENING TORQUE 45 NM. FOR TRANSPORT CLOSED* *WITH THREADED PLUG*
	GETRIEBE IST MIT OEL BEFUELLT *GEARBOX IS FILLED WITH OIL* OELSORTE: ZF ECOFLUID LIFE OELMENGE: 42 L *OILTYPE: ZF ECOFLUID LIFE OIL VOLUME: 42 L*

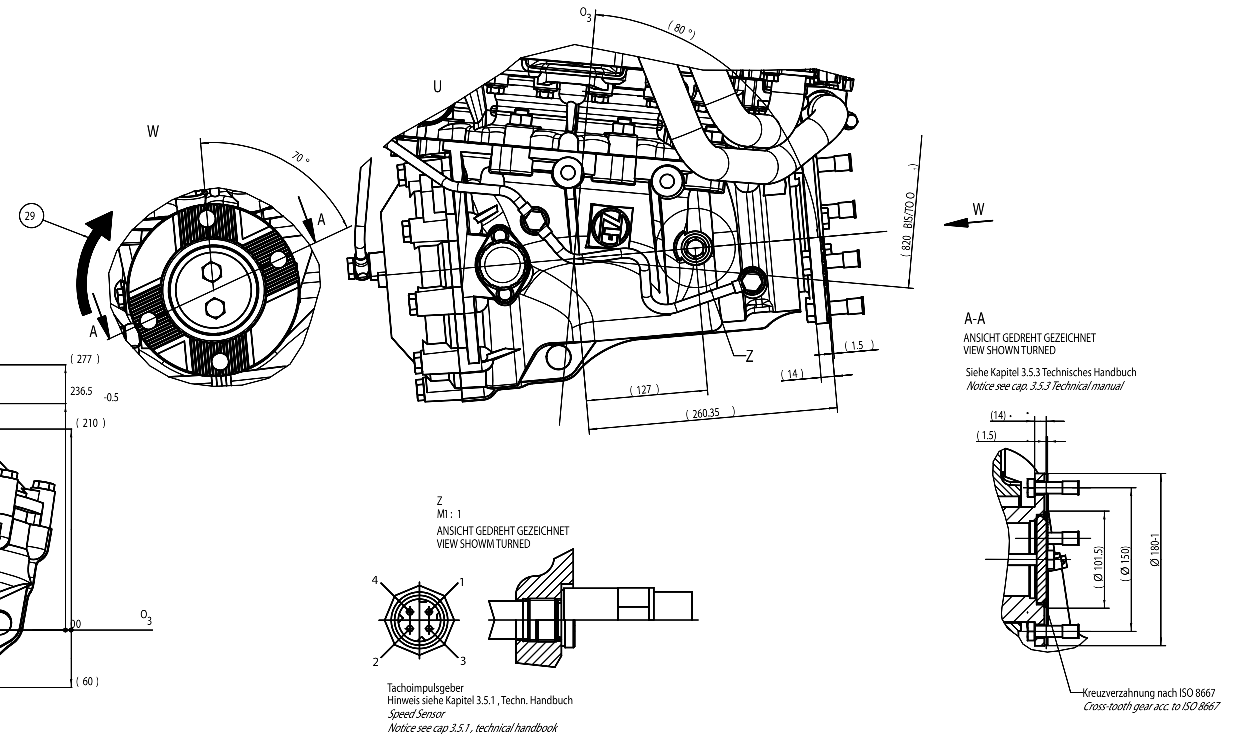
( ) MASSE NUR ZUR INFORMATION
( ) DIMENSION FOR INFORMATION ONLY

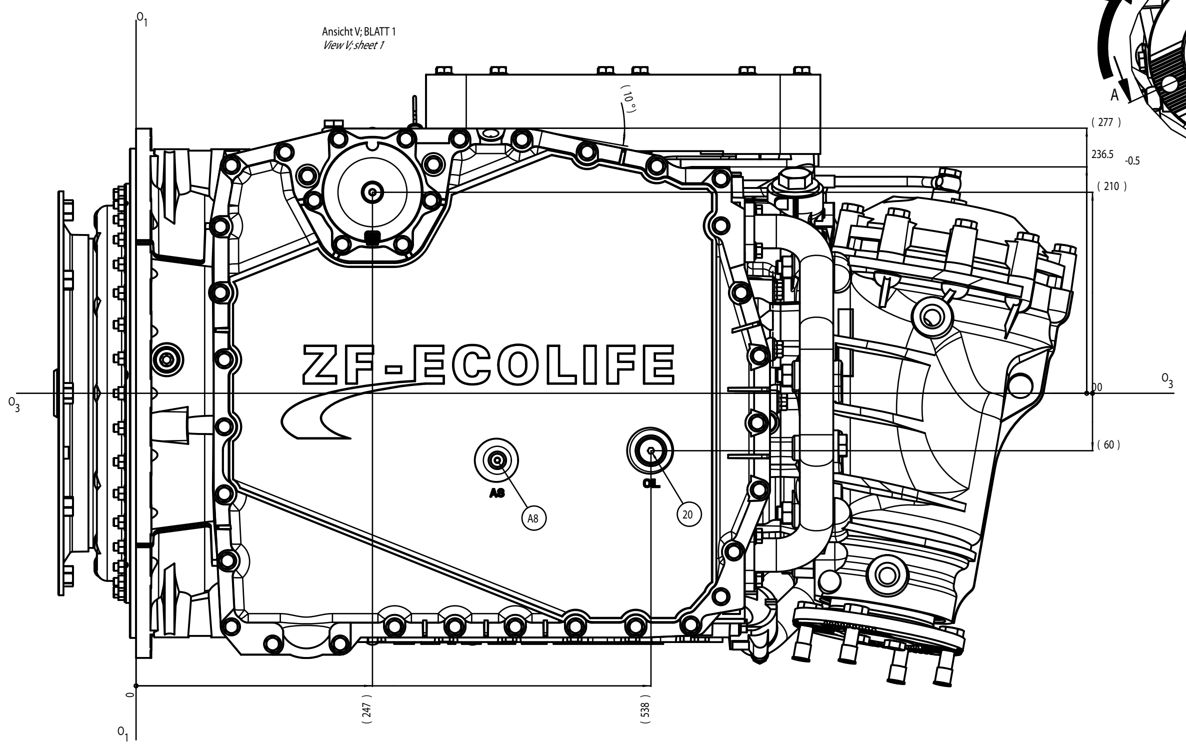
ROHKONTUR OHNE GUSSTOLERANZ
CASTING CONTURE WITHOUT CASTING TOLERANCE

From drawing no. 4181 602 035b-2



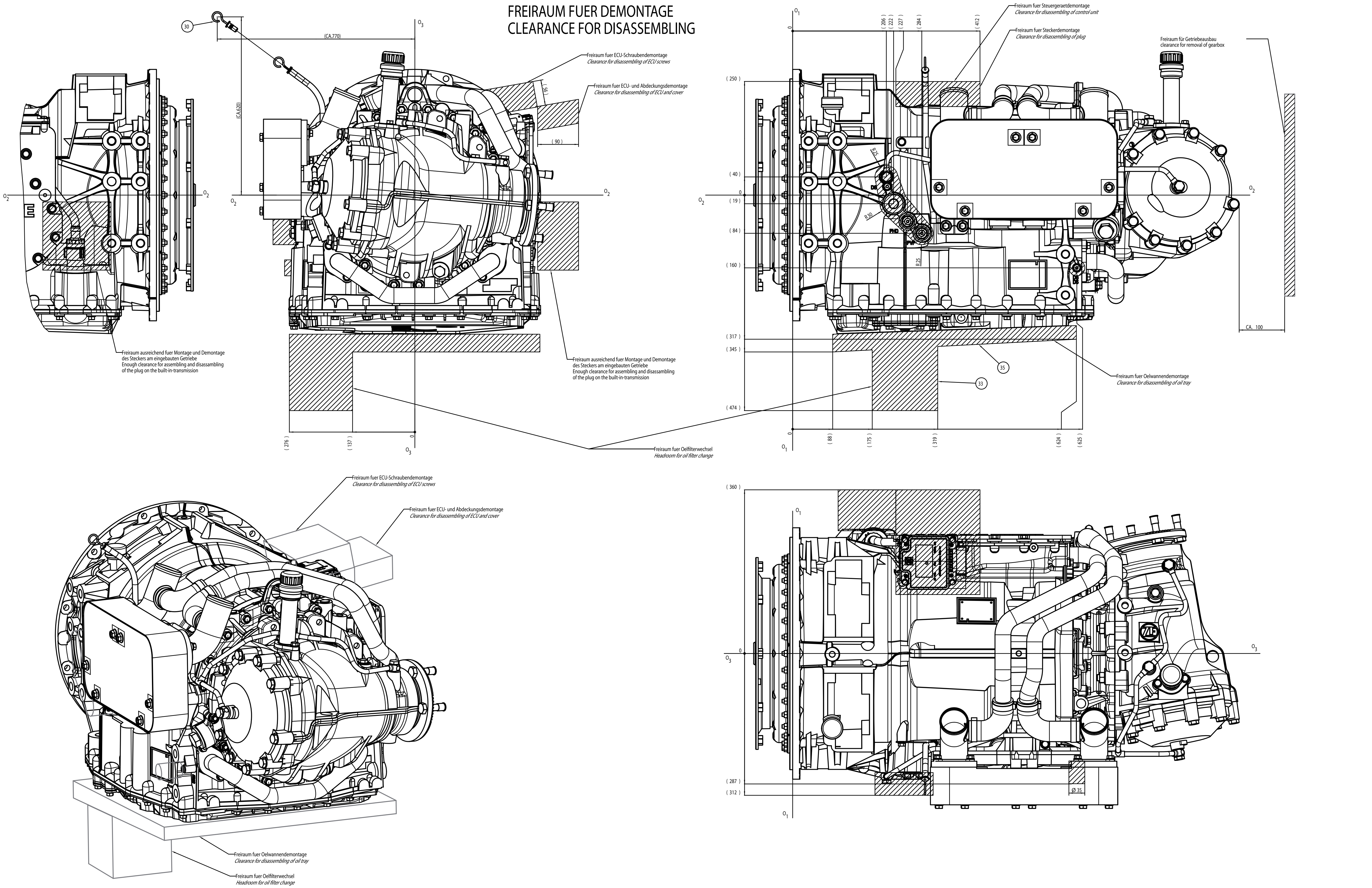






								SCHWERPUNKT UND MASSENTRAEGHEITSMOMENTE MIT OELBEFUELLUNG *CENTRE OF GRAVITY AND INERTIA MATRIX WITH OIL FILLING*								
								ALLE ABMESSUNGEN BEZIEHEN SICH AUF DIE MOTORANSCHLUSSFLAECHE ALL DIMENSIONS ARE BASED ON ENGINE CONNECTION INTERFACE								
	UEBERSETZUNGEN INCL. WINKELTRIEB *MECHANICAL RATIOS INCL. ANGLE DRIVE*							GETRIEBETYP GEAR BOX TYPE	GESAMTGEWICHT TOTAL WEIGHT	SCHWERPUNKT CENTRE OF GRAVITY			MASSENTRAEGHEITSMOMENT INERTIA MATRIX			
	GETRIEBE *GEARBOX*							MIT OELKUEHLER WITH OIL COOLER J01	MIT OEL WITH OIL	s (mm)			J (kgm^2)			
WANDLER	TYP *TYPE*	1	2	3	4	5	6	R	UND OELBEFUELLUNG AND OIL FILLING	m(kg)	X_s	Y_s	Z_s	J_x	J_y	J_z
W370	6 AP 1403 B	3.265	1.853	1.380	0.971	0.699	0.597	4.112	6 AP 1403 B	494	422	-9	-27	14.9	45	45.7
W370	6 AP 1203 B	3.265	1.853	1.380	0.971	0.699	0.597	4.112	6 AP 1203 B	491	422	-9	-27	14.8	44.7	45.4

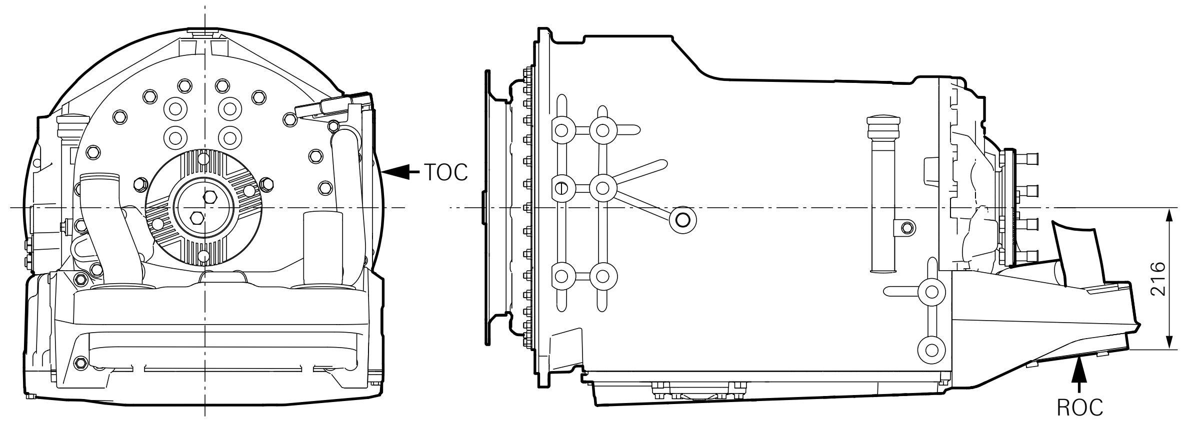
From drawing no. 4181 602 035b-3



3.2 Heat exchanger arrangement

3.2.1 Coaxial transmission version, 6 AP 1000 B to 6 AP 1400 B with directly attached heat exchangers (ROC – flat version)

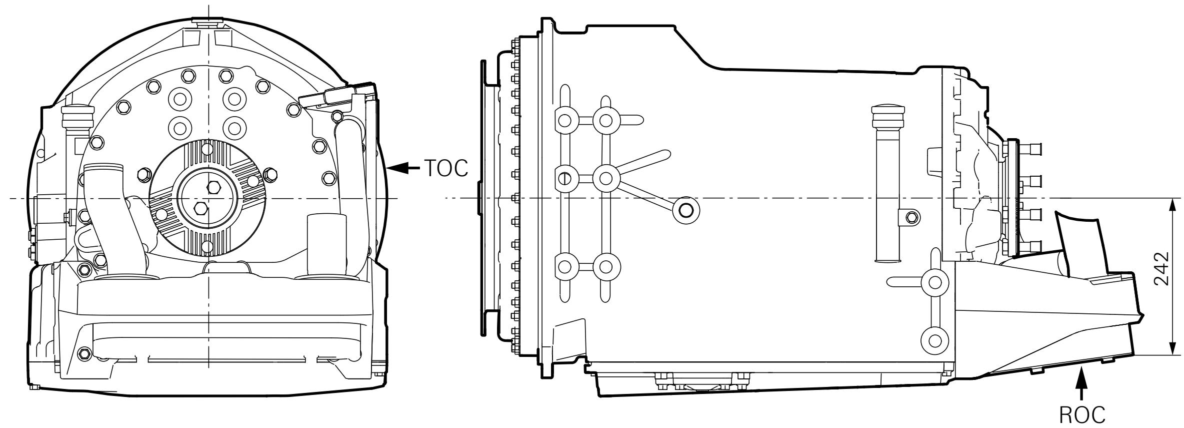
The retarder heat exchanger (ROC) is mounted at the output-end of the basic transmission while the transmission heat exchanger (TOC) is side-mounted.



TOC – integrated in the transmission housing
ROC – flat version, mounted to output end

028081

3.2.2 Coaxial transmission version, 6 AP 1700 B to 6 AP 2000 B with directly attached heat exchangers (ROC – deep version)

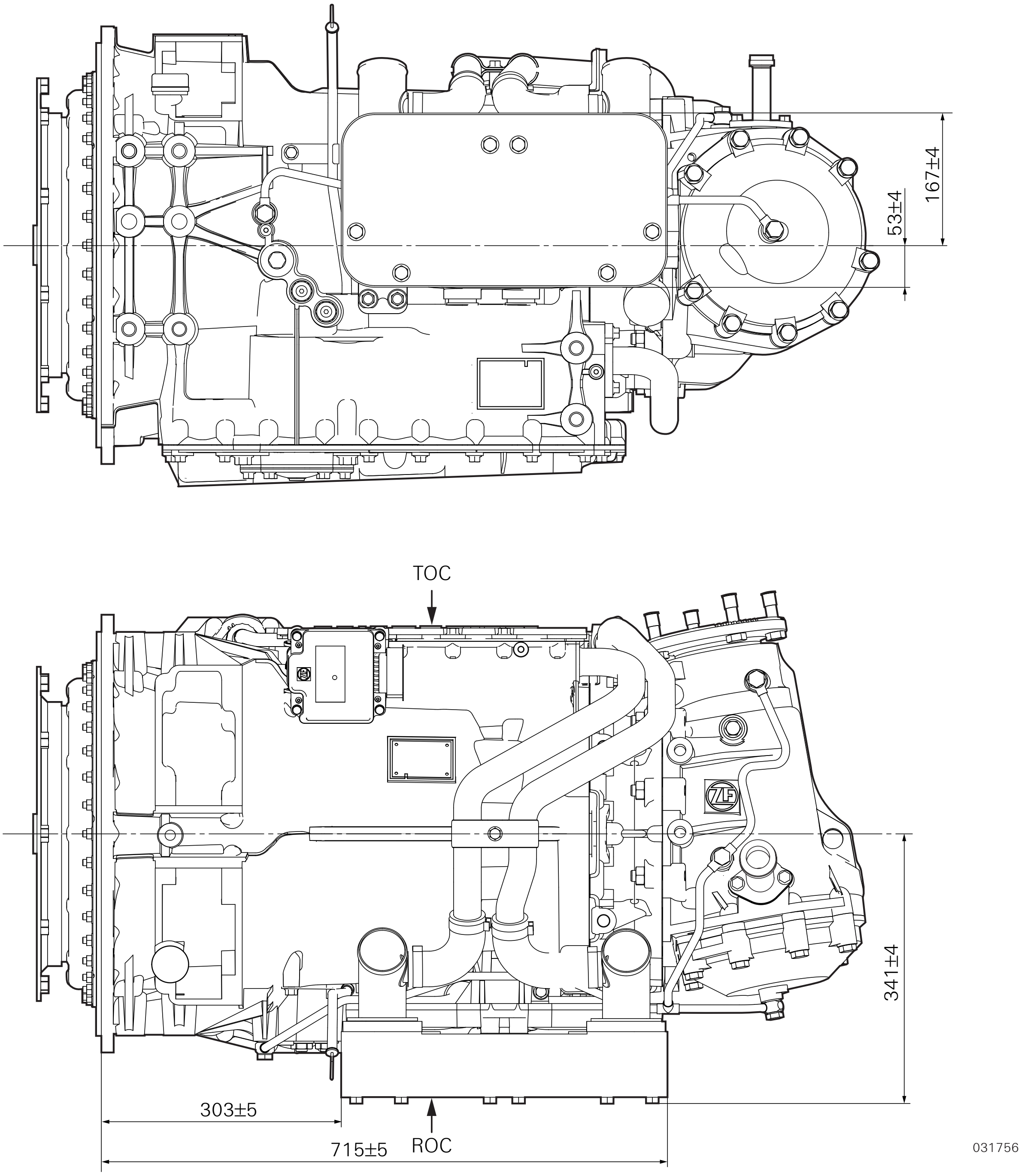


TOC – integrated in the transmission housing
ROC – deep version, mounted to output end

028082

3.2.3 Transmission with angle drive of 80° RHD and special heat exchanger arrangement

An angle drive of 80°, RHD, can be flange-mounted to the basic transmission.
A special retarder heat exchanger arrangement is made available for this purpose.



TOC – integrated in the transmission housing
ROC – laterally flange-mounted (E2 standard)

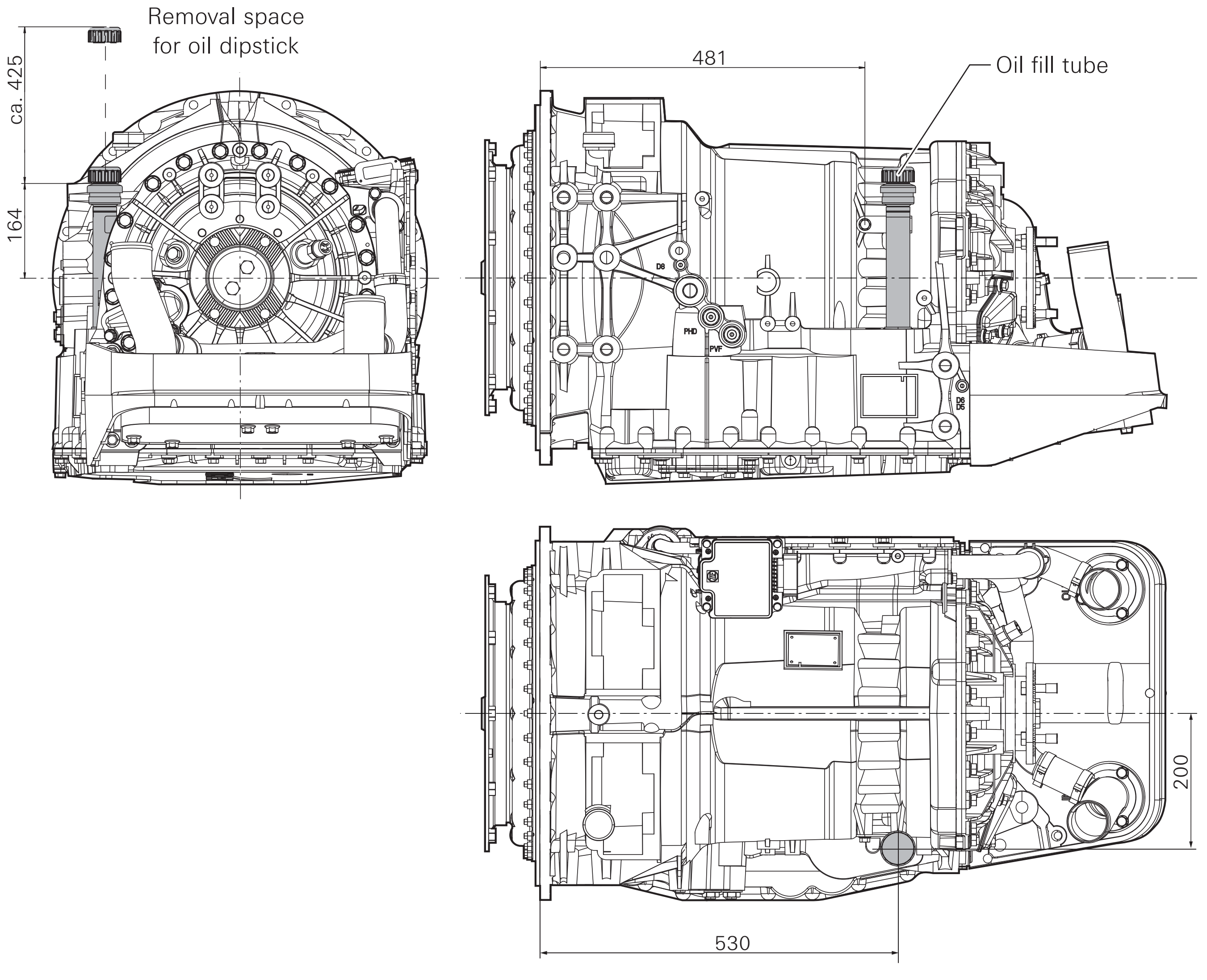
3.3 Oil pan

NOTE
For description of oil drain, see Chapter 18.8 and/or oil fill in Chapter 18.9

CAUTION
Always use genuine ZF oil drain plugs.
The torque converter drain valve is operated via the oil drain plug.

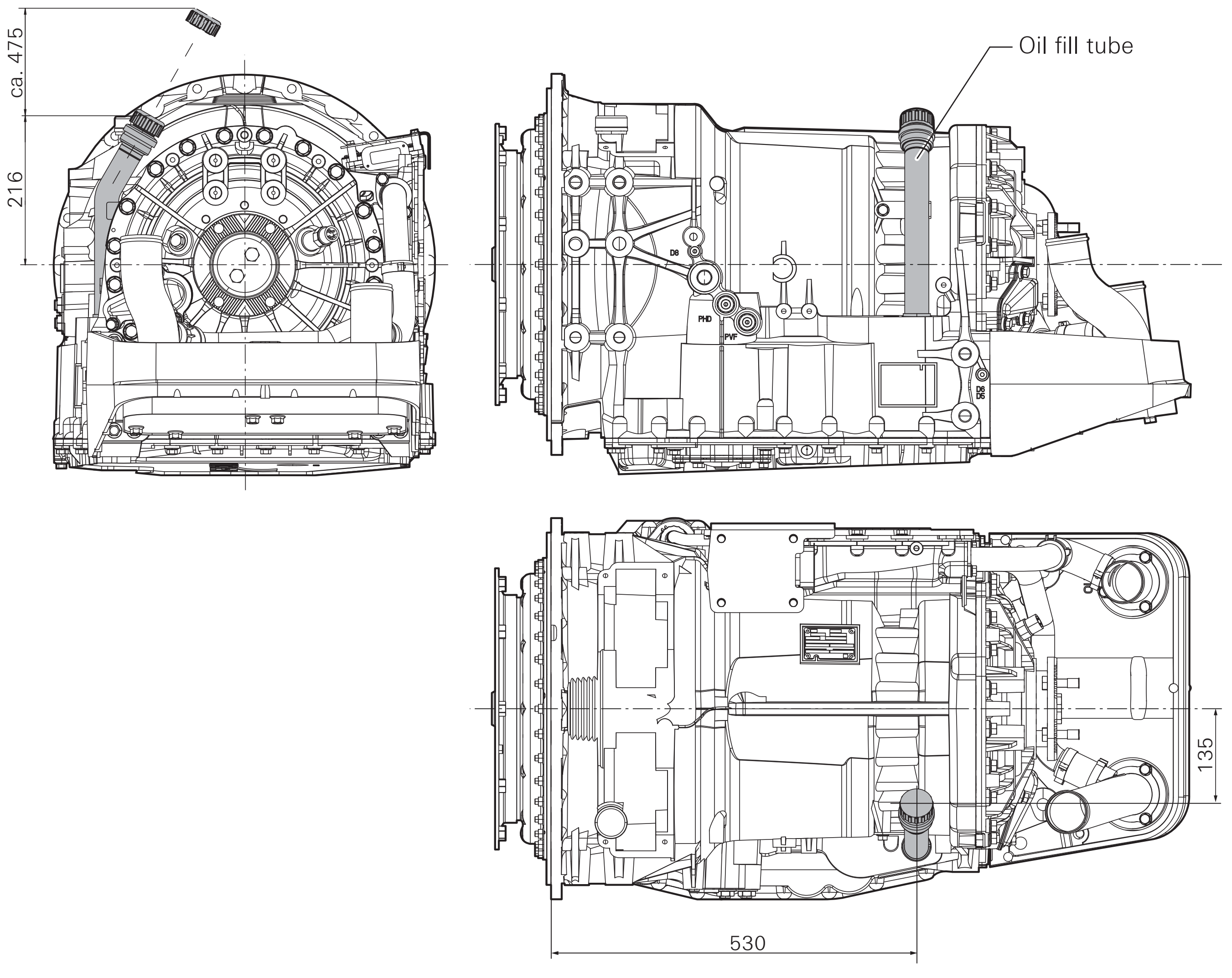
3.4 Oil fill

3.4.1 Oil fill for coaxial transmission version – standard tube – straight



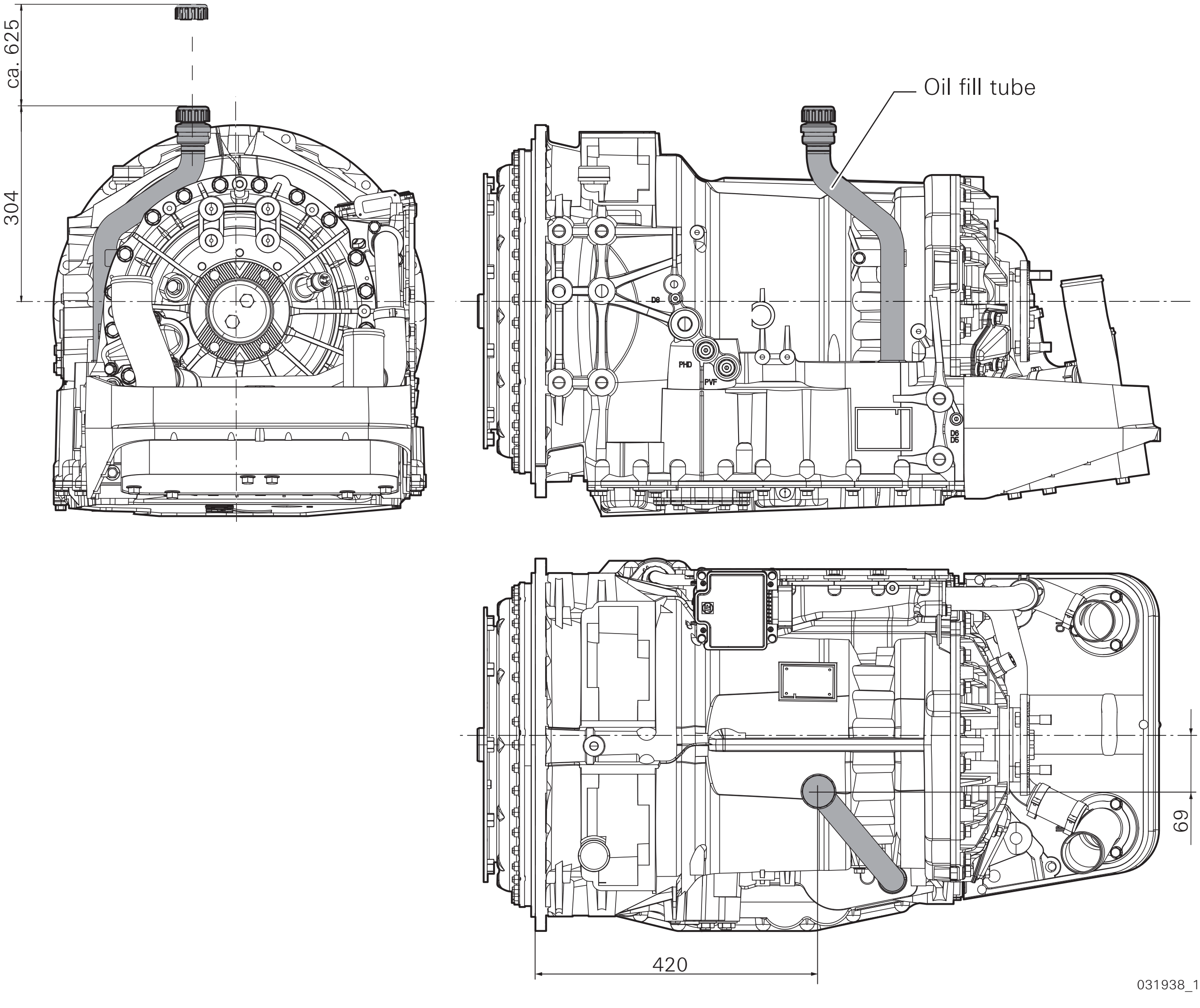
Oil dipstick depends upon the transmission installation position (longitudinal inclination/transverse inclination)

3.4.2 Oil fill for coaxial transmission version – variant 1 – tube with simple bends



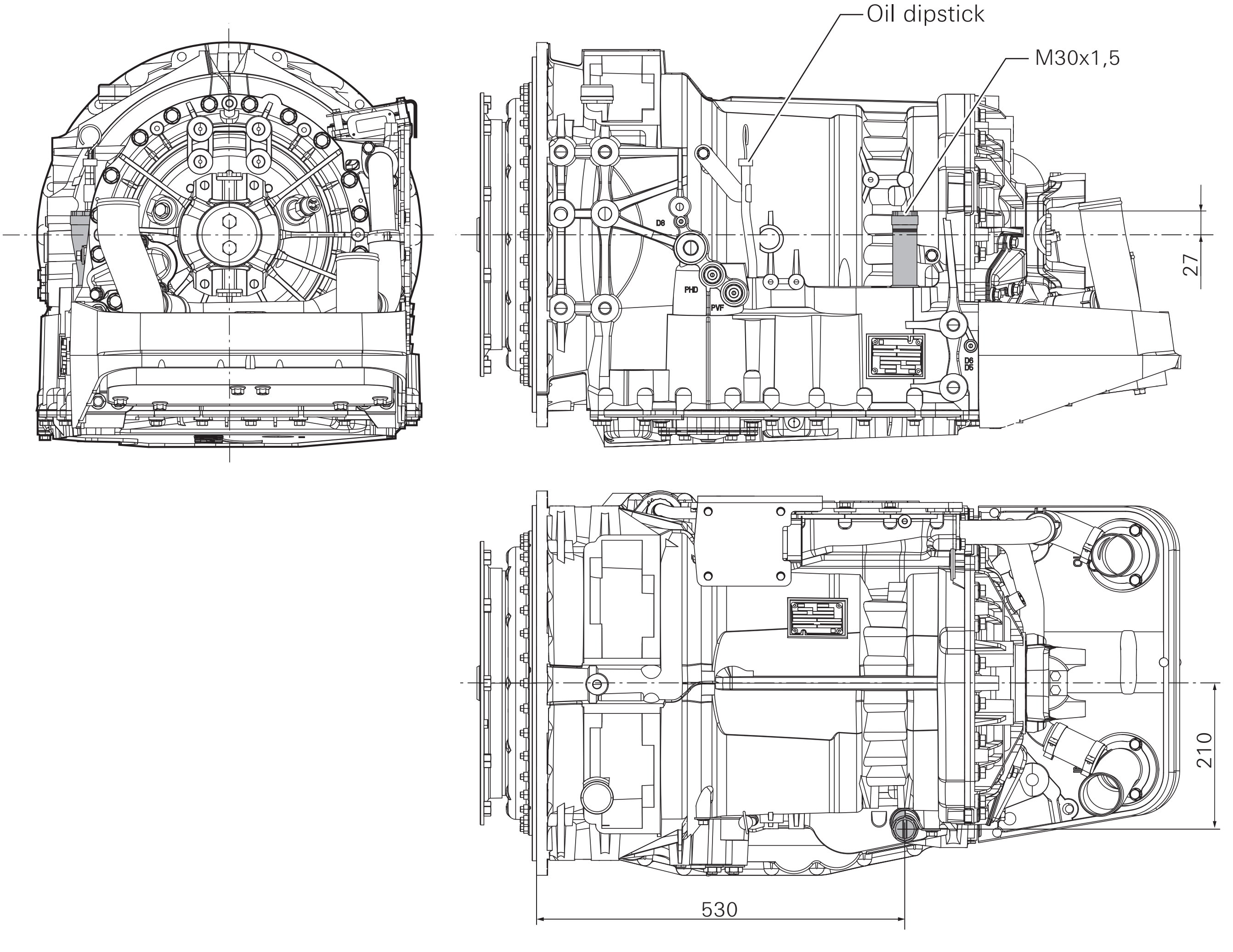
Oil dipstick depends upon the transmission installation position (longitudinal inclination/transverse inclination)

3.4.3 Oil fill for coaxial transmission version – variant 2 – tube with double bends



Oil dipstick depends upon the transmission installation position (longitudinal inclination/transverse inclination

3.4.4 Oil fill for coaxial transmission version – variant 3 – tube with threaded connections



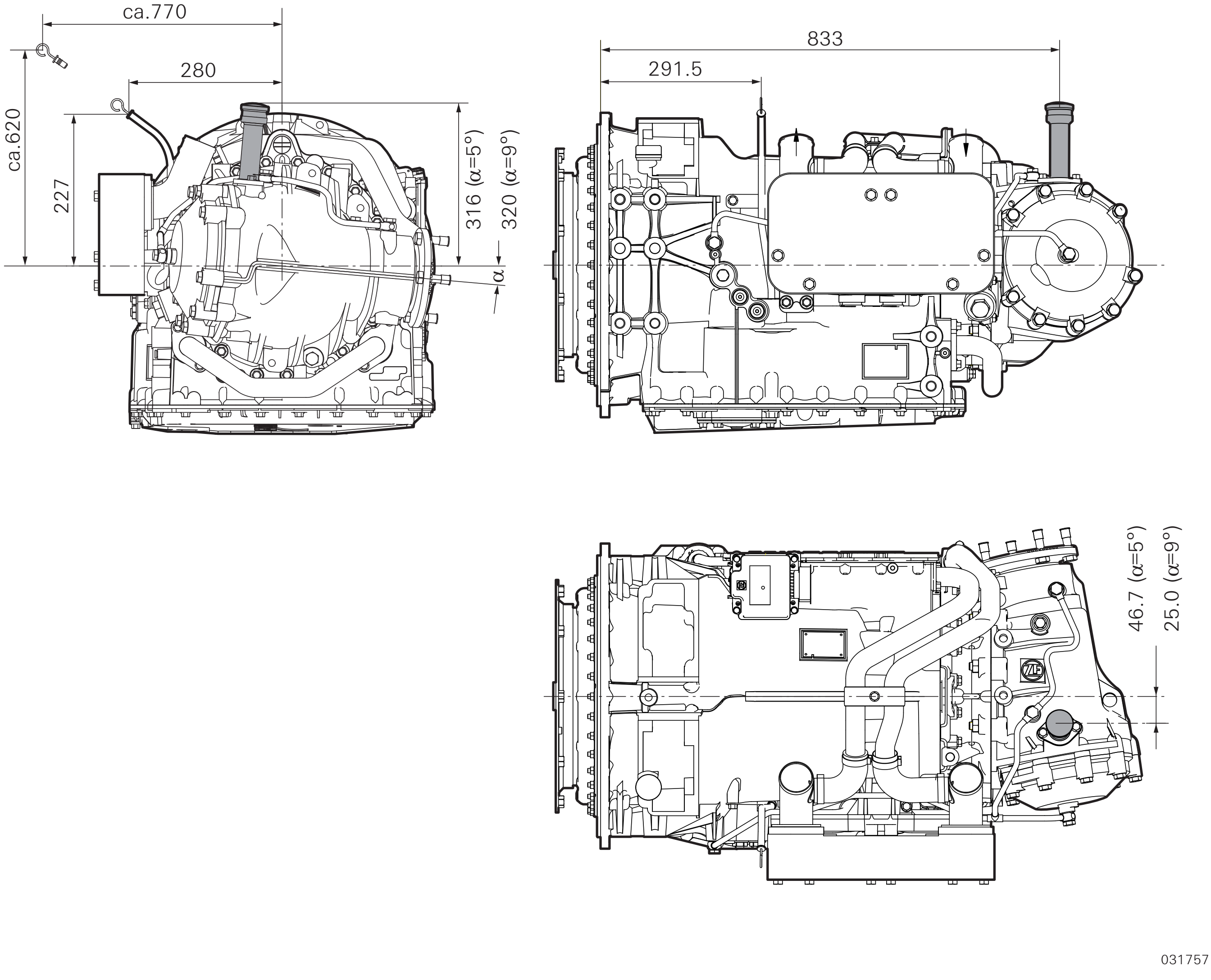
Determination of the oil-level marks on the vehicle manufacturer's oil dipstick:

- Oil filler tube is made available by the vehicle manufacturer and has to be screwed to the oil filler neck.
- The measuring marks at the dipstick depend upon the transmission inclination and are to be determined in close cooperation with our Sales and Applications department.
- Oil dipstick marks must be checked upon initial operation.

CAUTION

- **The cover is to be designed with a vent.**
- **The relevant oil level check is to be performed with the ZF transmission oil dipstick.**
- **Transferring the correct oil level to the vehicle manufacturer's oil dipstick resides within the scope of responsibility of the vehicle manufacturer.**

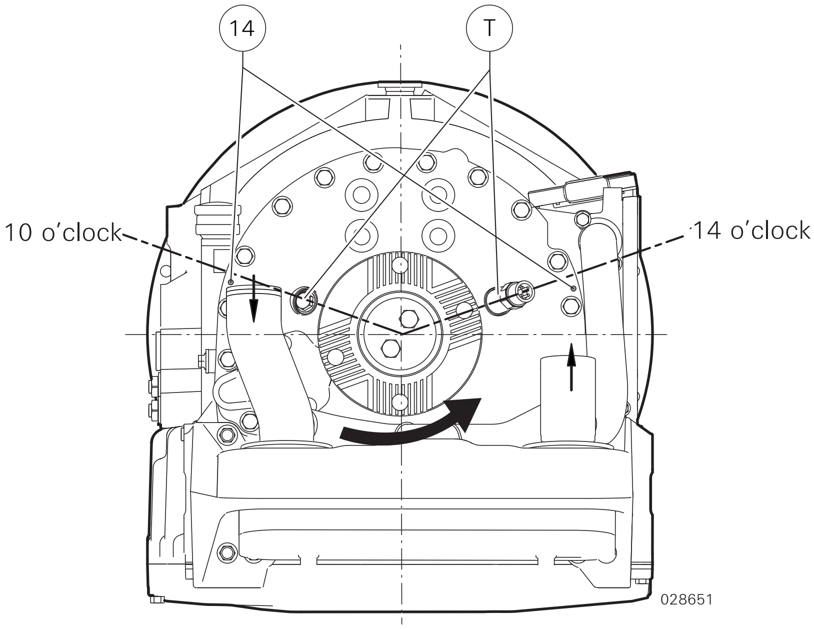
3.4.5 Oil fill for transmission version with angle drive of 80° RHD



Oil dipstick depends upon the transmission installation position (longitudinal inclination/transverse inclination)

3.5 Output

3.5.1 Coaxial output

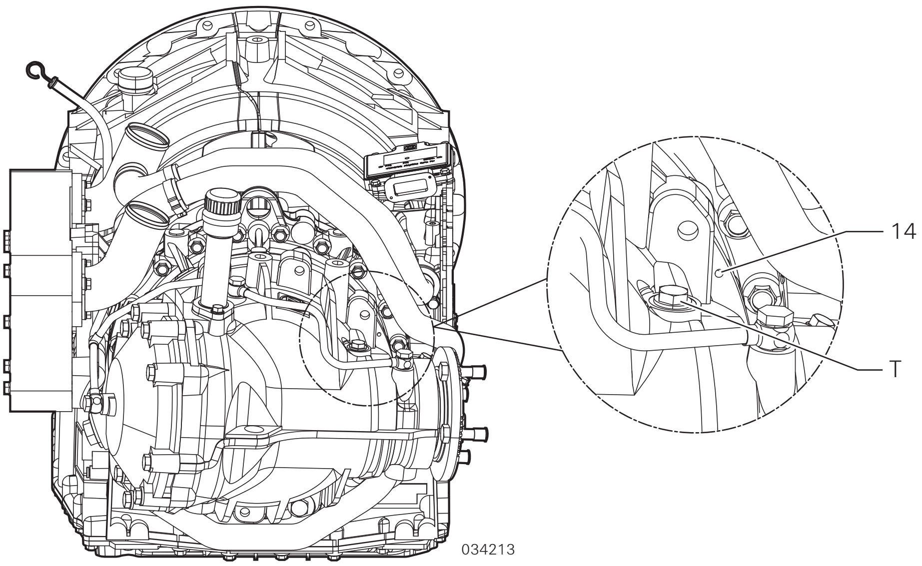


Item T = mounting position of speedometer impulse sensor (tightening torque: 45 Nm)
Item 14 = bores for (lead) seal wire

3.5.2 Angle drives of 80°

Angle drive	Ratios	Max. engine torque (Nm)	Mass (approx. kg)	position right	position left
80° RHD	0.971	See Chapter 2.4	See Chapter 2.6	α = 5°	
80° RHD	0.971	See Chapter 2.4	See Chapter 2.6	α = 9°	

Angle Drives of 80°, RHD



Item T = mounting position of speedometer impulse sensor (tightening torque: 45 Nm)
(For overview of impulse sensors, see table in Chapter 3.5.3)
Item 14 = bore for (lead) seal wire

3.5.3 Variant overview, impulse sensor – for manufacturer see collective drawing

Sensor generation	**Impulse sensor "Inductive"**	**Impulse sensor "Hall"**	**KITAS II "Hall"**
Plug connection	Joint fitting	Bayonet fitting DIN 72585	Bayonet fitting DIN 72585
Collective drawing	**0501 208 790**	**0501 210 854**	**0501 214 767**
Sensor length: 35 mm	0501 208 793	0501 210 857	0501 214 772
Third-party part number	refer to collective drawing		

NOTE
The transmission standard version is delivered without impulse sensor.
Pulse-generator wheel: 6 pulses per revolution

3.5.4 Output flange for coaxial output and angle drive

Fig. I

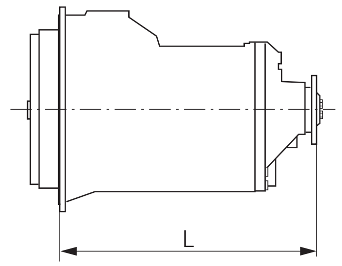


Fig. II

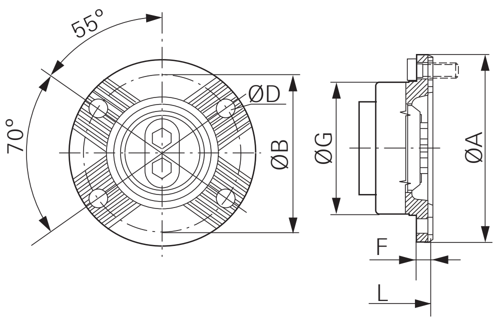
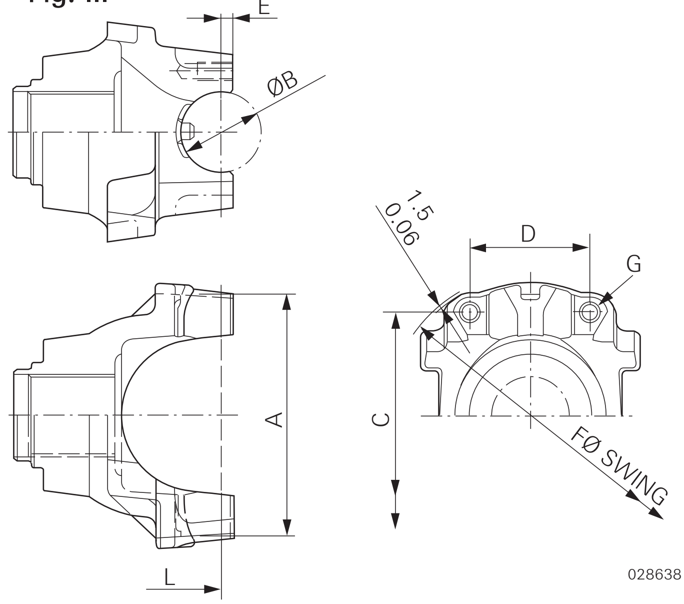


Fig. III



NOTE
Clean output flange before assembling propshaft!

Screws pre-fitted	ZF-No.	ØA	ØB	ØC_{h6}	ØN_{H7}	ØD	E	F	ØG	L	Fig.	6 AP 100x B 6 AP 120x B 6 AP 140x B	6 AP 170x B 6 AP 2000 B
M12*	4181 383 002	150	130	–	–	13.0	–	12	110.3	732	I / II	X	X **
M14*	4181 383 003	180	150	–	–	15.0	–	14	127.3	732	I / II	X	X

All dimensions in millimeter
*Uphill gradient, threaded length, and strength class are to be defined together with the OEM.
** Allocation in accordance with the vehicle manufacturer's provisions

YOKE Series	ZF-No.	ØA	ØB	C	D	E	F*	G	L	Fig.	6 AP 1000 B 6 AP 1200 B 6 AP 1400 B	6 AP 1700 B 6 AP 2000 B
1710	4181 383 008	157,112	49.2	141,986	71,254	8,014	184.0	0.5-20 UNF 2B	782.0	I / III	X	–
1810	4181 383 009	194,120	49.3	179,020	71,250	7,900	228.6	0.5-20 UNF 2B	794.3	I / III	X	X
1)	4181 383 010	138,600	49.2	123,000	76,000	8,000	185.0	M12x1.25	798.5	I / III	X	–

1) For connection to a propshaft which e.g. can also be connected to the DANA-Spicer series SPL140

* Oscillatory circuit diameter with clearance of 1.5 mm for output flange yoke

4 Application, Documentation, Document Overview

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4.3.1 Transmission type plate 4-5
4.3.2 EcoLife ECU type plate 4-5

4.4 Hanging sign “Oil level check” 4-6

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4 Application, Documentation, Document Overview

4.1 Form for design of driveline and performance calculation

Customer: ________________ Number of vehicles: ________________
E-mail: ________________ Phone: ________________

Vehicle:
☐ City bus/type ________ ☐ Suburban bus/type ________ ☐ Coach/type ________

Solo: Articulated:
☐ _____ m ☐ 12 m ☐ 15 m ☐ 18 m ☐ _____ m

Tires: ________________ Permissible total weight : ___ t Curb weight: ____ t

Engine torque deduction:
Auxiliaries: ________________ Deduction: ______ Nm

Previous vehicles:
Type: ________________ Engine rating: _____ kW Transmission: ____________ Axle i_{HA}: ______

Statistics memory data available from the transmission electronics: ☐ yes ☐ no
Speedometer dial of representative routes available: ☐ yes ☐ no

Engine:
Type: ________________; _____ kW ________________; _____ kW
________________; _____ kW ________________; _____ kW
Remarks: ________________

Transmission version, coaxial:
☐ ZF-6 AP 1000 B ☐ ZF-6 AP 1700 B
☐ ZF-6 AP 1200 B ☐ ZF-6 AP 2000 B
☐ ZF-6 AP 1400 B

Angle drive RHD:
☐ ZF-6 AP 1003 B ☐ ZF-6 AP 1703 B
☐ ZF-6 AP 1203 B
☐ ZF-6 AP 1403 B

Remarks: ________________

Topography: ☐ Level ground ☐ Medium ☐ Difficult
Utilization (%): Low ____ %; Medium ____ % High ____ %
Application (%): City ____ %; Suburban service ____ % Mixed traffic ____ %

Max. uphill gradient: ______ % **Approx. length of gradient:** _______ m

Average distance between stops: _____ m **Max. speed:** _______ **km/h**

ZF recommendation:
Engine: ____________, ___ kW Transmission: 6 AP______ B Axle ratio i_{HA} = __,__

Date: ________________ Name: ________________ Department: ________________

4.2 Overview

In the case of microprocessor-controlled automatic transmissions of the EcoLife model range, the components engine, transmission and electronic control unit (EcoLife ECU), which is attached to the transmission, are tuned to each other. These three components may be installed in the vehicle only in the combination documented by ZF.
The application process involves several steps in the course of which the following documents are created.

CAUTION
Prior to every EcoLife installation, check whether the components engine, transmission, and electronic control unit correspond to the documentation by means of the parts list numbers on the type plates. For correspondence and queries, always specify the parts list number and serial number of the ZF-EcoLife transmission and electronic control unit (ECU EcoLife)!

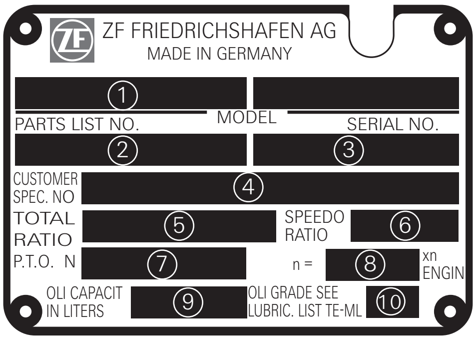
	Step	Responsible	Document
1	Specify hardware and system layout, Specify amplitude/scope of signals, agree a malfunction specification	ZF together with OEM	• Customer specification • Signal specification • Malfunction specification • Design modifications
2	Create parts list according to iDAS application system (iDAS = intelligent Data Application System)	ZF	• Parts list numbers • Circuit diagram • Terminal connection plan for ZF wiring only • Installation drawings
3	Perform vehicle integration FMEA (can also be done after the initial start-up)	ZF together with OEM	• I-FMEA document
4	Deliver transmission with start-up program	ZF	–
5	Install transmission in vehicle	OEM	–
6	Perform initial start-up and installation inspection, and adjust transmission program to customer vehicle	ZF together with OEM	• Initial start-up report Only ZF internal mailing list
7	Vehicle acceptance by OEM	OEM	• Informal confirmation
8	Installation release	ZF	• Release letter to OEM

4.3 Identification of transmission and control unit

4.3.1 Transmission type plate

Standard scope of supply: 1 type plate
Optional: 2nd and 3rd type plate possible

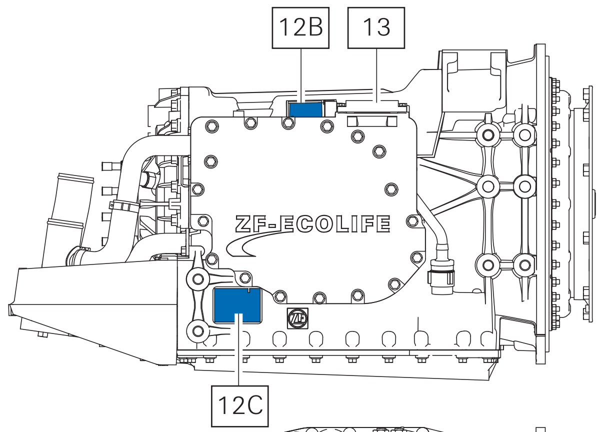
Pos.: 12

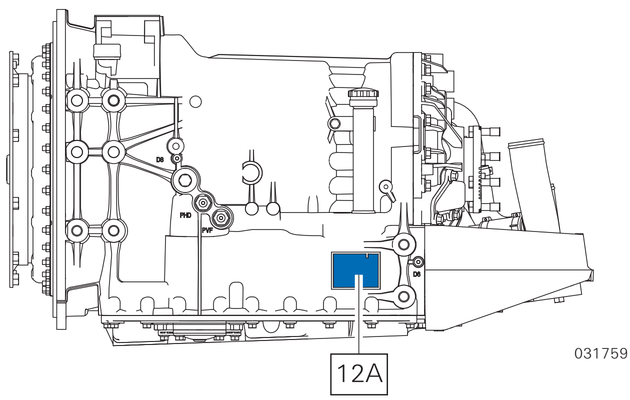


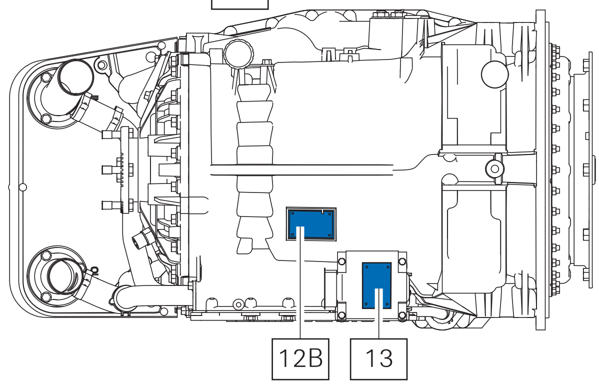
4.3.2 EcoLife ECU type plate

Pos.: 13

ZF material number 6070 003 XXX
ZF serial number
Customer order number
Nominal voltage
e1 number







Type plate positions: 12 and 13
valid for coaxial transmission version(s) and the corresponding angle drive variants, 6 AP xx03 B.
For position, also refer to installation drawing in Chapters 3.1.1 and 3.1.2

Transmission type plate:

1 Product designation and transmission type with number of gears
2 Transmission parts list number
3 Transmission serial number
4 Customer order number, if known to ZF
5 Ratio 3.364 to 0.615 (coaxial transmission)
6 Speedometer ratio (impulses/revolutions)
7 Type of power take-off
8 Power take-off ratio
9 Approx. oil quantity for initial filling
10 Designation of ZF List of Lubricants

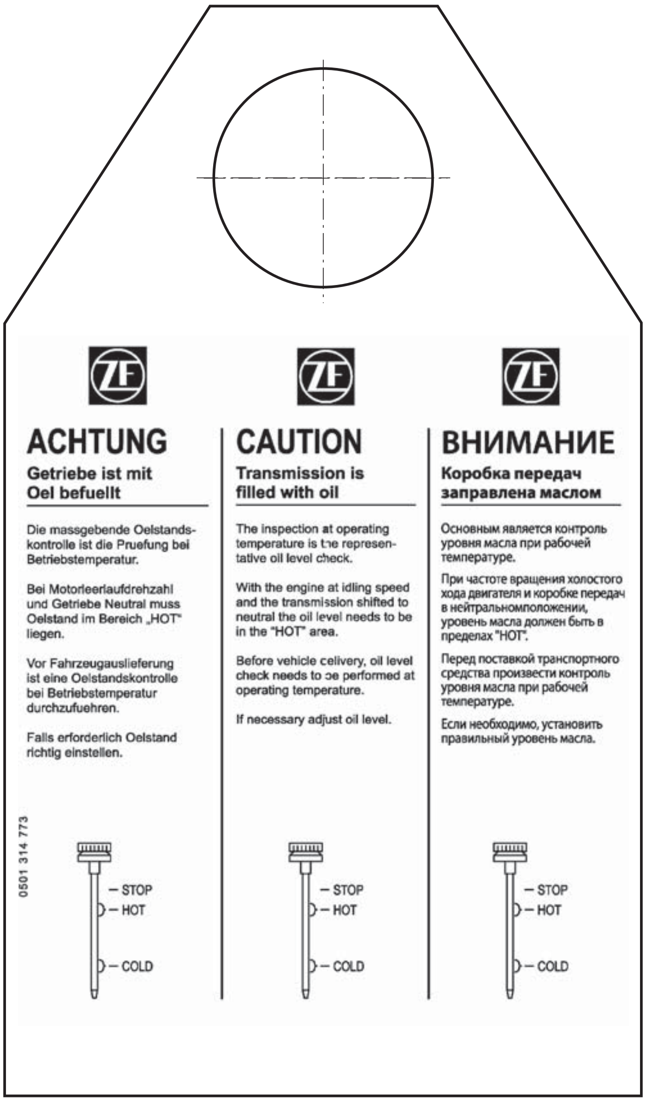
EcoLife ECU type plate:

1 ZF material number
2 ZF serial number
3 Customer order number (if known to ZF)
4 Rated voltage
5 e1 number

4.4 Hanging sign "Oil level check"

Transmission is filled with oil at the factory.

CAUTION
Before vehicle delivery, oil level check
at operating temperature is to be carried out.



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4.5 Integration FMEA

4.5.1 Definition of I-FMEA

The FMEA (**F**ailure **Mode** and **E**ffects **A**nalysis) is a method for preventive failure prevention. In an early development stage, the risks should already be estimated and measures for risk reduction should be initiated if necessary.

The high degree of functional networking of the ZF-EcoLife transmission system with other vehicle components requires systematic inspection of possible failures/faults. For this reason, ZF performs an integration FMEA (I-FMEA) together with the vehicle manufacturer. The Integration FMEA is derived from the System FMEA. In the I-FMEA, possible malfunctions of the transmission-vehicle interface are looked at.

4.5.2 Purpose of I-FMEA

The purposes of the I-FMEA are

- Show consequences of interface faults :
  - from the vehicle to the automatic transmission, e. g. power supply, CAN signals, etc.
  - from the automatic transmission to the vehicle, e. g.: communication between EcoLife ECU and engine control or other vehicle-related systems
- Outline the limits of ZF responsibility
- Sensitize vehicle manufacturers for their responsibilities regarding system interfaces

4.5.3 Implementation of I-FMEA

The I-FMEA is performed and implemented in the following steps

1. Identification of sub-systems (e. g. engine) and system elements (e. g. engine control) of the vehicle. Structuring of sub-systems system elements.
2. Allocation of functions and malfunctions to sub-systems and system elements.
3. Structuring of malfunctions (cause of fault – fault – consequence of fault).
4. Risk assessment of individual causes of fault.
5. Derive measures to reduce risk.

All interface experts (electrics, mechanics, etc.) have to participate in the I-FMEA implementation.

NOTE

The malfunctions in the transmission itself and malfunctions which cannot be traced back to the transmission system, e. g. malfunctions/top events at vehicle level when output signals of the ZF transmission control unit are used, are not looked at. If the OEM or other system manufacturers use signals of the transmission, risks regarding possible malfunctions at vehicle level have to be evaluated (e. g. within a system FMEA of the overall vehicle). The type, quality, and generation of output signals by the ZF transmission control unit are described in the ZF-EcoLife Signal Specification 6070 703 002. A malfunction specification has been assigned to the iDAS application system.

4.6 Initial start-up

After the initial installation of the transmission in the vehicle has been completed, ZF and OEM perform start-up operation together, including temperature measurement according to ZF check list.

The start-up process and potential defects are documented. The OEM is informed about detected defects and has to eliminate them.

4.7 Installation release

The installation release is a confirmation by ZF for the OEM that the transmission system can be installed by the OEM as a standard production part.

NOTE
Installation release applies exclusively to the configuration defined in the customer specifications. Installation release requires that the OEM eliminates the defects pointed out in the start-up report / release document and accepts the consequences depicted in the I-FMEA.

4.8 Information obligations of OEM towards body manufacturer

4.8.1 Responsibilities

Responsibility and implementation of the individual steps from the chassis to the completely assembled and mounted vehicle are organized as follows:

		Implementation	Responsibility
Chassis acceptance	Prototype	ZF	OEM
	Volume production delivery	OEM	OEM
Duty to provide information Technical documents from OEM to body manufacturer		OEM	OEM
Storage of chassis and **transport** to body manufacturer		OEM	OEM
Completely assembled vehicle **Initial operation**	Prototype	ZF	OEM and body manufacturer
	Volume production delivery	Body manufacturer	OEM and body manufacturer

Technical documentation
- The specifications of transmission, peripherals, and wiring are documented by the chassis manufacturer together with ZF.
- Chassis start-up is carried out by ZF. The installation must be approved and released by ZF.
- The chassi manufacturer must provide binding technical documents (e. g. body mounting instructions for chassis, operating instructions,...).

Storage and transport
- It must be ensured that electrical components, such as e. g. dashboard, electronic control units and wiring as well as ZF-EcoLife transmission are protected against ingress of water and dirt during transport, storage/warehousing, and the mounting/assembly phase.

Start-up
- After the body mounting work has been completed, ZF staff has to see to start-up of prototype vehicle.
- In the case of production delivery, a complete check/inspection is to be carried out by the body manufacturer using the form for delivery inspection 4181 754 102.

NOTE
- ZF can only be held accountable for initial installation faults, when acceptance was done by authorized ZF staff and all defects detected by ZF have been removed by the OEM or body manufacturer.
- The vehicle and body manufacturer will be exclusively liable for damage caused by defects which the vehicle or body manufacturer is to be held accountable for and which were not detected during initial acceptance by ZF.
- The OEM is responsible for the implementation of a thorough and professional installation inspection at the body manufacturer’s (except for initial start-up).
- Release will immediately become void if the OEM or body manufacturer changes or modifies the installation configuration. Once the release becomes void, all warranty obligations on the part of ZF are automatically nullified.

4.8.2 Installation instructions

Installation directive 4181 765 107 is to be observed.

4.9 Document overview

The specifications listed in these documents must be observed because they are a prerequisite for fault-free operation of the ZF-EcoLife transmission system as well as for the warranty cover granted by ZF.

Please turn to your personal contact if you need binding drawings for installation inspections etc.

Order no.	Type of document	Techn. information	
0000 766 707	CD-Rom	Propshaft calculation program	
0000 766 708	Floppy disk	Propshaft calculation program	
6074 766 701	CD-Rom	TopoDyn Life	
TE- ML 20	List of Lubricants	TE-ML 20 (for the latest List of Lubricants, go to www.zf.com)	
4181 765 107	Installation instructions	Instructions for the OEM	
4181 765 106	Body mounting instructions	Instructions for the vehicle body manufacturer	
4181 754 102	Form	OEM delivery check	
4181 754 704	Checklist	Start-up	
4181 758 101	Operating instructions	Operation, maintenance, troubleshooting	
4181 751 102	Repair manual	Repair Levels 1 - 2	
4181 751 101	Repair manual	Repair Level 3	
4181 753 101	Plan	Hydraulics 1 ‘off’ position	
4181 753 102	Plan	Hydraulics 2 ‘on’ position	
6008 750 102	Product brochure	ZF-Testman	
6070 703 002	TCI	EcoLife ECU	
6006 741 001	TCI	Speed range selector	
6041 722 041	TCI	ZF e module 2	
6041 722 043	e24 certificate	ZF e module 2	No.: e24 03 1504
6070 703 006	e1 certificate	EcoLife ECU	No.: e1 03 4776
6070 703 017 [1)]	e1 certificate	Speed range selector	no.: e1 03 5219
4181 701 007	Application instructions	MF motors, standard (torque-managing motors)	
4181 701 008	Application instructions	MF motors, special version (torque-managing motors)	
4181 701 040	Application instructions	Engine category	
4181 701 041	Application instructions	EMF motors (limited torque-managing motors)	

[1)] Applies to all speed range selectors

5 EcoLife Arrangement in Vehicle

5.1 Driveline variants 5-3

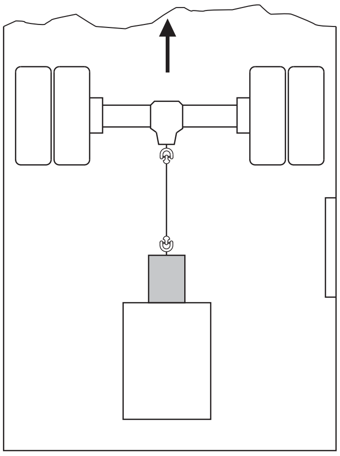
5.2 Transmission longitudinal inclination 5-4

5.3 Transmission transverse inclination 5-4

5 EcoLife Arrangement in Vehicle

5.1 Driveline variants

T-drive, conventional arrangement, tail installation



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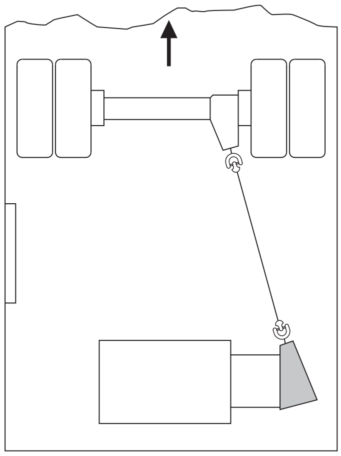
Transverse tail installation, 80°, angle drive of 80° RHD (right)



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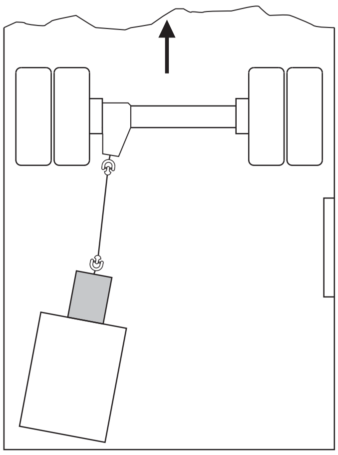
Drive element offset, e. g. to left side



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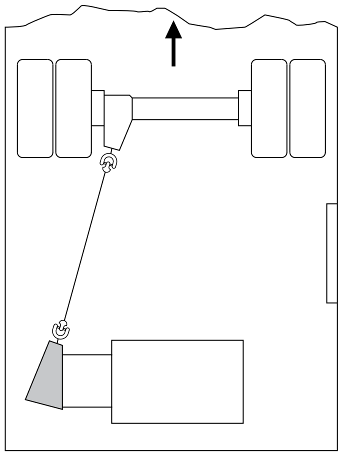
Transverse tail installation, 80°, angle drive of 80° LHD* (left)



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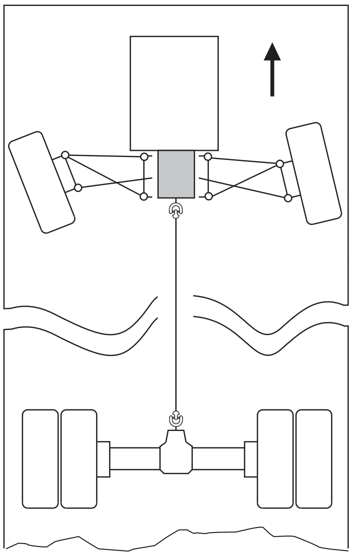
* Development project

Front-mounted engine



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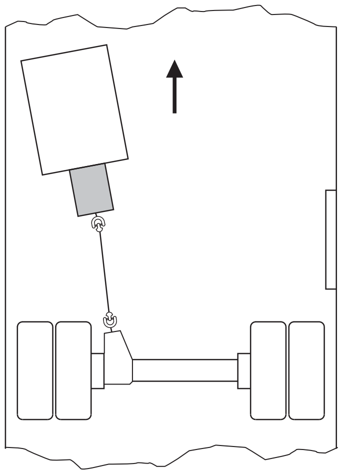
Drive element offset, mid-mounted engine



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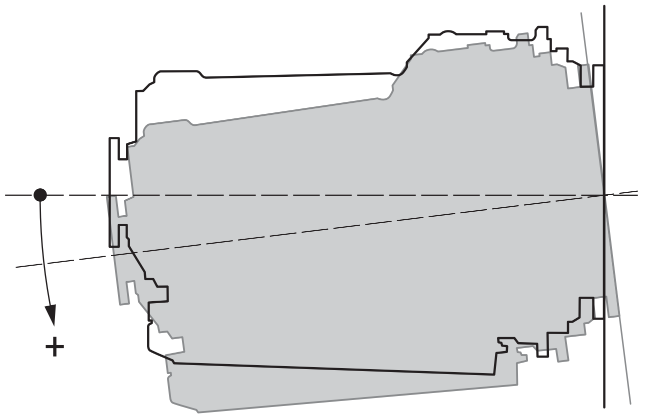
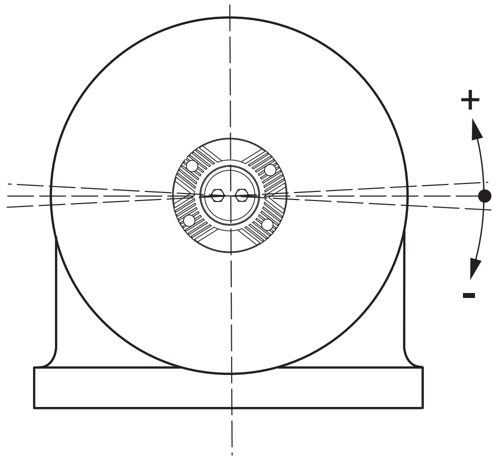
5.2 Transmission longitudinal inclination

Maximum permissible longitudinal inclination +10°



5.3 Transmission transverse inclination

Maximum permissible transverse inclination in both directions maximum ± 5°



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NOTE
Also see Chapter 3.4 “Oil fill”

6 Suspension, Installation, Ambient Temperatures

6.1 Mounting 6-3

6.2 Installation 6-4
6.2.1 Accessibility 6-4
6.2.2 Additional fastening 6-4
6.2.3 Sealing of torque-converter bell housing 6-4

6.3 Ambient temperatures 6-5

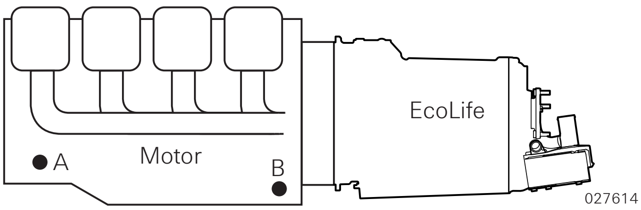
6 Suspension, Installation, Ambient Temperatures

6.1 Suspension

The transmission may only be suspended from the bolt attachment faces provided for this purpose on the transmission housing and/or auxiliary unit. Transmission mountings on the vehicle frame must be designed as agreed with ZF in such a way that no additional forces are transferred to the transmission housing by vehicle frame distortions. Connecting dimensions of the transmission suspension, transmission weight, and position of center of gravity are to be provided in the corresponding installation drawing.

ZF recommendation:

Suspension at the engine-end at A+B
(floating transmission suspension)
(applicable to all transmission variants)



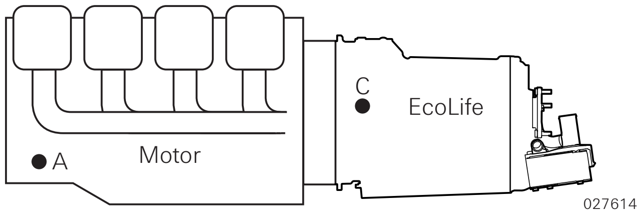
Special variants

If screw-connections are necessitated for the transmission housing in relation to the engine/transmission suspension, e. g. like in the case of special variant no. 1 and special variant no. 2, then, the entire suspension arrangement is to be agreed with and released by our "Sales and Application" department within the context of the application process (see Chapter 4.2, Step 1). A single release on the basis of the concluding installation inspections (refer to Chapter 4.2, Step 6) is not admissible."
The following information is required from the OEM:
- Drawing or sketch with dimensions
- Material of suspension components (cast or welded part)
- Weight and center of gravity of engine/transmission block
- Screwing data
- i.a.

The screw connections at the suspension points C + D must live up to the following requirements:
- **Use of hex head screws of strength class 10.9 or higher**
- **Friction values for threads and head support: min. 0.1/max. 0.2**
- **Tightening torque: 205 ± 20 Nm**
- **Screw-in depth, measured as of the flange facing at the transmission housing: min. 20 mm/ max. 24 mm**

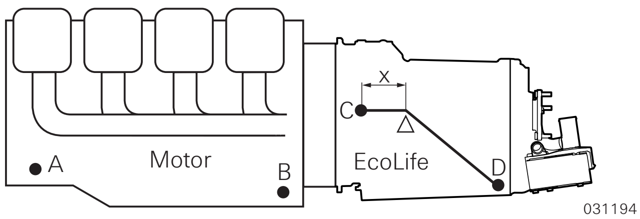
Special variant 1

Suspension A + C on both sides of the transmission
(applicable to all transmission variants)



Special variant 2

Suspension A + supporting point on both sides of the transmission*
(applicable to all transmission variants)



- Suspension supporting point on both sides at distance X with connecting bracket from C to D.

6.2 Installation

NOTE
For the assembly of the engine and the transmission, please refer to Chapter 8.1.

6.2.1 Accessibility

For identification, test, maintenance, and repair purposes, the following parts of the EcoLife Rail transmission must be accessible in accordance with the **installation drawing no. 4181 602 022/035, Chapter 3**:

- Transmission type plates, *item 12*
- Oil filler tube, *item 28*
  Observe clearance!
- Oil dipstick, *item 30*
  Observe removal space!
- Oil pan, *item 35*
  Observe removal space!
- Oil filter, *item 33*
  Observe removal space!
- Oil drain plug, *item 20*
- EcoLife ECU, *item 1*
  Observe removal space!
- Wiring connection to EcoLife ECU, *item 2*
- Speedo sensor, *item designation "T"*
- Pressure measuring connections,
  Item: 8 (PVF), 11 (PHD), D5 and/or D6 (depending upon transmission design), D8, A8

Accessories:

- Diagnosis plug at vehicle end for connecting ZF diagnosis system
- Connector on speed range selector and possibly E Module 2

CAUTION
Adherence to the clearance in accordance with Sheet 3 of the respective installation drawing is considered mandatory.

6.2.2 Additional fastening

No screw connection on the EcoLife transmission must be unscrewed subsequently in order to e. g. attach additional fastening.

6.2.3 Sealing of torque converter bell housing

Optionally possible! No ZF requirement
In order to seal the converter chamber in the case of a floating suspension, a sealing plug is to be fitted by the vehicle manufacturer on both sides to the through holes of the "C" flange connection.

6.3 Ambient temperatures

Temperature measuring runs are required for the release of all EcoLife applications as specified in Chapter 12.5.

During these measuring runs, the vehicle manufacturer must prove that the maximum ambient temperature or the permissible continuous temperature is below the threshold specified in the following.
Otherwise, measures must be implemented to reduce the temperature.

Reasons for exceedingly high ambient temperatures

- Encapsulated and noise-insulated transmission installation
- Insufficient distance between exhaust system / turbocharger and transmission
- No air exchange with transmission environment possible
- Air feed channel coming from radiator is leaking

Permissible ambient temperatures at the transmission max. 105 °C

The following measures are required:

- Distance between exhaust system or other sources of heat and transmission: min. 100 mm. the distance is too small, suitable shields have to be fitted.
- Ensure sufficient air circulation by means of louvers and air ducts.
- Seal air feed channel coming from the radiator.

NOTE: Use at low temperatures and longer downtimes

Outside temperature	down to –20°C	from –20 °C to –30 °C	from –30 °C to –40 °C
Oil grade	in accordance with ZF List of Lubricants TE-ML 20	permitted in accordance with ZF List of Lubricants TE-ML 20	permitted in accordance with ZF List of Lubricants TE-ML 20
Engine start	permitted	permitted	Transmission must be preheated before the engine is started
To be considered for starting	–	Warm-up phase of at least 10 minutes at increased idling speed of max. 1500 rpm, transmission in Neutral position.	Preheating can be done e. g. with warm air which must not exceed +130 °C on the transmission. **Caution: Do not heat up directly at the transmission and/or close to the ECU and the wiring.**
Limitations	none	During the warm-up phase, the electronic automatic control unit will activate several functional restrictions (maintaining Neutral position despite selected driving range via pushbutton, limitation of speed and torque).	

7 Guidelines for Propshaft Installation

7.1 Torque vibration measurements 7-4
7.1.1 Turbine shaft vibration measurements (limits) 7-4

7.2 Torsional acceleration vibration measurements 7-5
7.2.1 Torsional acceleration (limits) 7-5

7.3 Definition of terms 7-6

7.4 Permissible spatial deflection angle 7-7

7.5 Phase displacement 7-8

7.6 Bending vibrations caused by propshaft and/or engine 7-10

7.7 Further instructions 7-11

7 Guidelines for Propshaft Installation

A propshaft can be the cause for inciting torsional and bending vibrations in the driveline.
The vehicle manufacturer is responsible for ensuring that the overall system works without additional loads on the individual units.

The admissible loads/stresses for ZF components are described in the Chapters 7.1 and 7.2. The reference values stated there not only apply to the excitations caused by combustion engines but also to excitations caused by propshafts. Note that propshafts and combustion engines stimulate vibrations in the same frequency range.

Since a vibration analysis cannot be performed for every application, basic conditions based on ZF's long-standing experience are stated below.
These basic conditions describe the operating ranges of a driveline in which no noteworthy additional strains due to vibrations need to be expected.
If these values cannot be met, a closer investigation by the vehicle manufacturer is required.
Approval may then only be granted by the vehicle manufacturer, upon prior consultation of ZF.

7.1 Torque vibration measurements

Cause
- Rotational irregularity of engine
- Rotational angle error of propshaft

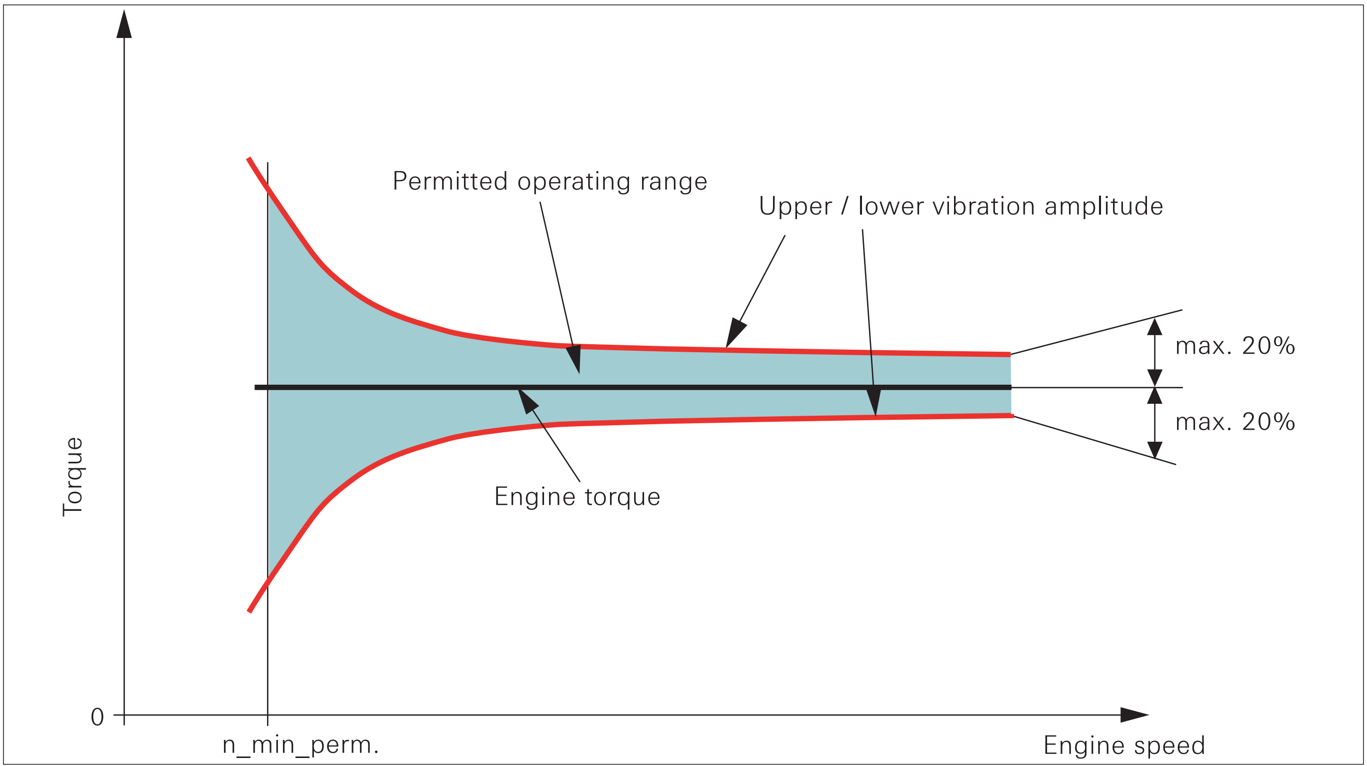
Permissible EcoLife values
- T_ab_schwing = T_nenn_ab ± 20 %
- T_tur_schwing = T_nenn_tur ± 20 %
- T_ab_schwing_min > 0 (no varying load)
- T_tur_schwing_min > 0 (no varying load)
- Exceptional case: at n_mot < 1 250 rpm
  T_tur_schwing_max < 3 000 Nm

Measurement required
- if engines show high rotational irregularities
- if resonance points are to be expected in operating range (4 and 5 cylinder engines)
- if torsional acceleration measurement at output end shows inadmissibly high values

Measurement
- Test transmission:
  – Strain gage-equipped turbine shaft
  – Special speed measurement equipment for turbine speed
  – Slotted disk (> 60 teeth) for output speed
- Measurement parameters:
  – n_mot, n_tur, n_ab, T_tur, gear
- Driving condition:
  – In all gears when the torque converter lock-up clutch is closed
  – Deceleration of vehicle from n_mot_max – 800 rpm (full throttle) in fixed gear
- Analysis:
  - Time recordings of all measuring parameters + presentation of vibration amplitude = f(n_mot)
  - Consideration of n_mot, n_tur, n_ab vibrations up to xth order (in relation to n_mot); x = number of cylinders + 1
  - Conversion of speed to torsional acceleration = f(n_mot) + order analysis

7.1.1 Turbine shaft vibration measurements (limits)

CAUTION
No varying load at the turbine shaft!



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7.2 Torsional acceleration vibration measurements

Cause

- Rotational irregularity of engine
- Rotational angle error of propshaft

Permissible EcoLife values

- d_EPS_ab = 2 000 rad/s^2
- d_EPS_tur = 2 000 rad/s^2

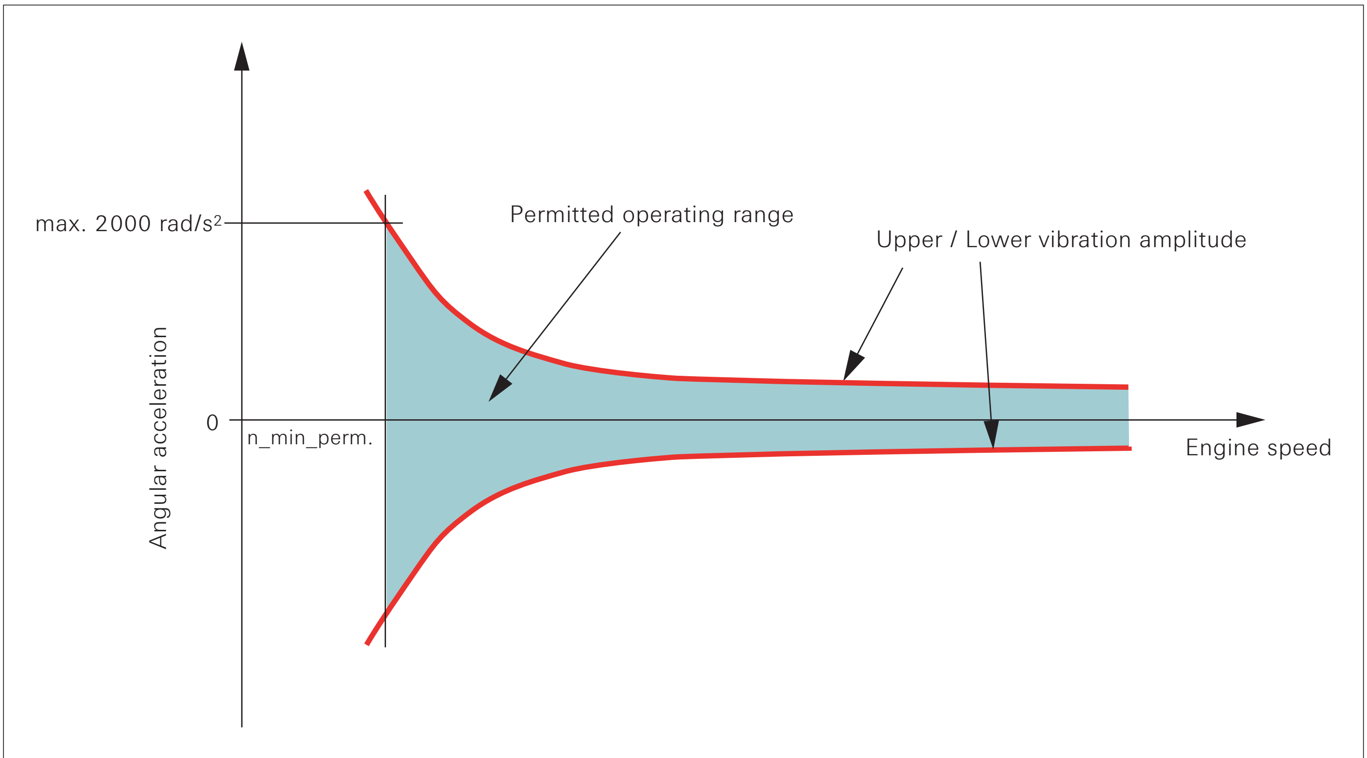
Measurement required

- If the output speed/rotational angle error lies outside of theoretical limiting curve

Measurement

- Test transmission:
  - Output flange with slotted disk (> 60 teeth) for output speed
- Measurement parameters:
  - n_mot, n_tur, n_ab, gear
- Driving condition:
  - In all gears when the torque converter lock-up clutch is closed
  - Deceleration of vehicle from n_mot_max – 800 rpm (full throttle) in fixed gear
- Analysis:
  - Time recordings of all measuring parameters + presentation of vibration amplitude = f(n_mot)
  - Consideration of n_ab vibrations up to xth order (in relation to n_mot); x = number of cylinders + 1
  - Conversion of speed to torsional acceleration = f(n_mot) + order analysis

7.2.1 Torsional acceleration (limits)



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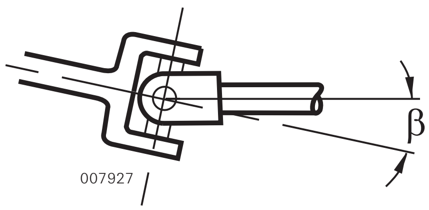
7.3 Definition of terms

The extent of a possible vibration stimulation by propshafts is largely determined by the deflection angles of the universal joints.
The following definitions apply:

The **deflection angle β** is defined as the angle between the axes of rotation in front of and behind the joint in the corresponding plane (see image).



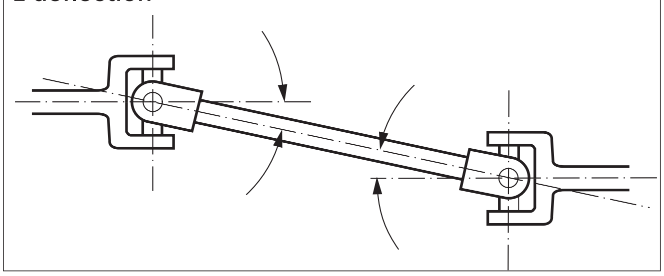
To evaluate a propshaft alignment, you first have to determine the **spatial deflection angle β_R** for each individual joint according to the following formula:

$$\beta_R = \arctan \sqrt{\tan^2 \beta_H + \tan^2 \beta_V}$$

β_H = Deflection angle in horizontal view
β_V = Deflection angle in vertical view

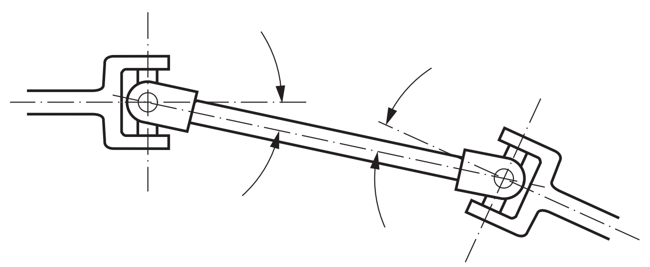
Depending on the shaft installation, it is called
z or w deflection:

z deflection



033139

w deflection



033140

7.4 Permissible spatial deflection angle

No torsional vibration problems are expected for deflection angles which, depending on the speed, are below the values stated in Fig. 7.1. Additional measures are not required.

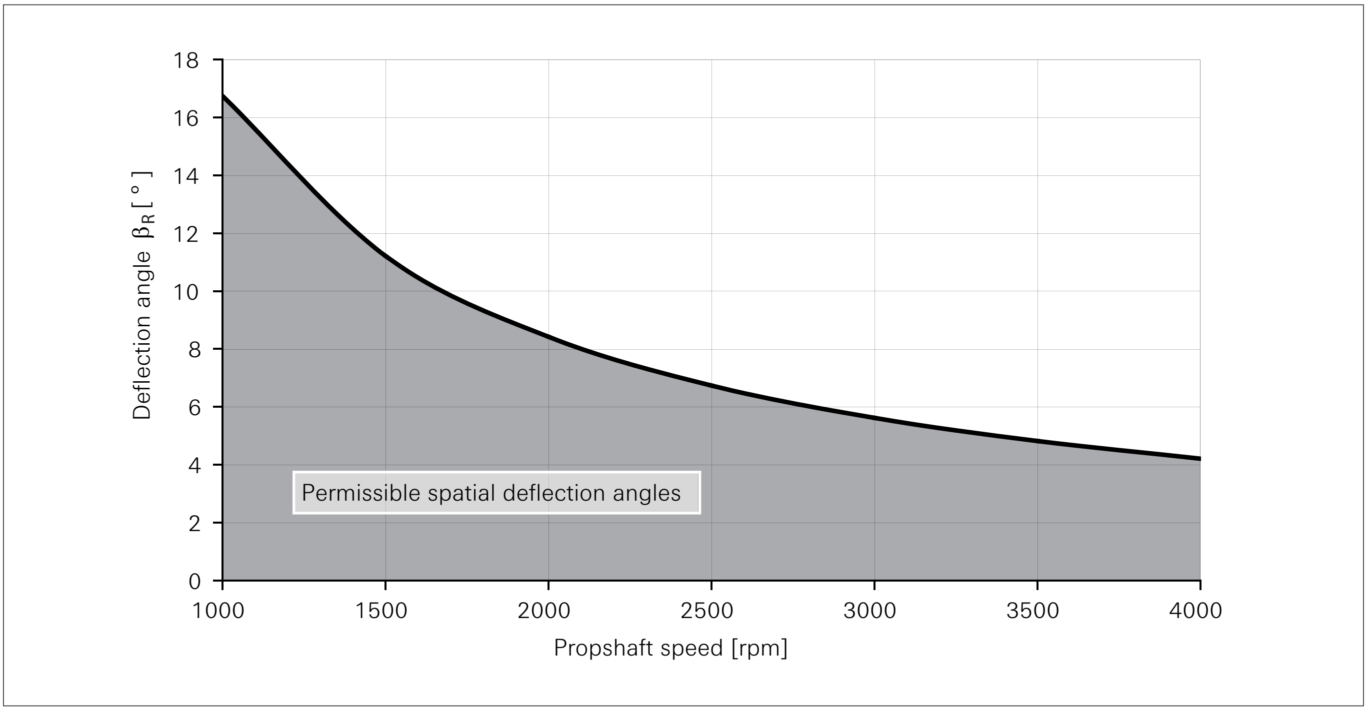


Fig. 7.1 Permissible spatial deflection angles

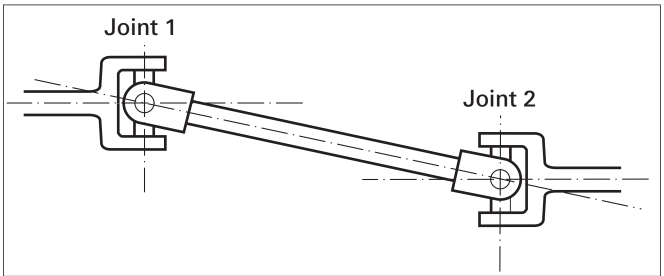
7.5 Phase displacement

All joints of a propshaft can incite torsional vibrations with the 2nd order of the rotary frequency. This can lead to overlaps of the different inciting elements (joints) in the driveline. Since all frequencies are the same, the vibration amplitudes are reduced or intensified, depending on the phase relation of the incitation. The actual overlap depends on the mass moment of inertia, in particular of the middle part of the propshaft. However, it is not possible to fully eliminate the vibrations even under optimal conditions, contrary to what is frequently assumed. However, incorrect phase displacement can considerably change the vibrations, leading to inadmissible strain on the neighboring components.

The following must be observed to prevent this kind of problems:

Propshaft with 2 joints

Both joints must be turned by 90° against each other (refer to Fig.).



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Output fork of joint 1 and input fork of joint 2 are parallel.

Usually shafts with length compensation are marked correspondingly by the manufacturer so it is impossible to assemble both parts in the sliding piece incorrectly.

ZF recommendation:
The spatial deflection angles of joint 1 and joint 2 should be the same.

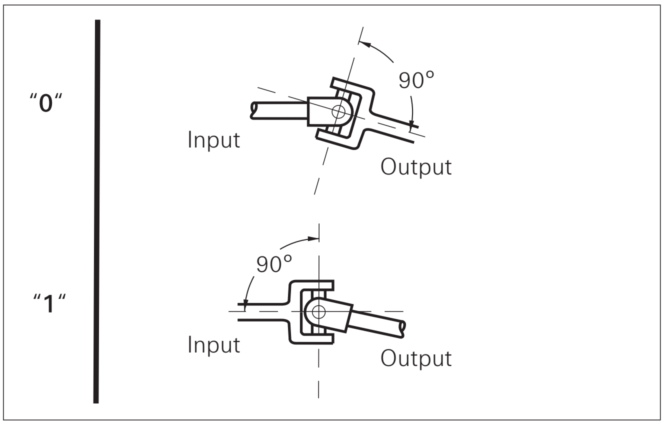
$$\beta_{R1} = \beta_{R2}$$

Every deviation from this recommendation means more vibration excitation by the propshaft. This can lead to a loss in comfort, especially with acoustically sensitive vehicles.

Propshaft line with more than 2 joints

If there are more than 2 joints, the joints with the largest deflection angles are to be turned by 90° against each other.

The following marking has been introduced for a check in the vehicle:



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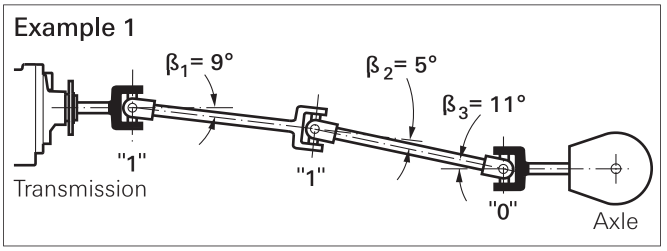
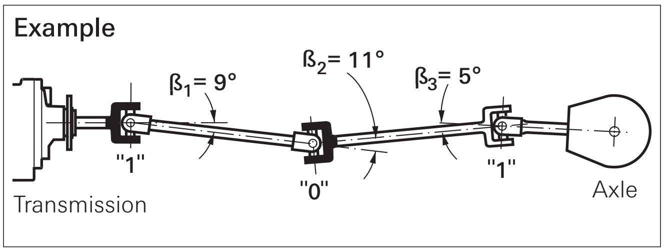
As shown in the examples below, the two joints with the largest deflection angles must not have the same marking.



033135



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A remaining joint (with uneven number) should be arranged like the joint with the smaller angle.

Spatial joint deflection

A special feature is the spatial joint deflection. Usually, joint deflection takes place in one plane for all joints. This is not the case for spatial deflection, e. g. if we have a “z deflection” in horizontal view and a “w deflection” in vertical view. The measures described in this guideline are not sufficient in such a situation.
An experienced propshaft manufacturer must always be consulted in such a case to prevent vibration problems.

7.6 Bending vibrations caused by propshaft and/or engine

To avoid bending vibrations, the propshaft must not be operated with more than 80 % of the speed critical for bending. Fig. 7.2 shows the limit speeds depending on the propshaft length as well as the pipe diameter (middle part). To a great extent, both these parameters are decisive for the first natural bending frequency.

The vehicle manufacturer is responsible for layout/arrangement and setup.

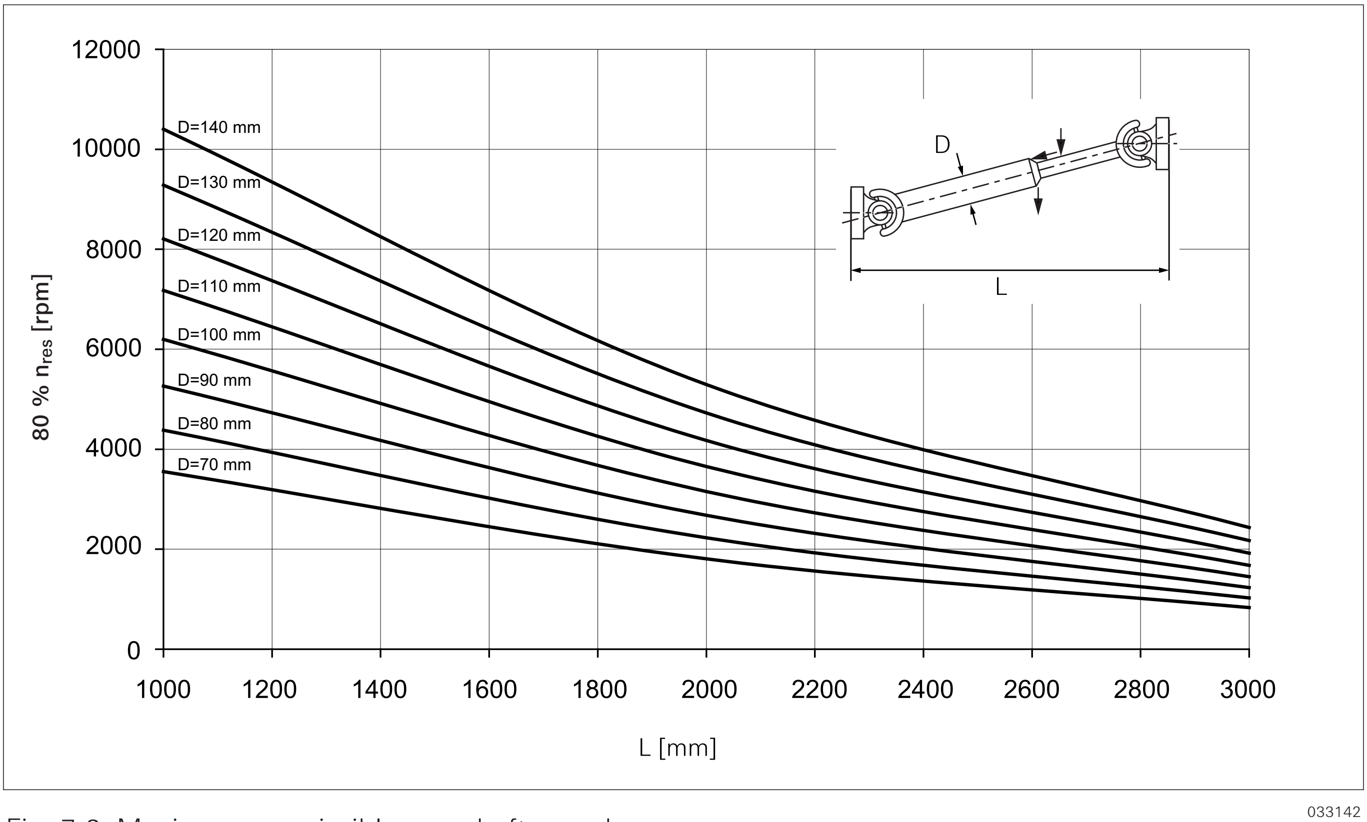

Fig. 7.2 Maximum permissible propshaft speed

7.7 Further instructions

- **Balancing:**
  The propshaft must be balanced dynamically in quality grade 16 according to DIN ISO 1940-1 (Fig. 7.3).

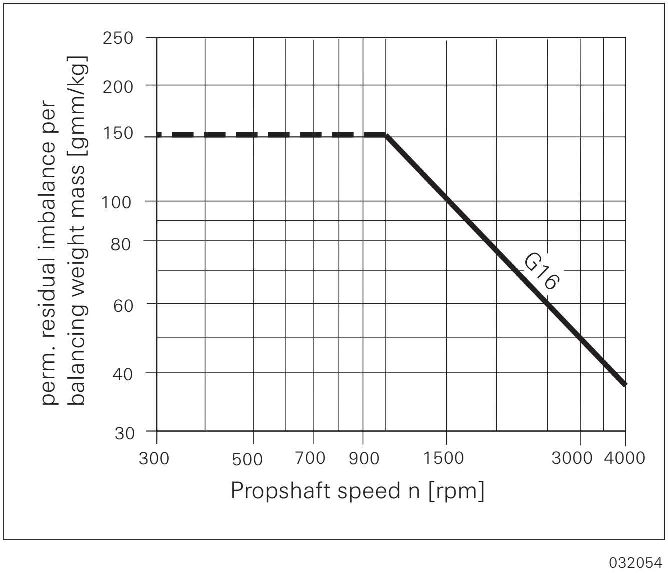

Fig. 7.3 Balancing grade G 16 according to DIN ISO 1940-1

- Permissible radial and lateral run-out of connecting flanges:

max. Speed [rpm]	Radial and lateral run-out [mm] ↗	Centering fit
500	0.10	h8
1500	0.07	h7
3500	0.06	h7

- **Lubrication:**
  The propshaft manufacturers' instructions are to be observed for lubrication.
  It must be ensured that the sliding piece is free-moving under load.

8 Engine Connection

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8.2 Important information 8-4

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8 Engine Connection

8.1 General

Before connecting the EcoLife transmission to the engine, the ZF Sales and Application department must carry out an engine connection analysis together with the engine and vehicle manufacturers. In this process, all transmission-related dimensions and tolerances important for the connection are determined and recorded in the transmission installation drawing. The overall responsibility lies with the vehicle manufacturer.

Two different engine connection variants are possible:

- **Variant 1 – standard engine connection with flywheel**

  The flywheel serves as the support for the starter ring gear. The diaphragms are connected directly with the converter.

- **Variant 2 – engine connection without flywheel**

  The flywheel is omitted. The ring gear carrier is directly mounted to the converter cover together with the starter ring gear. The diaphragm abuts with the ring gear carrier and is connected with the torque converter.

Other information:

– If possible, design engine connections in line with Variant 1 – standard engine connection with flywheel.

– In the case of the design in accordance with Variant 2, engine connection without flywheel, the engine's mass moment of inertia is modified due to the lacking flywheel. In the worst case, this may result in resonance vibrations and finally diaphragm failure.

CAUTION
Variant 2, engine connection without flywheel, may only be considered upon prior consultation of the ZF "Sales and Applications" department.

8.2 Important information

To be used:

- Screws/Bolts according to DIN 912, DIN 931, DIN 933, DIN 960, DIN 961, and/or DIN EN ISO 4762,
  DIN EN ISO 4014, DIN EN ISO 4017,
  DIN EN ISO 8765, DIN EN ISO 8676
- Collar screws as defined in DIN EN1665
- Studs as defined in DIN 835, DIN 938, and DIN 939
- Nuts as defined in DIN 934 and/or DIN EN ISO 4032, DIN EN ISO 8673
- Shims as defined in DIN 125 and/or DIN EN ISO 7089/7090

The following table contains information about tightening torques for bolts of property class 8.8 and 10.9 and nuts of property class 8 and 10, as

	Strength class	
Screw/Bolt	8.8	10.9
Nut	8	10
Measurement	Tightening torque MA [Nm] ± 10 %	
M10	46	68
M10x1.25	49	72
M12	79	115
M12x1.5	83	120

defined in ZFN 148.

Surface conditions of screws/nuts:
thermally blackened and oiled or galvanized and oiled.
Screws/Bolts are to be tightened using a calibrated torque wrench, screw/bolt connection class 4: tightening torque [Nm] ± 10 %.

CAUTION
Before connecting the engine and the EcoLife, please always note and/or check:

- Remove conservation at the torque converter by means of a suitable cleaning agent (gasoline, petroleum, diese oil)

  CAUTION
  Alkaline washing solutions may not be used!
- Clean the connecting face of the torque converter
- When assembling the engine and the transmission, attention must be paid to the fact that the torque converter centering pin must not be damaged in the process. The EcoLife's oil sump bottom does not proceed parallel to the transmission's longitudinal axis. Adapt existing assembly fixtures respectively!
- Both flywheel housing and flywheel must be provided with assembly opening.

When attaching the transmission to the flywheel housing, make sure of and/or use the following:

- Screws/Bolts with a high material strength (8.8 and/or 10.9).
  In the case of the 6 AP 170x B/2000 B with the floating transmission suspension, only use M10 10.9 or M12 8.8 and/or 10.9
- Shims/Washers with HV [hardness number] 200 – 300
- Screw-in depth in gray cast or light alloy as specified in VDI guideline 2230.
- All screws/bolts must be tightened to the specified tightening torque (refer to table).
- Note additional thermal load (e. g. by using screw/bolt 10.9 with tightening torque of screw/bolt 8.8)
- Do not use lock-head bolts and/or washers!
- Check the following tolerances:
  - Diaphragm thickness (D):
    4 x 0.5 mm ± 0.04 mm and/or
    6 x 0.5 mm ± 0.04 mm
  - Concentricity tolerance of flywheel inner diameter or centering ring to centering diameter on flywheel housing:
    max. 0.3 mm
  - Permissible deviation from dimension "C" is:
    For Variant 1
    4 diaphragms ± 0.46
    6 diaphragms ± 0.54
    For Variant 2
    4 diaphragms ± 0.71
    6 diaphragms ± 0.79
  - Dimension "A" is set by ZF to ± 0.3 mm
  - The permissible deviation from measurement "E" is for Variant 2: ± 0.25 mm.

8.3 Assembly sequence and ZF scope of supply

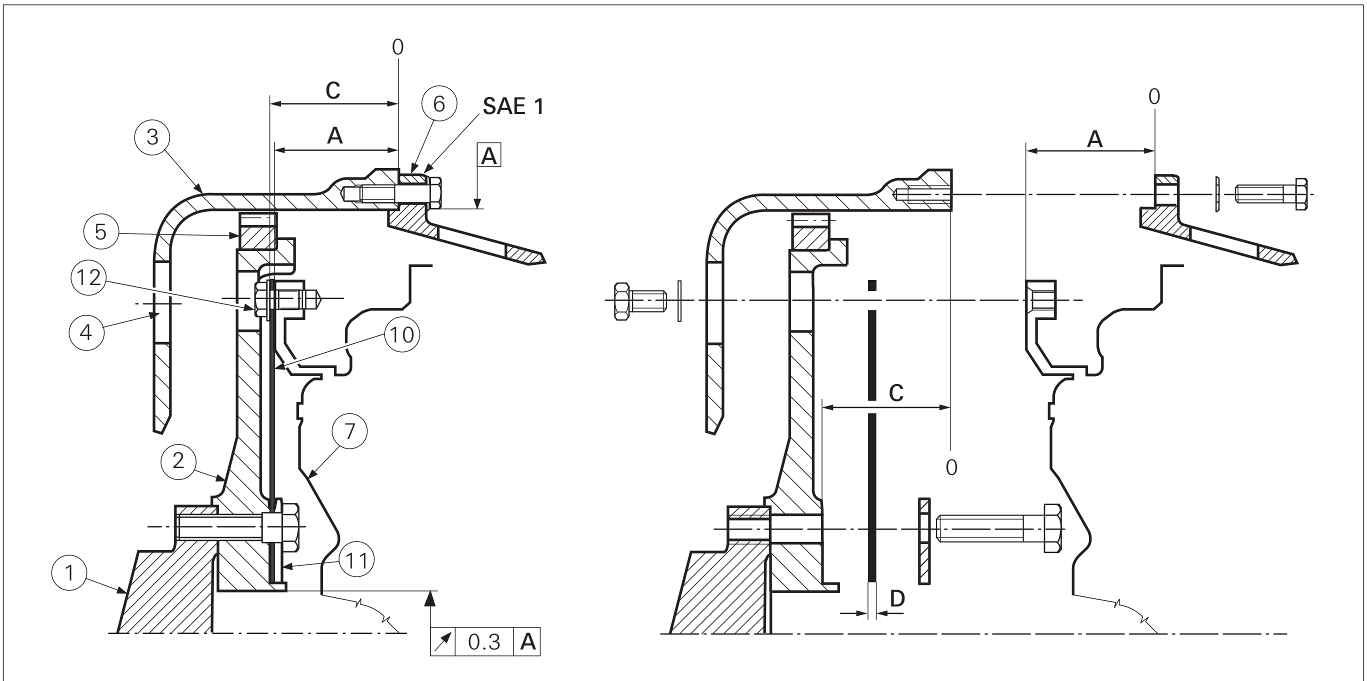
8.3.1 Variant 1 – standard engine connection with flywheel

Assembly activity at the vehicle manufacturer

- Screw connect the crankshaft **(1)**, flywheel **(2)**, diaphragms **(10)**, and clamping disk **(11)**. In this regard, observe dimensions provided by ZF with tolerances. Consult engine manufacturer for correct tightening torque.
- Screw connect the transmission housing **(6)** and flywheel housing **(3)** according to the engine connection drawing, Chapter 8.5.1. Tightening torque (see table, Chapter 8.2)
- Use assembly opening **(4)** in flywheel housing and flywheel to screw connect the diaphragms **(10)** with the torque converter **(7)** by means of screws **(12)**. Tightening torque (see table, Chapter 8.2)

ZF scope of supply

The ZF scope of supply includes diaphragms **(10)** and the corresponding screws/bolts **(12)** to attach diaphragms to torque converter. By agreement, diaphragms can be delivered by engine manufacturer already fitted to the engine.



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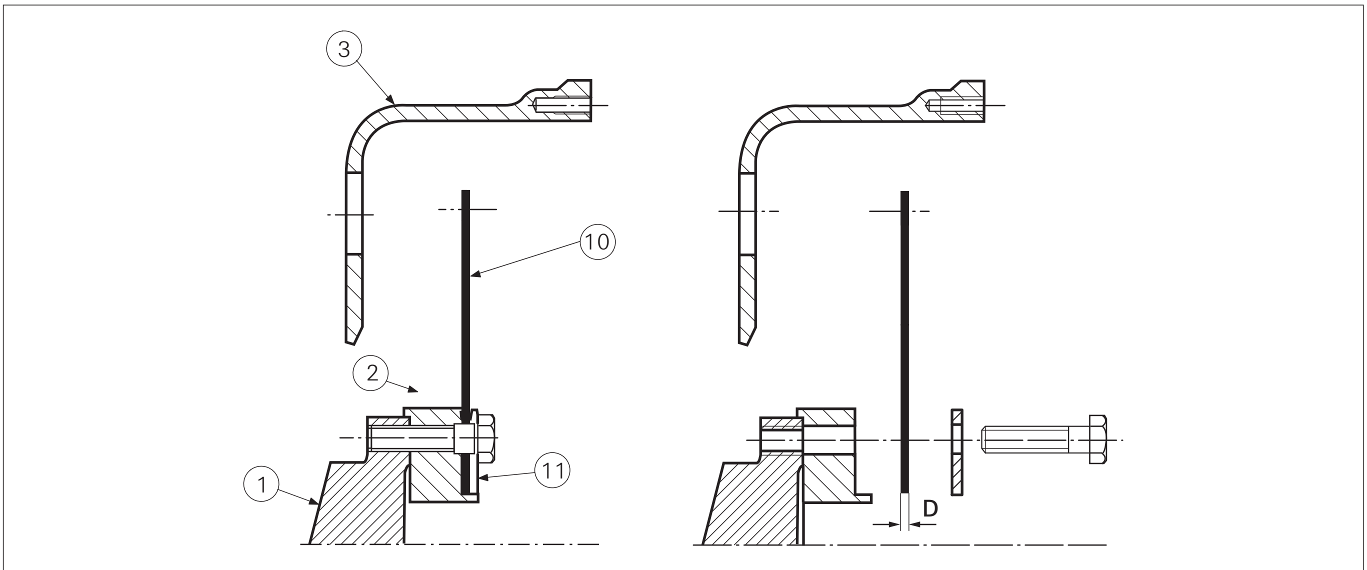
8.3.2 Variant 2 – engine connection without flywheel

8.3.2.1 Assembly activity at the engine manufacturer

- Screw connect the crankshaft **(1)**, centering ring **(2)**, diaphragms **(10)**, and clamping disk **(11)**. In this regard, observe dimensions provided by ZF with tolerances. The tightening torque is determined by the engine manufacturer.

Engine manufacturer's scope of supply

The diaphragms **(10)** are sourced by the engine manufacturer with ZF and the engine manufacturer delivers the engine including the assembled diaphragms to the vehicle manufacturer.



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8.3.2.2 Assembly activity at the vehicle manufacturer

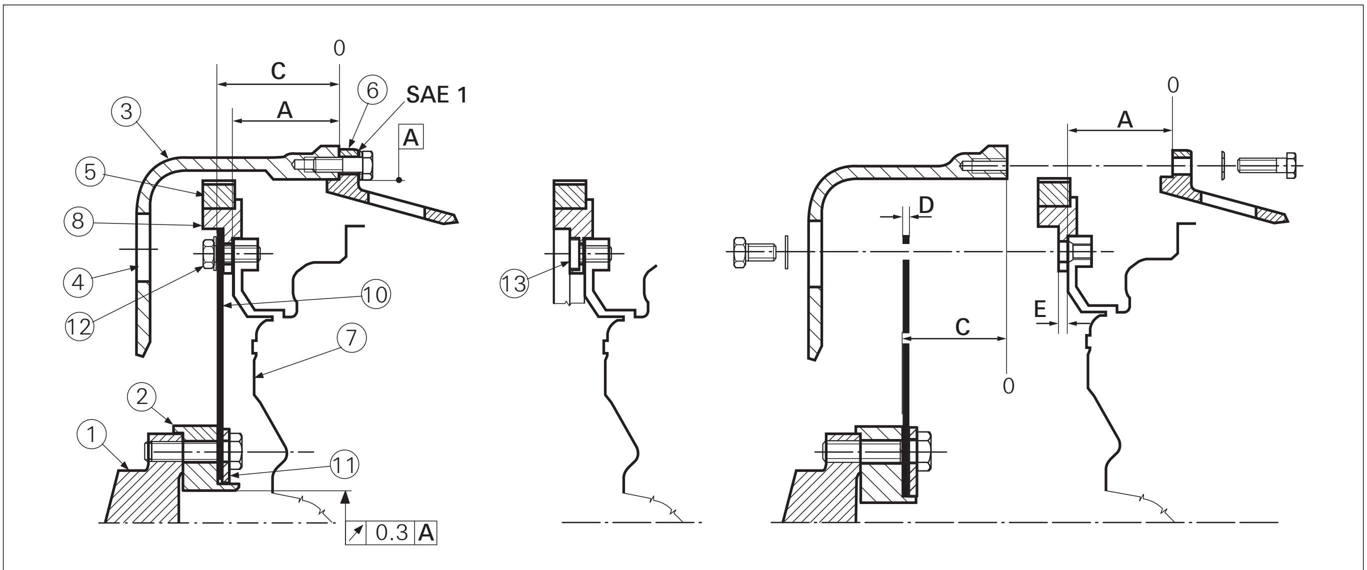
- Mount the ring gear carrier **(8)** with the integrated ring gear **(5)** to the torque converter **(7)** by means of 2 screws/bolts **(13)**.
- Screw connect the transmission housing **(6)** and flywheel housing **(3)** according to the engine connection drawing, Chapter 8.5.2. Tightening torque (see table, Chapter 8.2)
- Use assembly opening **(4)** in flywheel housing to screw connect the diaphragms **(10)** with the torque converter **(7)** by means of screws **(12)**. Tightening torque (see table, Chapter 8.2)

Engine manufacturer's scope of supply

The engine manufacturer's scope of supply includes the ring gear carrier **(8)** with the integrated ring gear **(5)**.

ZF scope of supply

The ZF scope of supply encompasses the screws/bolts **(13)** for the pre-assembly of the ring gear carrier and the screws/bolts **(12)** required to attach the diaphragms to the torque converter.



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8.4 Engine connection inspection

If no engine connection drawing is available, the following documents are required for the engine connection investigation:

- Detailed drawing of flywheel housing
- Detailed drawing of end of crankshaft
- Assembly drawing of engine output showing axial and radial tolerance range for crankshaft and distance between end of crankshaft and flange-mounting face of flywheel housing.
- Detail drawing of the flywheel (engine connection in accordance with Variant 1)
- Detail drawing of the centering ring and the ring gear carrier with the integrated ring gear (engine connection in accordance with Variant 2)

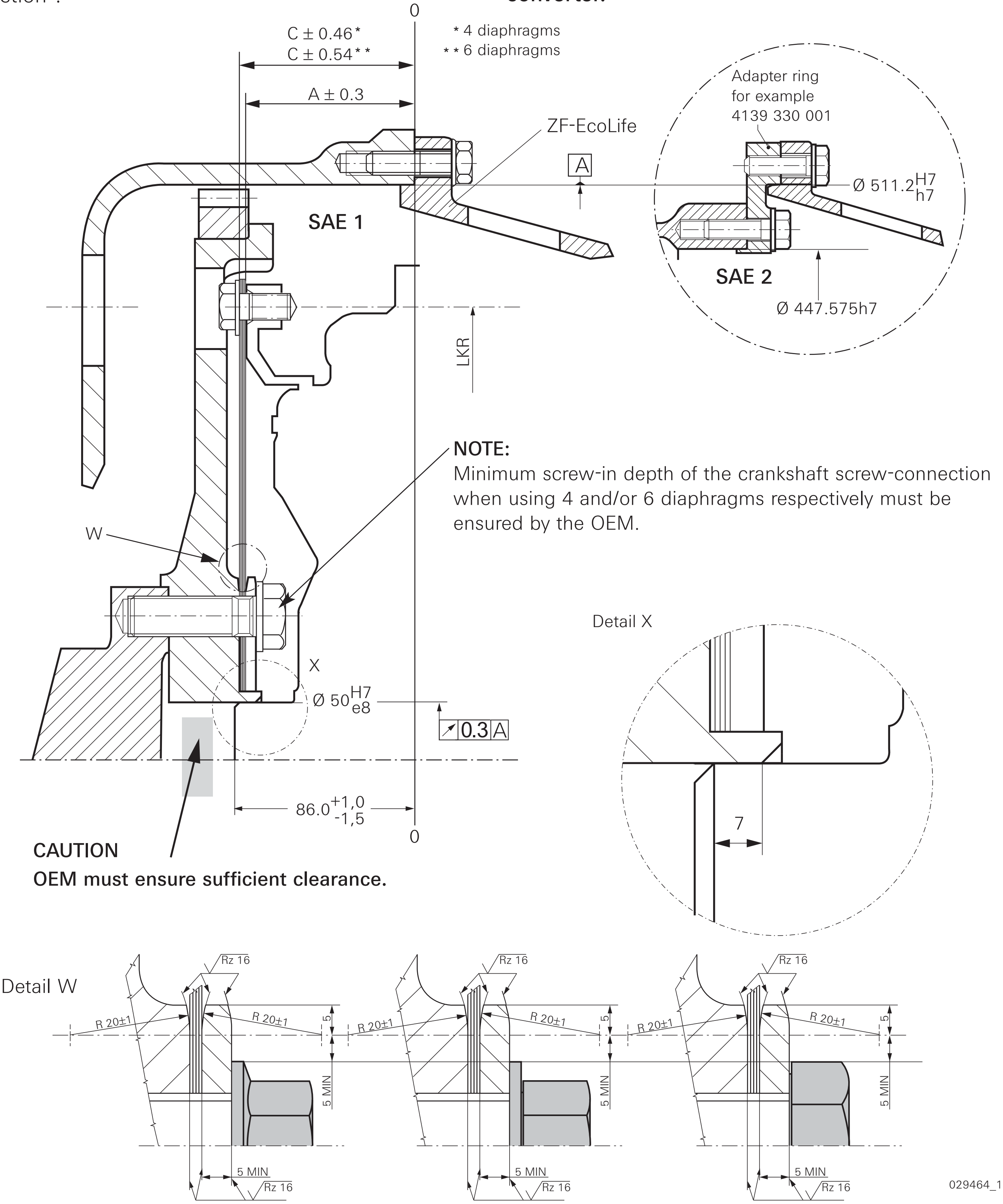
8.5 Engine connection drawing

8.5.1 Variant 1 – standard engine connection with flywheel

Engine connection detail drawing SAE 1 valid for transmission type AP xx0x B.

Number of the required diaphragms, also refer to Chapter 8.6 “Overview of torque converter connection”.

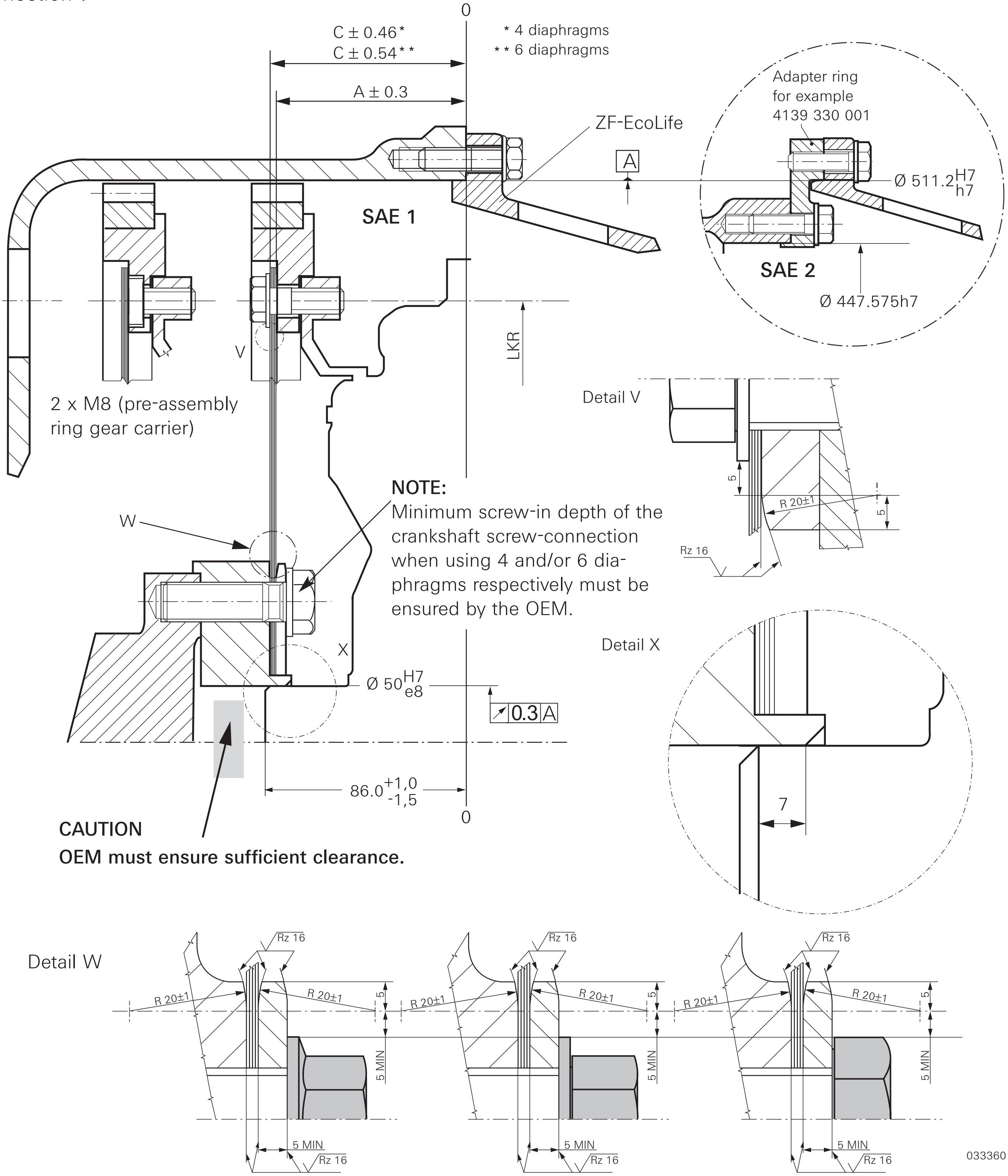
Engine connection detail drawing SAE 2 only valid for transmission with W 370 torque converter.



8.5.2 Variant 2 – engine connection without flywheel

Engine connection detail drawing SAE 1 valid for transmission type AP xx0x B.
Number of the required diaphragms, also refer to Chapter 8.6 “Overview of torque converter connection”.

Engine connection detail drawing SAE 2 only valid for transmission with W 370 torque converter.



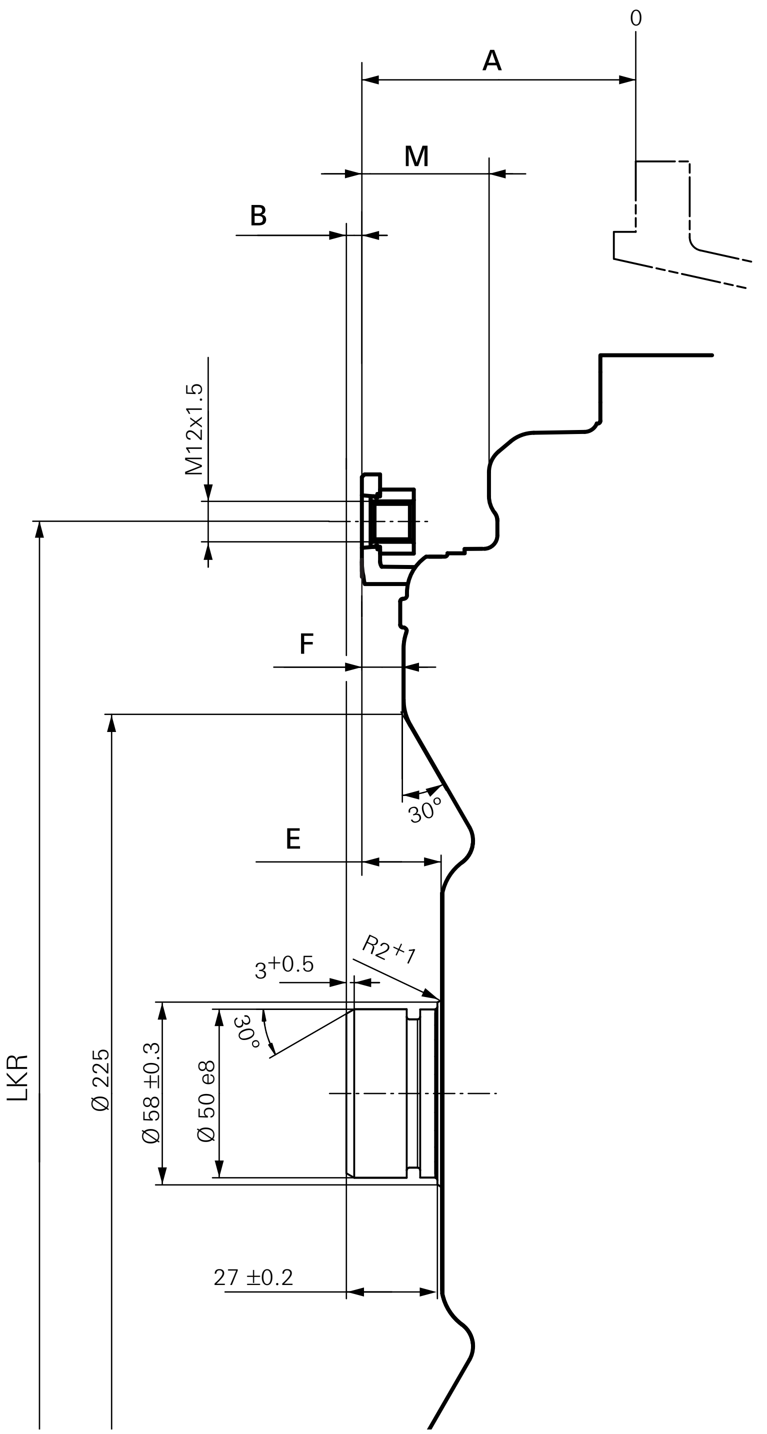
8.6 Overview of torque converter connection

<table>
<tr><th>Torque converter</th><th>Dimension "A" static
[mm]</th><th>Pitch circle LKR
[mm]</th><th>Use for transmission type
Required number of diaphragms</th></tr>
<tr><td rowspan="7">W370</td><td>71.25</td><td>402</td><td rowspan="7">6 AP 100x B
6 AP 120x B
6 AP 140x B
Connection with 4 diaphragms</td></tr>
<tr><td>77.00</td><td>402</td></tr>
<tr><td>81.25</td><td>402</td></tr>
<tr><td>71.25</td><td>380</td></tr>
<tr><td>77.00</td><td>380</td></tr>
<tr><td>81.25</td><td>380</td></tr>
<tr><td>86.25</td><td>326</td></tr>
<tr><td rowspan="8">W410</td><td>77.00</td><td>402</td><td rowspan="4">6 AP 140x B
6 AP 170x B
Connection with 4 diaphragms
*)</td></tr>
<tr><td>81.25</td><td>402</td></tr>
<tr><td>77.00</td><td>380</td></tr>
<tr><td>81.25</td><td>380</td></tr>
<tr><td>76.00</td><td>402</td><td rowspan="4">6 AP 2000 B
Connection with 6 diaphragms</td></tr>
<tr><td>80.25</td><td>402</td></tr>
<tr><td>76.00</td><td>380</td></tr>
<tr><td>80.25</td><td>380</td></tr>
</table>

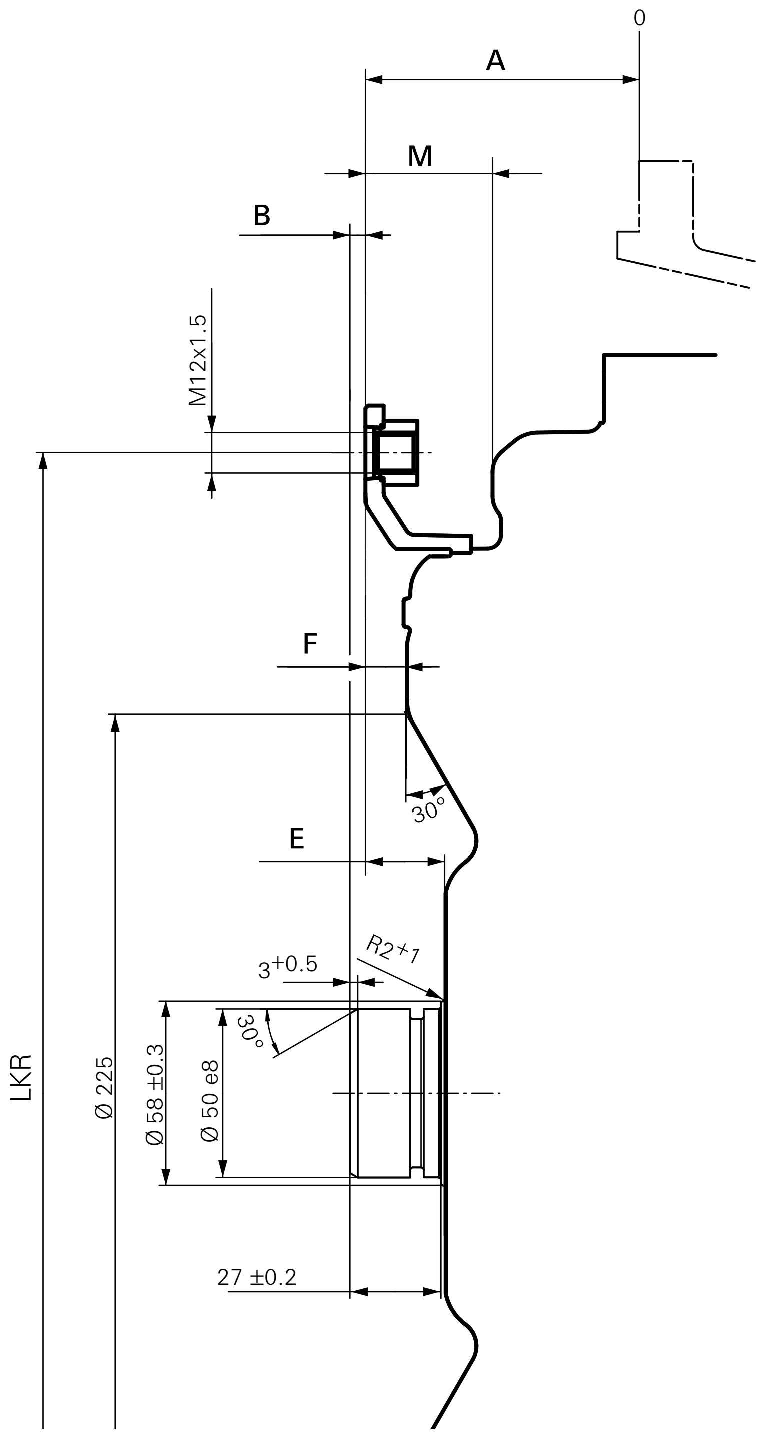
*) optional 6 AP 2000 B connection with 6 diaphragms im conjunction with the special flywheel (axial -1 mm) possible

8.7 External contour of torque converter W 370 and W 410 for engine connection inspection

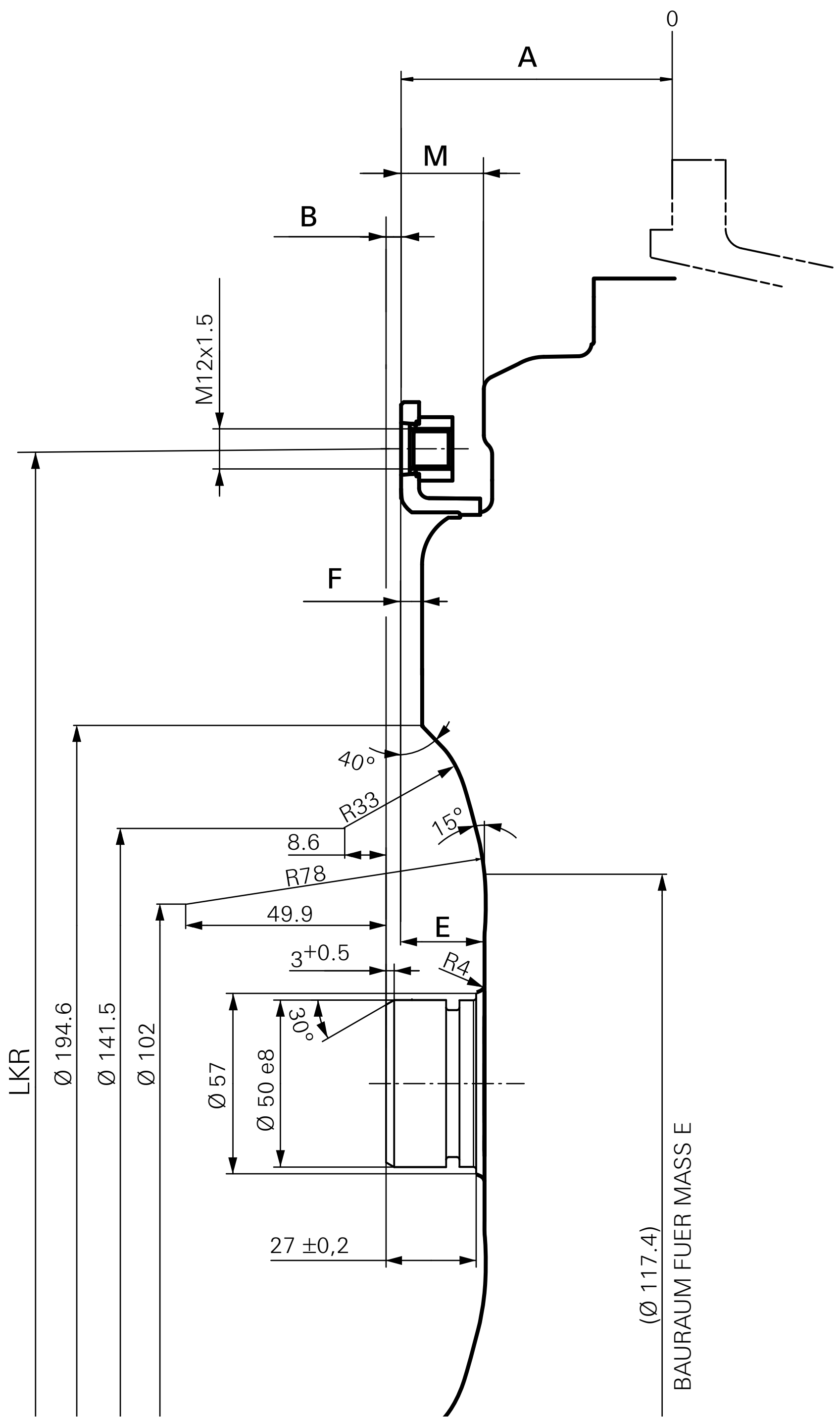
NOTE
Dimension “A” static, refer to table in Chapter 8.6 “Overview of torque converter connection”.
Dimensions A, B, E, F, M, LKR depend upon the torque converter design.
The binding torque converter contour can be taken from the installation drawing and/or 3D installation model.
3D installation models can be made available upon request



Torque converter 370
(LKR 326)



Torque converter 370
(LKR 380, LKR 402)



Torque converter 410
(LKR 380, LKR 402)

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9 Torque Converter

9.1 Torque converter: description 9-3

9.2 Torque converter mode of operation 9-3

9.3 Torsional damper 9-4

9.4 Cooperation of torque converter and engine 9-5

9.5 Engine/torque cooperation diagram 9-6

9.6 Torque converter characteristic maps 9-8

9 Torque Converter

9.1 Torque converter: description

On the input side, the torque converter is mounted upstream of the planetary transmission. It consists of the impeller, turbine wheel, reaction member (stator), and the oil needed for torque transmission.

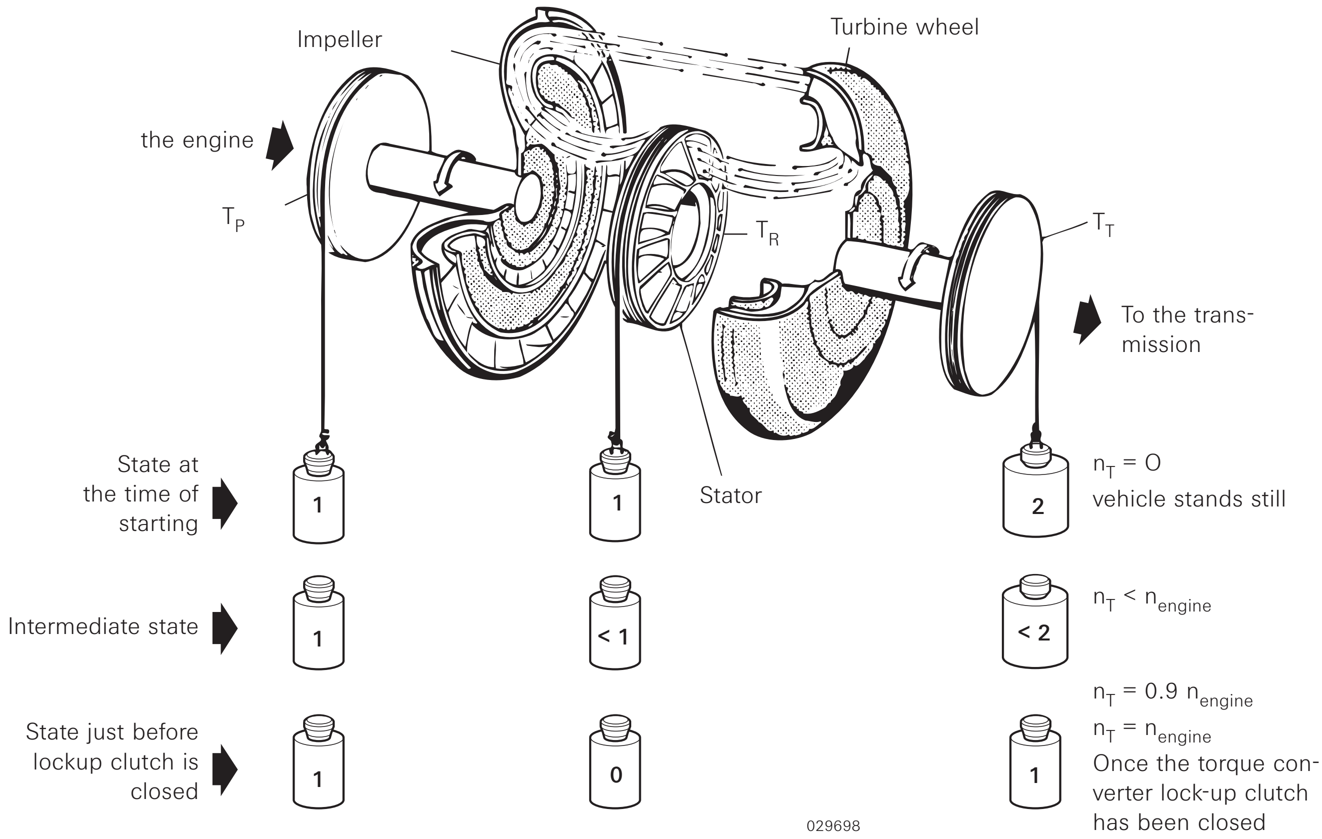
The engine torque is transmitted to the torque converter by the crankshaft via a diaphragm connection.

9.2 Torque converter mode of operation

The turning impeller makes the oil flow. The oil flow is guided to the turbine wheel and is then diverted.

The stator is connected with the transmission housing by a sprag clutch. The stator's purpose is to re-divert the oil flowing off the turbine wheel again and feed the impeller with it from a suitable flow direction. This re-direction of flow creates a reaction torque on the stator which is supported by the blocking sprag clutch on the housing. Thus, the turbine wheel torque increases. The stator torque always equals the difference between turbine wheel and impeller torque. The ratio between turbine torque and impeller torque is known as torque conversion μ . The greater the difference between impeller and turbine wheel speed, the higher the torque conversion. Maximum torque conversion is generated when the turbine wheel is stationary (stall speed).
If the turbine wheel speed reaches approx. 90 % of the (pump) impeller speed, then, conversion is m = 1, in other words, the turbine torque equals the pump torque. From this point, the torque converter has the mere function of a hydraulic coupling. In this condition, the stator operates freely in the flow following the Trilok principle.

The high ratio of the 1st mechanical gear allows for early closing of the torque converter lock-up clutch (LuC) when starting and thus economical driving without hydrodynamical torque loss.

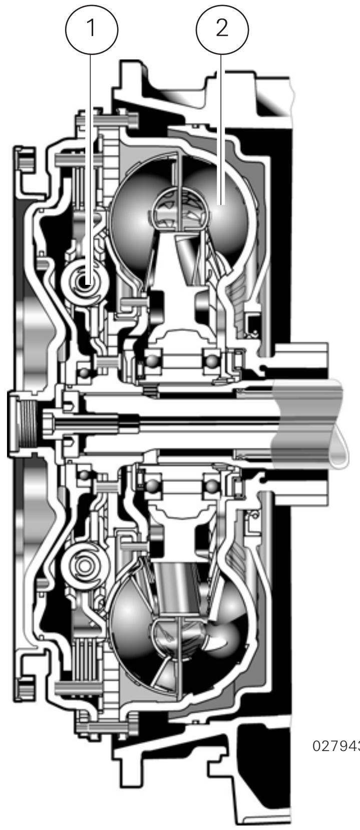


T_P = Impeller torque
T_T = Turbine wheel torque
T_R = Stator torque

9.3 Torsional damper

As a standard, all torque converter types are equipped with a torsional damper which offers the following advantages:

- Preservation of the driveline thanks to reduced vibrations
- Possibility of driving at low engine speeds and thus reduction of:
  - Fuel consumption
  - Exhaust gas emissions
  - Noise



1 Torsional damper
2 Hydrodynamic Torque Converter

9.4 Cooperation of torque converter and engine

In cooperation with the OEM, the ZF “Sales and Application” department specifies a suitable torque converter for each new engine-transmission combination.

The selection criteria for torque converters are:

- Engine characteristics (full load torque and transient torque build-up characteristics)
- Engine speed decrease at starting
- Fuel consumption or performance optimization
- Traction force at engine idling speed

The cooperation diagram shows the cooperation of engine and torque converter; refer to example in Chapter 9.5.

In order to determine the operating points between torque converter and engine under stationary, full-throttle conditions, the engine torque characteristic curve is entered into the torque converter’s primary characteristic map. This process is carried out by a computer program.

Several torque converter variants are available for EcoLife transmissions. They differ in the torque intake of the impeller, the hydraulic diameter, and the stall torque ratio. Please observe allocation to individual transmission types!

Example for torque converter designation:

Torque Converter
Size
Number of friction surfaces of torque converter lock-up clutch
Dampers

W 370 - 6 - TP6 D

Impeller torque value
TP1 = low intake torque until
TP6 = high intake torque

Torque converter designation	µ 0 [-]	Torque converter characteristic map	Allocation transmission types*	Note
W 370 - 6 - TP4 D	2.32	4168 780 006	6 AP 100x B 6 AP 120x B 6 AP 140x B	Volume Production
W 370 - 6 - TP5 D	2.16	4168 780 007		Volume Production
W 370 - 6 - TP6 D	1.94	4168 780 001		Volume Production
W 410 - 6 - TP1 D	2.24	4168 780 002	6 AP 170x B 6 AP 2000 B	Volume Production
W 410 - 6 - TP2 D	2.32	4168 780 003		Volume Production
W 410 - 6 - TP3 D	1.95	4168 780 004		Volume Production

9.5 Engine/torque converter cooperation diagram

The cooperation diagram (see drawing on next page) shows the following data:

- Stall torque = max. turbine torque TT (A with limitation or B without limitation)
- Stall speed = impeller speed nP at turbine speed nT = 0 rpm.

  Example with turbine torque limitation:
  nT = 0 min^{-1} ➛ nP = 1 583 rpm

- Engine power $P_{Max}(n_{Mot})$ (kW)
- Engine torque $T_{Max}(n_{Mot})$ (Nm)

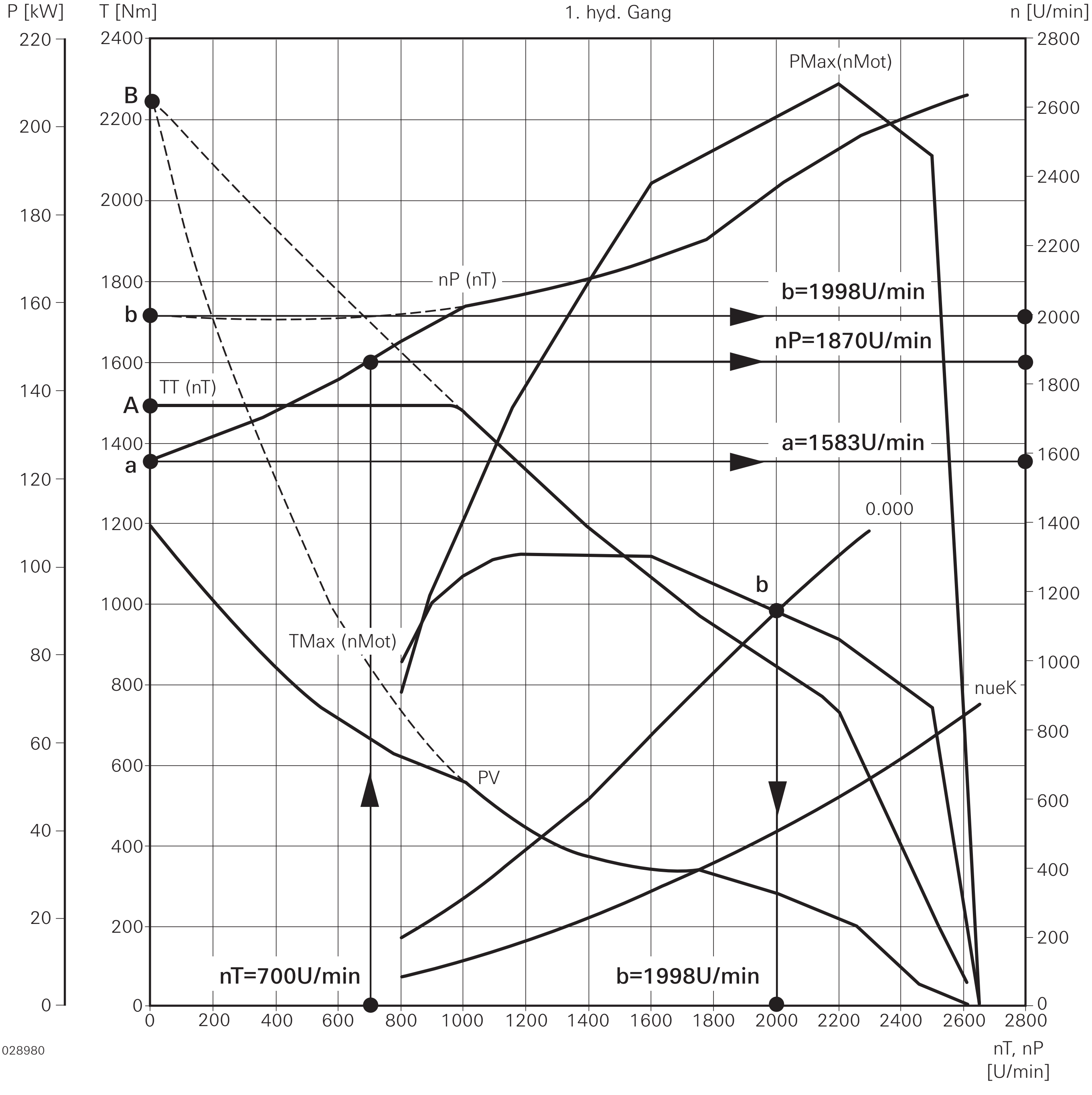
NOTE
Auxiliaries such as e. g. air conditioning and limitations of engine and turbine torques controlled by the EcoLife ECU are also considered in the diagram if applicable.

- TP pump/impeller intake torque (Nm) via pump speed n_P
- TT turbine torque (Nm) via turbine speed n_T
- Power loss PV = P_{Mot} x (1-mue x nue)
- nP Speed curve of impeller via turbine speed nT
  Example with turbine torque limitation:
  nT = 700 rpm ➛ nP = 1 870 rpm

All calculated curves consist of stationary operating points under full-throttle condition and do not represent a real starting process.

Engine/torque converter cooperation diagram

Example W370



Engine: xx_xxxxx_210_2200_1120_1200.mot

210 [kW] at **2200** [rpm] **/** **1120** [Nm] at **1200** [rpm]

Intermediate ratio: ivm = 1 eta = 1

Torque converter: W370_example

Stall speed:

nP = 1 583 [rpm] MP = 658.7 [Nm] 1st hydraulic gear

nP = 1 998 [rpm] MP = 981.7 [Nm] unlimited

Engine PTO: 0.0 [Nm] at stall speed

Torque converter PTOs: 0.0 [Nm] at stall speed

Coupling point:

nT = 2 237 [rpm] nP = 2 513 [rpm] nue = 0.89

Load take-over point:

nT = 1 510 [rpm] nP = 2 136 [rpm] nue = 0.707

———— : Turbine torque limitation not active

A: Stall torque with turbine torque limitation

a: Stall speed with turbine torque limitation

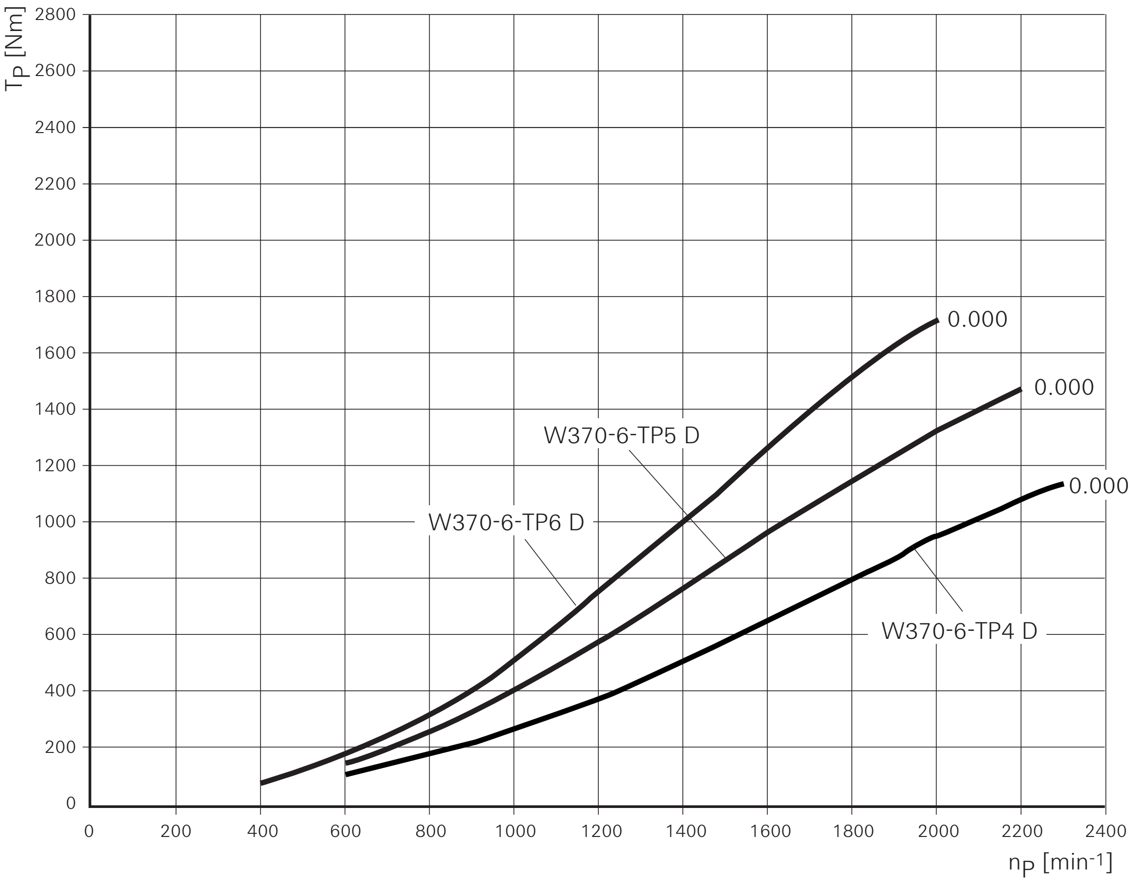
B: Stall torque without turbine torque limitation

b: Stall speed without turbine torque limitation

9.6 Torque converter characteristic maps

W 370 - 6 - TP4 D
W 370 - 6 - TP5 D
W 370 - 6 - TP6 D

Transmission types:
6 AP 100x B, 6 AP 120x B, 6 AP 140x B



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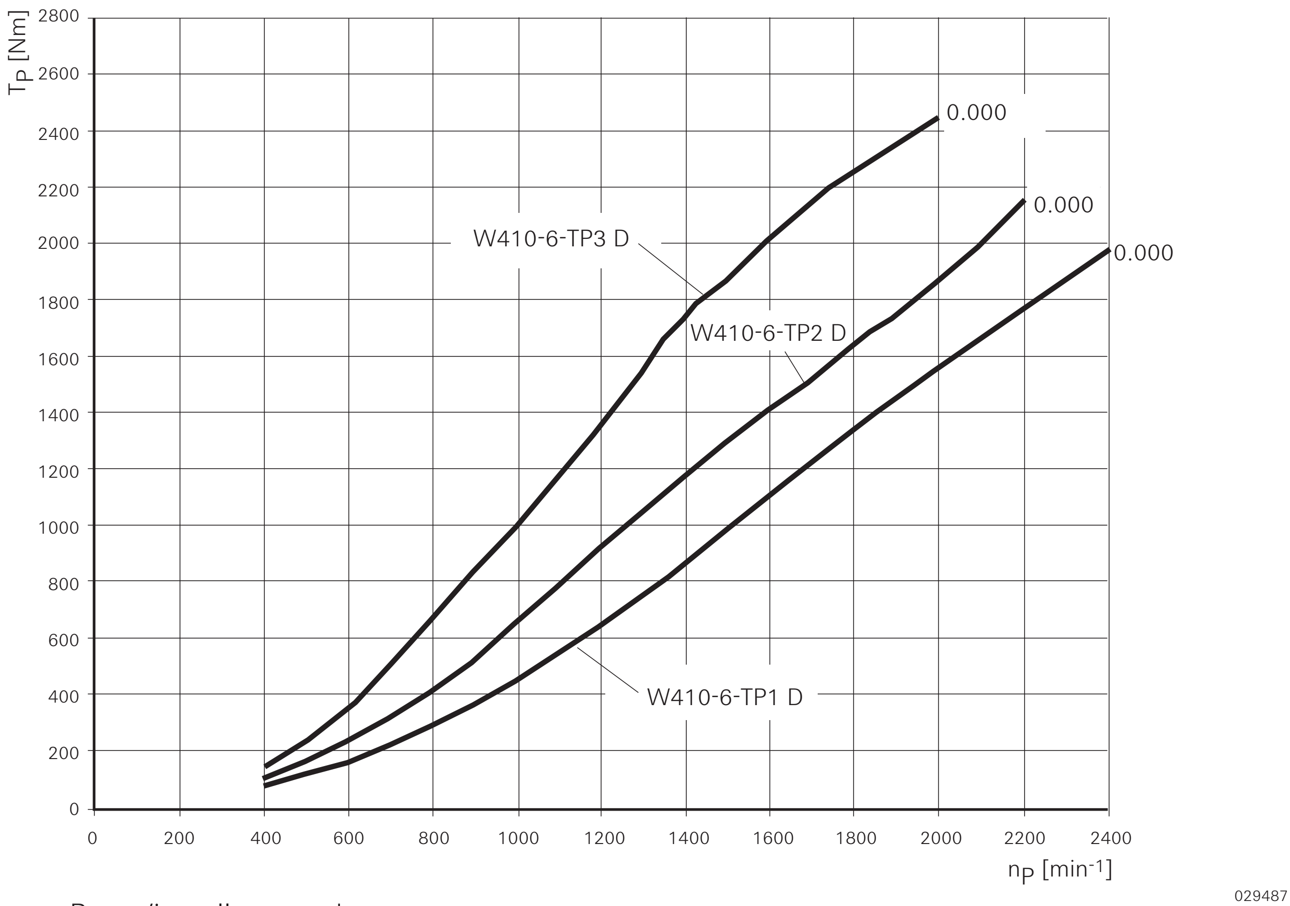
n_P: Pump/impeller speed
n_T: Turbine speed
ν: Speed ratio $\nu = \frac{n_T}{n_P}$

T_P: Pump/impeller torque
T_T: Turbine torque
μ: torque conversion $\mu = \frac{T_T}{T_P}$

W 410 - 6 - TP1 D
W 410 - 6 - TP2 D
W 410 - 6 - TP3 D

Transmission types:
6 AP 170x B, 6 AP 2000 B



n_P: Pump/impeller speed

n_T: Turbine speed

ν: Speed ratio $\nu = \frac{n_T}{n_P}$

T_P: Pump/impeller torque

T_T: Turbine torque

μ: torque conversion $\mu = \frac{T_T}{T_P}$

10 Retarder

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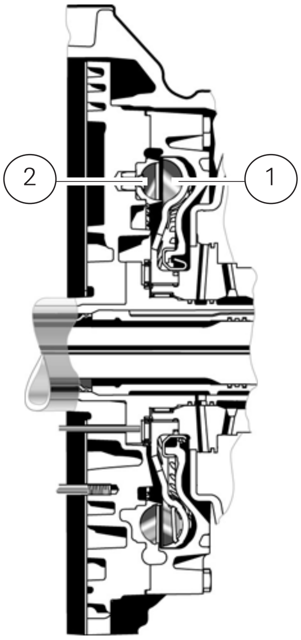
10 Retarder

10.1 Function and structure of the Retarder

The powerful retarder integrated in the EcoLife is arranged as hydrodynamic continuous brake on the primary side between the torque converter and the transmission. The braking torque depends on the gear engaged and the turbine speed.
The retarder consists of 2 components, rotor **(1)** and stator **(2)**.



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A proportional valve controlled by the EcoLife ECU sets the requested retarder torque in a continuously variable manner.

10.2 Retarder mode of operation

During braking with the retarder, there are different control options (refer to diagram in Chapter 10.5). Depending on the type of control, it may be in stages or a gradual manner.
In overrun mode, the rotor is driven by the turbine shaft of the vehicle and guides the oil flow against the stator. As a result, the rotor's rotary motion and thereby also the speed of the vehicle are retarded. The friction caused in the oil flow is converted into heat and released to the vehicle cooling system via the heat exchanger.
The retarder's response time is reduced by an oil storage volume preloaded by spring force. After the charging process of the retarder circuit, the accumulator is pushed to the starting position and is available again.

10.3 Retarder and engine brake

For permissible brake torques for city and suburban buses and coaches**, refer to Technical Data, table in Chapter 2.4.**

10.4 Retarder reduction at excessive temperature

If the permissible transmission oil temperature is exceeded in the transmission sump or at the retarder oil outlet to the heat exchanger, the retarder torque is reduced. Optionally, the retarder torque can also be reduced as a function of the coolant temperature.
Max. permissible coolant temperatures are to be coordinated with the OEM.

10.5 Retarder control variants: brake pedal/control lever

Examples of different retarder control variants:

			Control lever					
			No function	Digital (ED)	Analog*	TSC1 primary/secondary		
			1	2	3	4		
Brake pedal	No function	1		1/2		1/4		
Brake pedal	Digital (ED)	2	2/1	2/2		2/4		
Brake pedal	Analog*	3						
Brake pedal	EBC1 brake pedal	4	4/1	4/2				
Brake pedal	TSC1 primary/secondary	5	5/1					
Brake pedal								

TSC1 primary = % retarder target torque request referring to reference torque at rotor
TSC1 sec = % retarder target torque request referring to reference torque at output

*** NOTE: Analog signal requests are not supported at the moment.**

Different retarder request possibilities:
- Digital brake pedal/control lever, e. g. in 3 stages
- Retarder direct activation
- Brake pedal position via CAN (TSC1 / EBC1)
- Control lever position via CAN (TSC1 / EBC1)
- Retarder torque via CAN (TSC1)

Brake stage switch

Example for shift variations through plugging-in of retaining stud:
Brake stage 4 = 3-stage retarder activation
Brake stage 3 = 2-stage retarder activation
Brake stage 2 = 1-stage retarder activation

Off	Braking stages						
0	1	2	3	4	5	6	
				●			Plug-in position
			●				
		●					

Further shift variations may only be used once the ZF "Sales and Applications" department has been contacted.

CAUTION
Control lever supplied with two loose pins. For the respective application case, plug in pins in accordance with the coded table.

10.5.1 Permissible variants of brake pedal/control lever request

Variant 1/2 or 2/1

Control by brake pedal or control lever is digital, e .g. with 3 stages. Percentage of retarder request can be parameterized freely.

Inputs:
Digital inputs are to be defined at CAN speed range selector or in the e-module 2; refer to Chapters 13 and 14.

Brake pedal deactivation is recommended.

Variant 2/2

If possible, different digital inputs are to be used for brake pedal and control lever.

Advantage:
Brake pedal and control lever request can be differentiated and used for advanced logics in the shift program.

Inputs:
Digital inputs are to be defined at CAN speed range selector or the e-module 2; refer to Chapters 13 and 14.

Brake pedal deactivation is recommended.

Variant 1/4 or 4/1

Retarder request via brake pedal or control lever value, output via CAN signal in percentage of brake pedal or control lever travel.

These percentages can be parameterized in the EcoLife ECU.

Brake pedal deactivation is recommended.

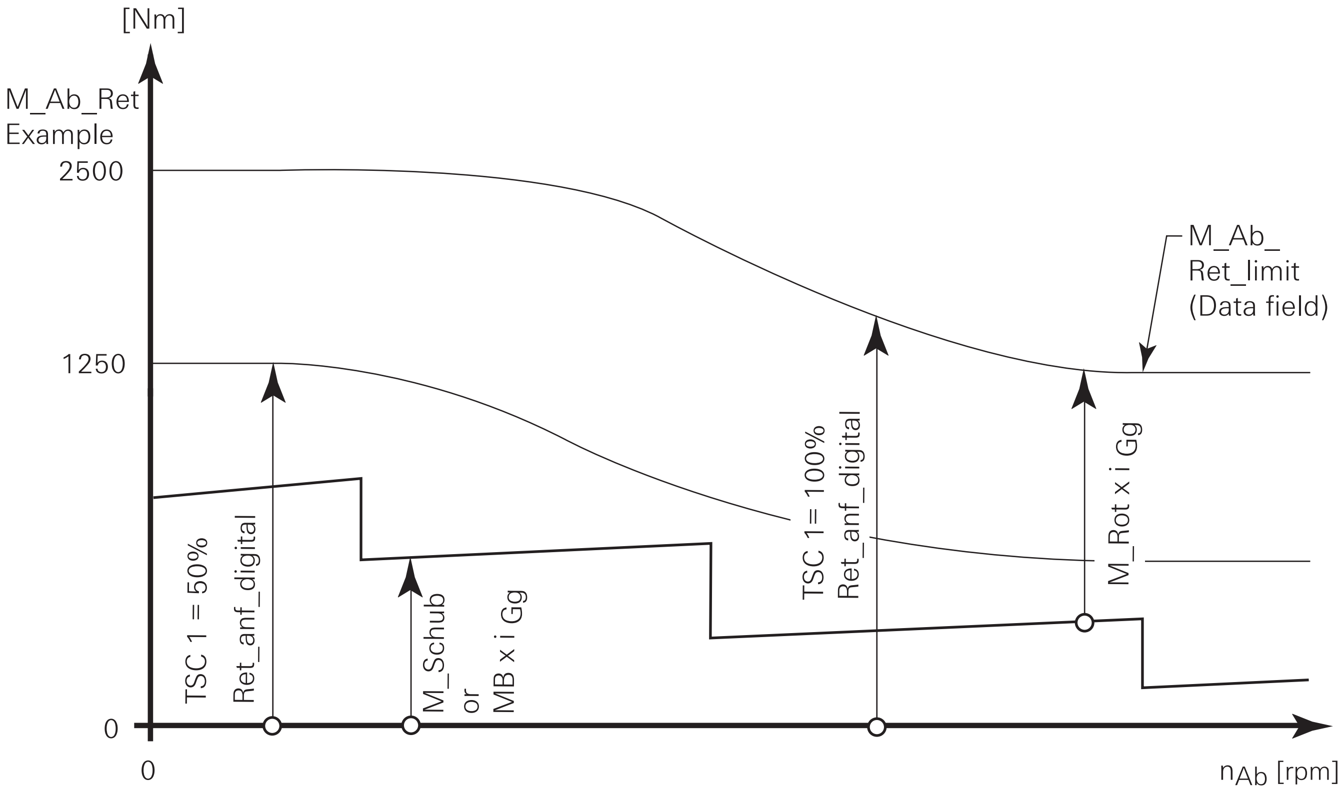
Variant 2/4 or 4/2

Inputs:
Digital inputs are to be defined at CAN speed range selector or in the e-module 2; refer to Chapters 13 and 14.

Brake pedal deactivation is recommended.

10.5.2 TSC1 control element

TSC 1 control element =
% of the maximum, speed-dependent retarder torque at the output or rotor-side



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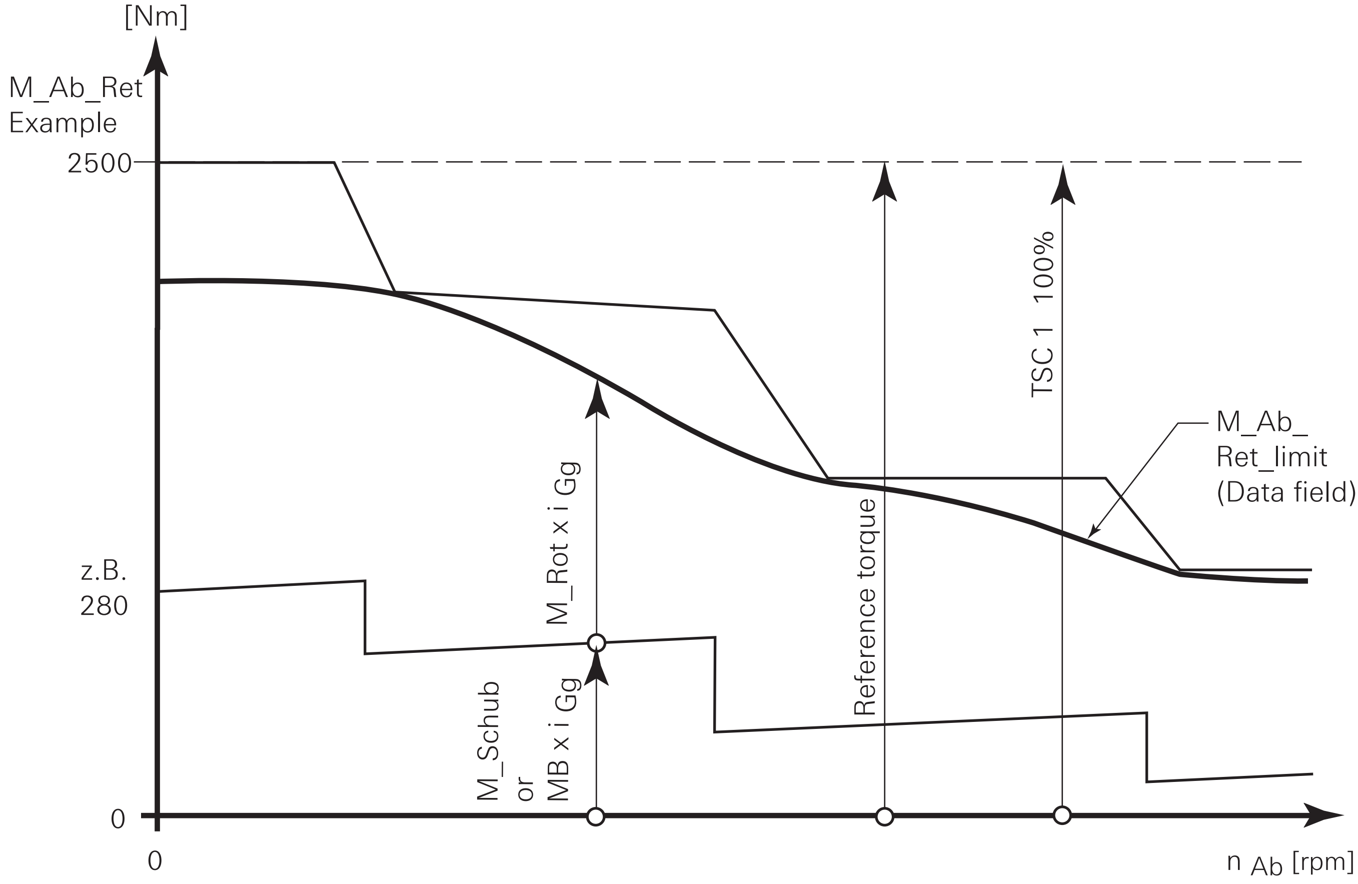
NOTE
Reduction refers to M_Rot_nominal = constant
(not to output torque curve).

10.5.3 TSC1 secondary

TSC1 sec = % retarder target torque request referring to reference torque at output



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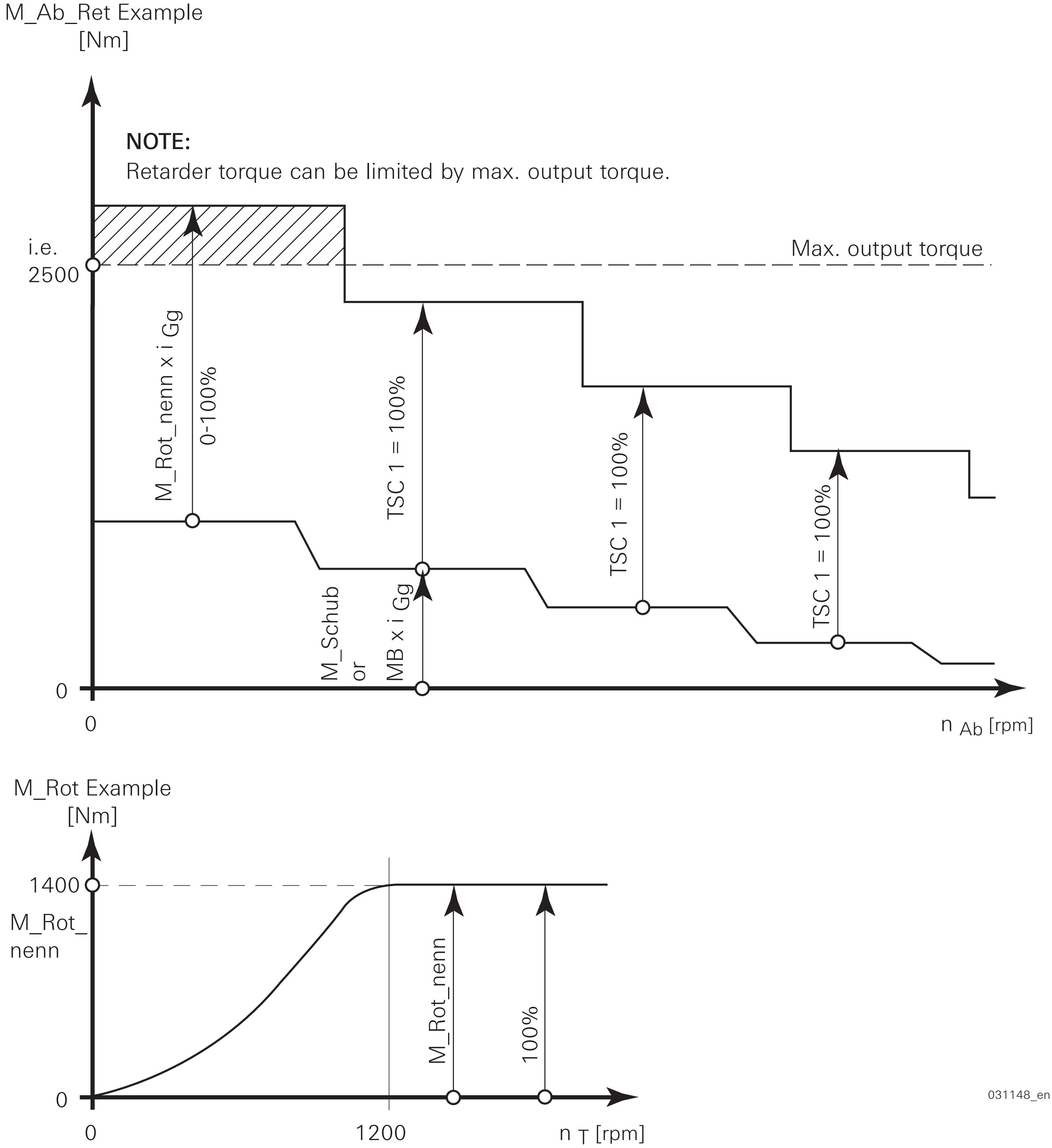
NOTE
Reduction refers to M_Rot_nominal = constant
(not to output torque curve).

10.5.4 TSC1 primary

TSC1 primary = % retarder target torque request referring to reference torque at rotor



NOTE

Reduction refers to M_Rot_nominal = constant
(not to output torque curve).

11 Hydraulics

Information on hydraulics diagram and hydraulics description
See Chapter 4. 9 “Document Overview”

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12 Cooling System

12.1 Design of the vehicle Cooling System

When designing the vehicle cooling system, the transmission’s power impact on the vehicle cooling system is to be considered in addition to the usual static design points (engine full throttle). Usually, this includes the converter’s and retarder‘s heat inputs.

Both heat inputs, but above all that of the retarder, take place with a very large dynamic and with high peak performance. For this purpose, the duration of the heat input is often relatively short (Esp.: retarder brake until vehicle standstill). This behavior is to be considered by providing for a dynamic design of the vehicle cooling system.

The vehicle’s cooling system is to be designed in accordance with the vehicle type and site of operation requirements to make sure that permissible temperatures are not exceeded over the entire driving cycle at dynamic operation. If the vehicle is to be used under special application conditions, e. g. continuous braking on longer downhill gradients, then this is to be considered when designing the cooling system. The driving cycle must be representative of the vehicle’s operating conditions. The temperature threshold values in the transmission (transmission sump temperature, maximum transmission oil temperature) and the maximum permissible coolant temperature must not be exceeded. The coolant must not exceed the boiling point in the heat exchangers and in the vehicle cooling system.

The vehicle cooling system is designed in coordination with the ZF “Sales and Application” department.

List of abbreviations:

Abbreviation	Unit	Description	Responsibility
$T_{KM,Getr,ein}$	°C	Coolant temperature at the inlet of the transmission cooling system	
$T_{KM,Getr,ein,Betrieb}$	°C	Coolant temperature at the inlet of the transmission cooling system, which is controlled by thermostat and breather at normal operation and a normally operating vehicle cooling system	Vehicle manufacturer
$T_{KM,Getr,ein,zul}$	°C	Permissible continuous coolant temperature at the inlet of the transmission cooling system. For this maximum coolant temperature, the application is released by ZF.	Result during Vehicle release
$T_{KM,Getr,ein,zul-max z}$	°C	Permissible peak coolant temperature at the inlet of the transmission cooling system. On the vehicle side, measures must be taken to protect the vehicle cooling system. E. g.: reduction of the engine torque, retarder torque	Vehicle manufacturer
$T_{KM,Getr,aus}$	°C	Coolant temperature at the outlet of the transmission cooling system.	
$T_{KM,Getr,aus,zul}$	°C	Permissible continuous coolant temperature at the outlet of the transmission cooling system. The components of the vehicle cooling system are designed accordingly.	Vehicle manufacturer
$T_{KM,Getr,aus,zul-max}$	°C	Permissible peak coolant temperature at the outlet of the transmission cooling system. If this temperature is exceeded, there is a risk of reaching the coolant's boiling point.	Vehicle manufacturer
$T_{KM,Motor,ein}$	°C	Coolant temperature at the inlet of the engine	
$T_{KM,Motor,aus}$	°C	Coolant temperature at the outlet of the engine	
$V_{KM,Pumpe}$	l/min	Coolant volumetric flow supplied by the coolant ump	
$V_{KM,Getr}$	l/min	Coolant volumetric flow through the transmission cooling system	
$p_{Abs,KM,Getr,ein}$	bar	Absolute coolant pressure at the inlet of the transmission cooling system	
$p_{Abs,KM,Getr,aus}$	bar	Absolute coolant pressure at the outlet of the transmission cooling system	
$p_{sys,AGB}$	bar	System pressure in expansion tank	
$T_{Getr,Sumpf}$	°C	Oil temperature in transmission sump	
T_{Amb}	°C	Ambient-air temperature	
$T_{Amb,zul}$	°C	Maximum ambient-air temperature.	Result from the vehicle release

Table 12.1: List of Abbreviations

12.2 Connection to the vehicle Cooling System

The ZF-EcoLife transmission is connected to the vehicle cooling system via the coolant connections of the retarder heat exchanger.

12.2.1 Position of fittings

Three versions of the EcoLife transmission are planned: one coaxial version and two versions with angle drive (output on the right / left side).
For coaxial mounting (Fig. 12.1) the retarder heat exchanger is positioned at the output end.
For the version with angle drive (Fig. 12.2) the retarder heat exchanger is mounted laterally on the EcoLife transmission.

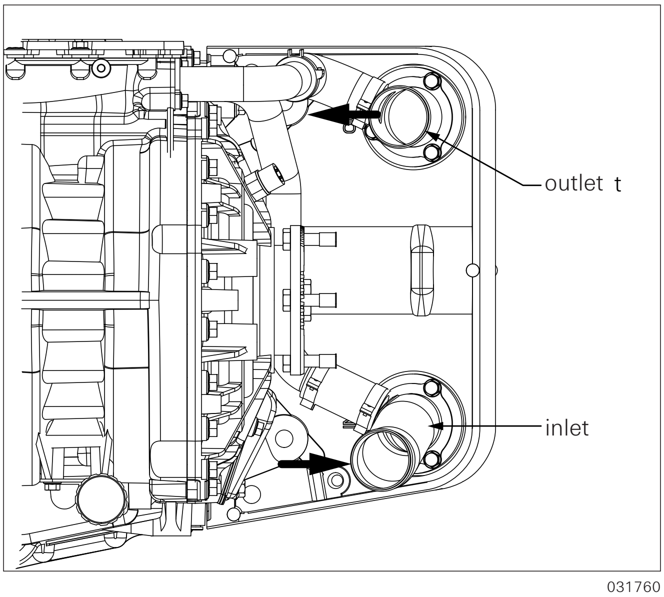


Fig. 12.1:
Heat exchanger attachment with fittings for coaxial transmission version based on countercurrent exchange principle

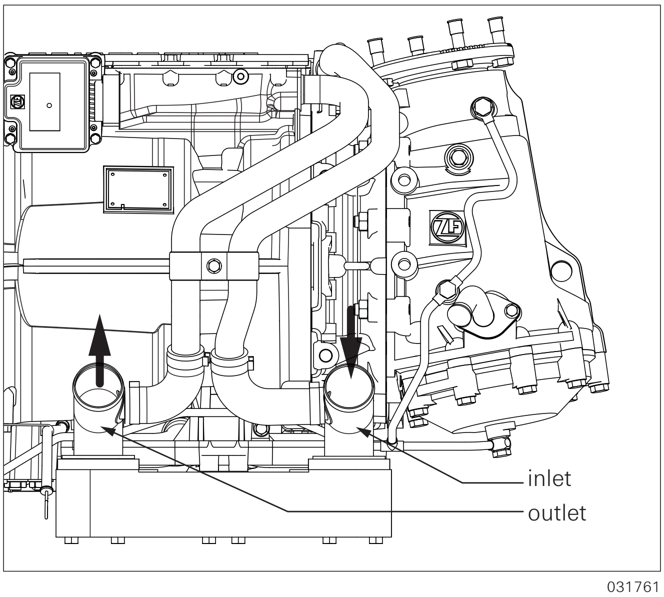


Fig. 12.2:
EcoLife heat exchanger mounting for angle drive version (RHD) based on countercurrent exchange principle.

12.2.2 Connections

Dimensioning of fittings:

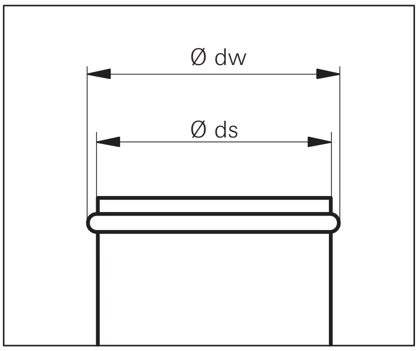


Fig. 12.3:
Fittings on the vehicle Cooling System

Standard:
∅ d_s = 60 mm diameter
∅ d_w = 63 mm diameter

Optional:
∅ d_s = 50 mm diameter
∅ d_w = 53 mm diameter

The transmission heat exchangers must be operated exclusively according to the countercurrent exchange principle.
Coolant connections according to installation drawing or Fig.12.1 and 12.2.

CAUTION
The concurrent exchange principle is currently not permitted.
In exceptional cases, consult our “Sales and Application” department.

12.2.3 Working instructions for fastening coolant hoses

- Refer to installation guidelines 4181 765 107

12.3 Coolant routing

12.3.1 General requirements

- The pressure-side arrangement on the cold water side is to be preferred (refer to Chapter 12.3.3).
- The transmission cooling system should be arranged in the primary current.
- Branching of coolant flows (e. g. vehicle heating) upstream of the transmission is to be avoided.
- The coolant volumetric flow at engine idling speed of at least 50 l/min.

CAUTION
If, for certain reasons, arrangement is possible in the bypass flow only, our "Sales and Application" department is to be consulted.

NOTE
When the thermostat is closed, the flow of cooling water through the heat exchanger is not assured.

12.3.2 Thermal and hydraulic interfaces

The transmission cooling system consists of a retarder and a transmission heat exchanger. Thus, transmission cooling can be guaranteed at every operating condition. Both heat exchangers are arranged in parallel on the coolant side (Fig. 12.4). Item 1 shows the coolant inflow at the transmission cooling system.
Item 2 shows the coolant outflow at the transmission cooling system.

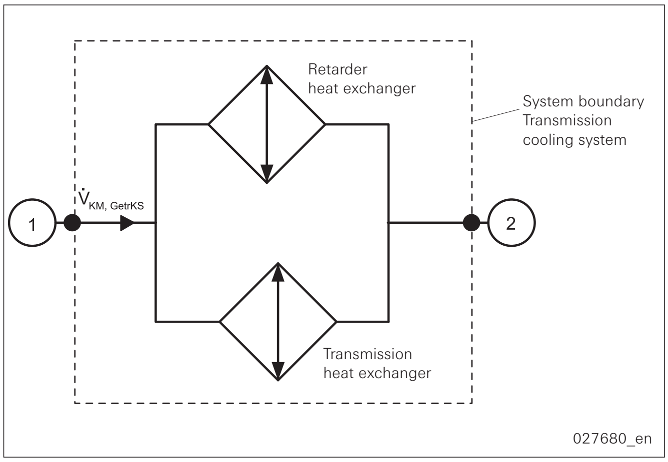


Fig. 12.4: Coolant routing in transmission Cooling System

The interface between the transmission cooling system and the vehicle cooling system is defined by the parameters shown in Table 12.2.
The definition of special temperatures is presented in Table 12.1 and depicted in Figures 12.5 and 12.6.

Size	Unit	Inlet at the transmission cooling system	Outlet at the transmission Cooling Sys-
temPosition	[–]	1	2
Coolant volumetric flow	[l/min]	$V_{KM,Getr}$	
Temperature	[°C]	$T_{KM,Getr,ein}$	$T_{KM,Getr,aus}$
Pressure (absolute)	[bar]	$p_{Abs,KM,Getr,ein}$	$p_{Abs,KM,Getr,aus}$
Medium	[–]	Material properties of the coolant	
Definition of special coolant temperatures			
Operating temperature	[°C]	$T_{KM,Getr,ein,Betrieb}$	
Permissible continuous temperature	[°C]	$T_{KM,Getr,ein,zul}$	$T_{KM,Getr,aus,zul}$
Permissible peak temperature	[°C]	$T_{KM,Getr,ein,zul\text{-}max}$	$T_{KM,Getr,aus,zul\text{-}max}$

Table 12.2: Definition of interfaces with transmission Cooling System

Definition of special temperatures: inlet of the transmission Cooling System

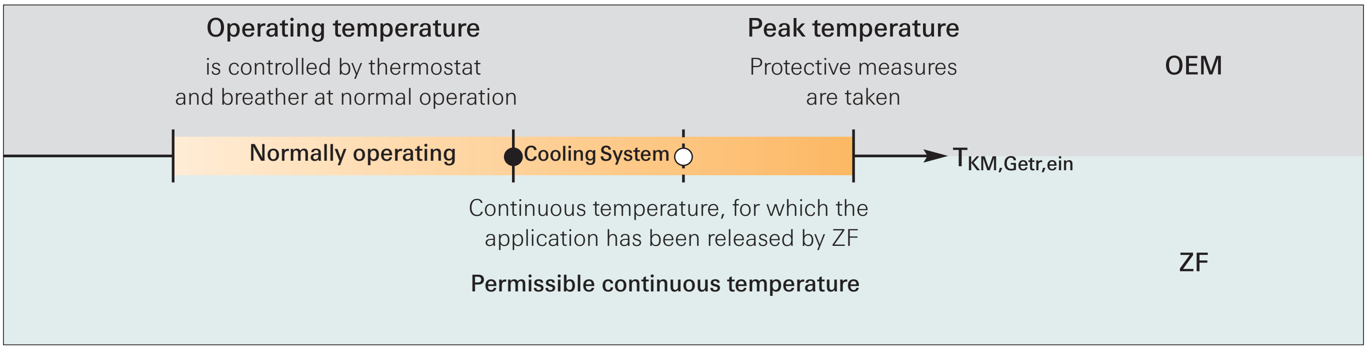


Fig. 12.5: Special temperatures at the inlet of the transmission Cooling System

Definition of special temperatures: outlet of the transmission Cooling System

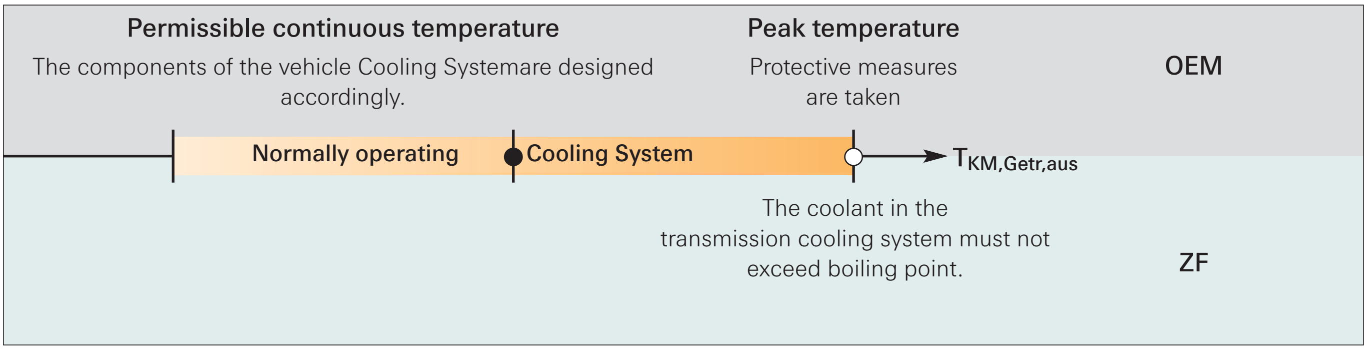
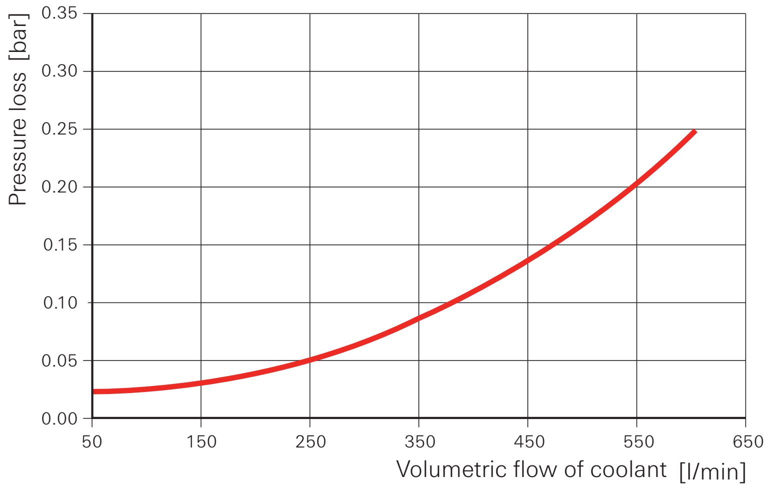
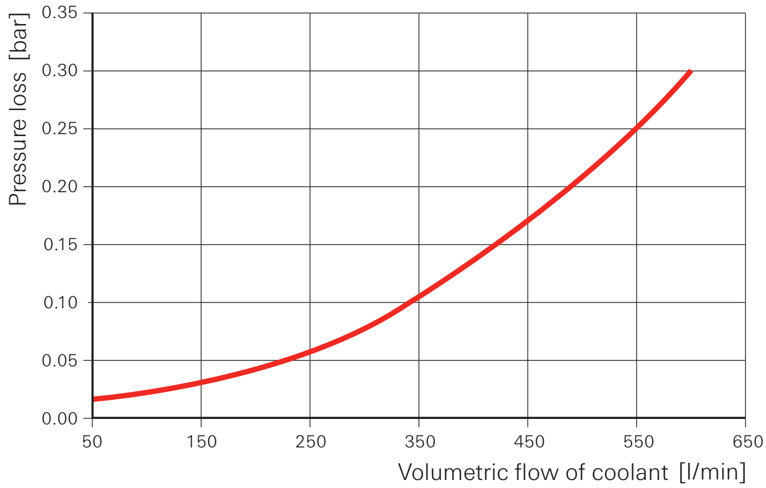


Fig. 12.6: Special temperatures at the outlet of the transmission cooling system

The permissible continuous temperature at the outlet of the transmission cooling system ($T_{KM,Getr,aus,zul}$) is to be determined by the vehicle manufacturer.
The OEM must make sure that the coolant has sufficient safety margin at all times before reaching the coolant boiling point. Besides the composition of the coolant, the boiling point also depends on the system pressure set in the cooling system.

General operating data with counter-flow principle

	Unit	Value
Coolant composition	Refer to Sec. 12.4	
Coolant volumetric flow	l/ min	50 – 600
Max. absolute pressure at the inlet	bar	3.5 bar – in the case of higher pressures, it is required to consult our “Sales and Application” department.
Pressure loss at transmission types: 6 AP 1000 B to 6 AP 1400 B, coaxial version Valid for fittings with 60 mm diameter (standard)	bar	
Pressure loss at transmission types: 6 AP 100X B to 6 AP 140X B, for angle drive variants Valid for fittings with 60 mm diameter (standard)	bar	

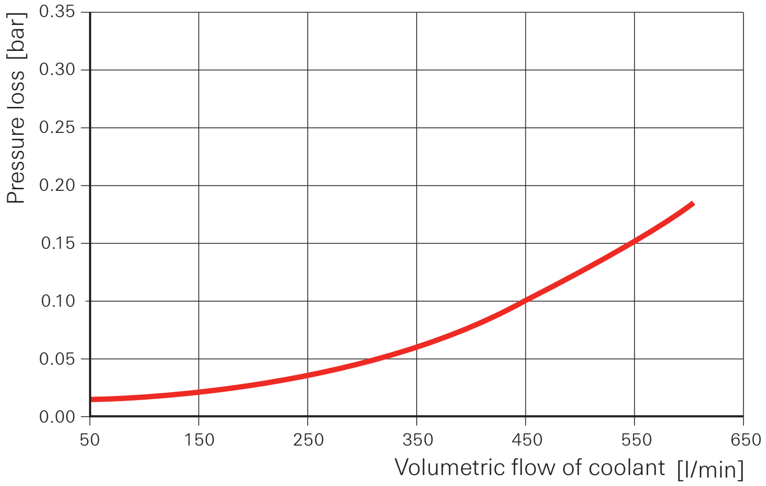
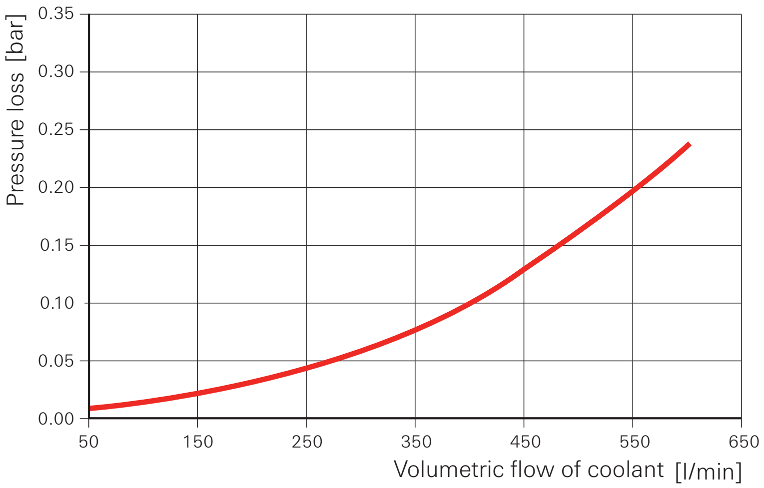
	Unit	Value
Pressure loss at transmission types: 6 AP 1700 B and 6 AP 2000 B, coaxial version Valid for fittings with 60 mm diameter (standard)	bar	
Pressure loss at transmission type 6 AP 170X B with angle drive variants Valid for fittings with 60 mm diameter (standard)	bar	

Table 12.3: General operating data at the transmission cooling system interface

12.3.3 Arrangement on the cold water side, pressure side

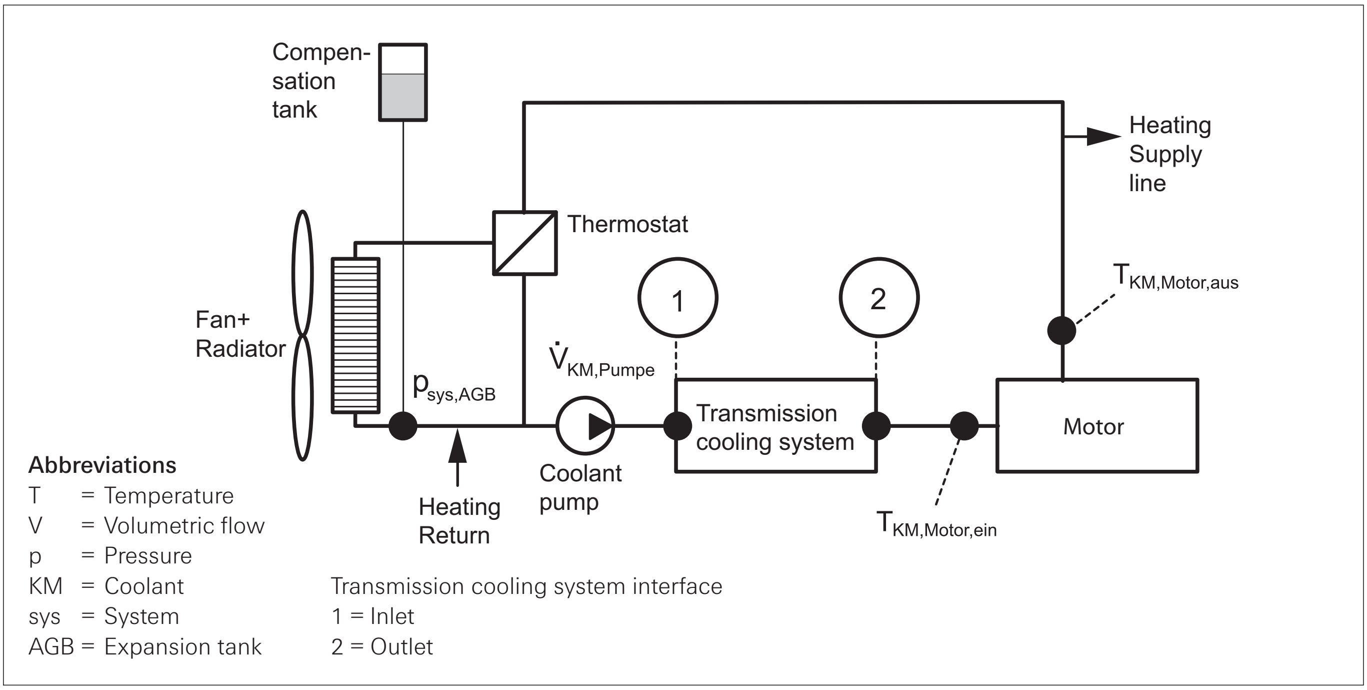


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Fig. 12.7:
Arrangement of the transmission cooling system on the cold water side, pressure side

12.3.4 Arrangment on the cold water side, suction side

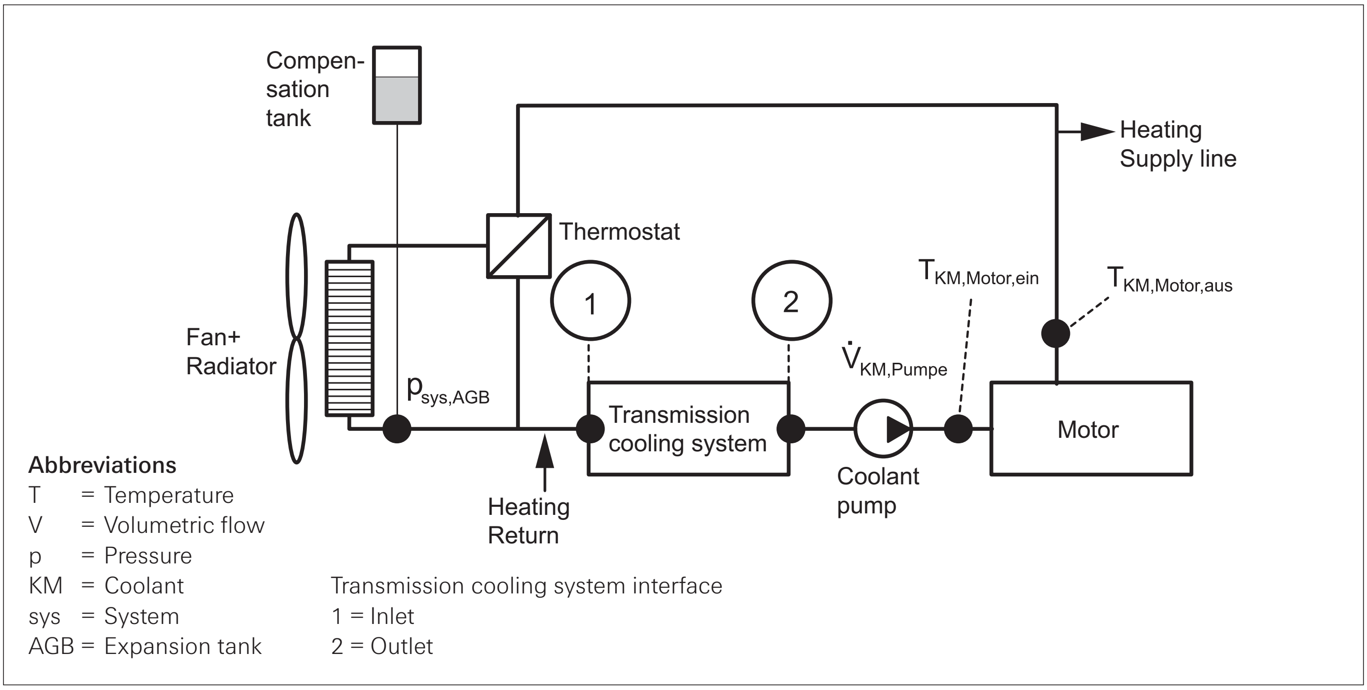

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Fig. 12.8:
Arrangement of the transmission cooling system on the cold water side, suction side

12.3.5 Arrangement on the hot water side, pressure side

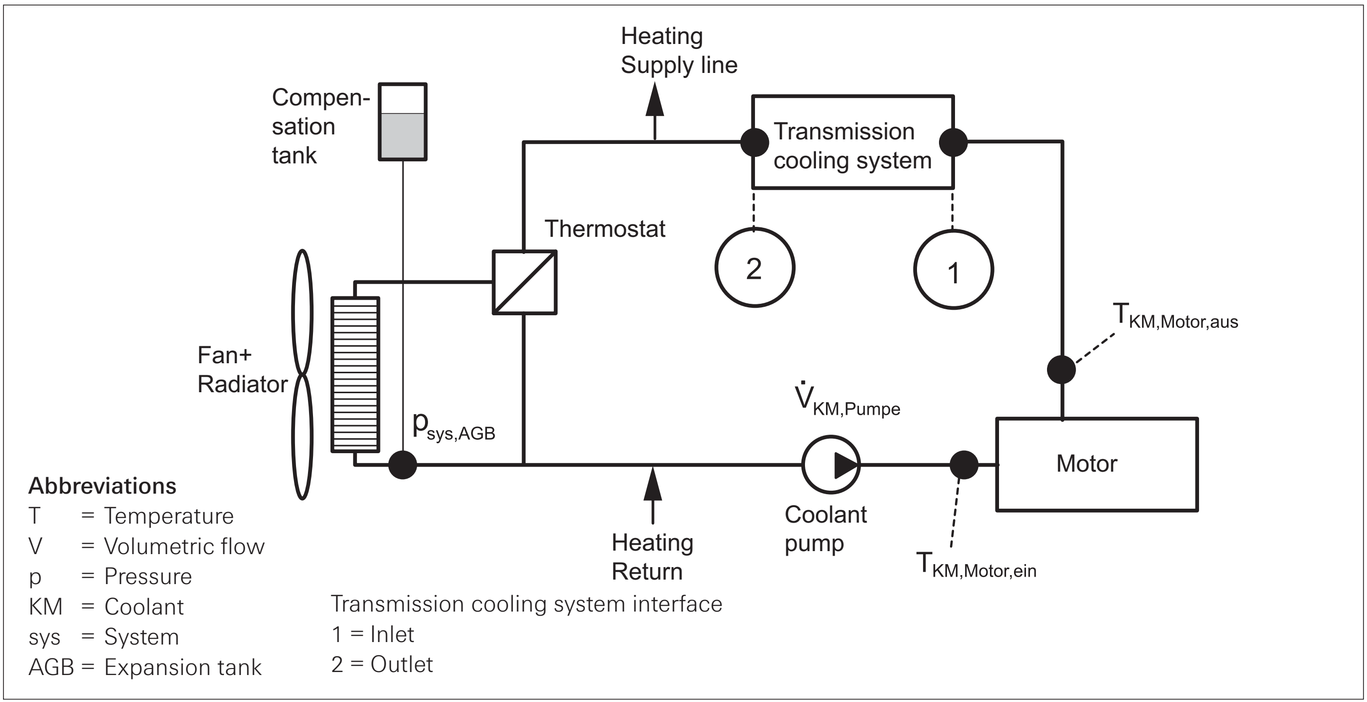

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Fig. 12.9:
Arrangement of the transmission cooling system on the hot water side, pressure side

12.4 Coolant requirements

Requirement specifications of heat exchanger manufacturer are binding!

12.4.1 General

The coolant is a specified mixture of fresh water and coolant additive. To protect units from cavitation and corrosive damage, the coolant quality must satisfy defined requirements.

12.4.2 Fresh water

To make sure the coolant does not contain particles or dirt, only clean water, which corresponds to the following quality and analysis values, is permitted:

Description	Value	Method
Particle:	<340 ppm	
Organic materials:	<15 mg/l	SS 028118
pH value (at 20 °C):	6.5 – 8.5	ASTM D 1293
Total hardness:	<9.5 °dH	ASTM S 1126
Iron content:	<0.10 ppm	ASTM D 1068
Chloride content:	<40 ppm	ASTM D 512
Sulfate content:	<100 ppm	ASTM D 516
Silicon content:	< 20 mg SiO_2 / l	ASTM D 859
Manganese content:	<0.05 ppm	ASTM D 858
Electrical conductivity:	< 500 µS/cm	ASTM D 1125

Table 12.4:
Quality and/or analysis values of fresh water

12.4.3 Coolant additives (antifreeze/corrosion inhibitor)

Coolant additives are made up by ethylene glycol with anti-corrosion additives (SCA). They enlarge the coolant's operating range between boiling and freezing point and increase corrosion protection.
Coolant additives produced by means of two different technologies are available on the market: Products containing silicate and products free of silicate (Organic Acid Technology).
The following requirements apply to coolant additives containing silicate and relate to the silicate content of products when new: 200 - 300 ppm Si.
Mixing different coolant additives must be avoided at all costs.
The agents must not contain the following: Amines, chlorides, phosphates, sulfates, carbonates, and chromates.

NOTE
Release for the coolant's composition must be granted by the original equipment and engine manufacturers.

Recommended Coolant Additives
Approval from the vehicle/engine manufacturer is mandatory for the use of the following coolants.

Manufacturer	Product designation
Agip Petroli S.P.A./Rome	Agip Antifreeze Plus
Aral Lubricants GmbH	Aral Antifreeze Extra Kühlerschutz Extra
Arteco	Havoline XLC
BASF AG	Glysantin G03/Kühlerschutz Glysantin G05/Antikorrosion Glysantin G48/Protect Plus Glysantin G30/Alu Protect
Castrol International	Castrol Antifreeze SF Castrol Antifreeze NF
DEA Mineraloel AG	DEA Kühlerfrostschutz
Elf Lubricants	Glacelf SX Glacelf MDX
OMV Aktiengesellschaft	OMV Kühlerfrostschutz
Shell Chemicals	Glycoshell N Glycoshell
TOTALFINA	Total Multiprotect
Valvoline Intern. Europe	G48 Antifreeze/Coolant
Veedol International Ltd.	Veedol Antifreeze N F

12.4.4 Coolant

The coolant consists of a mixture of fresh water (in accordance with 12.4.2) and coolant additive (in accordance 12.4.3).

The coolant is permissible in concentrations of 40 - 50 % coolant additive.

Use suitable measuring equipment (aerometer, hydrometer) to determine the coolant’s concentration. The concentration is to be checked at two different coolant levels.

Coolant is to be changed at the service intervals of the OEM, at least every 2 years. The coolant must also be replaced in the case of sludge formation or clear concentration drops.

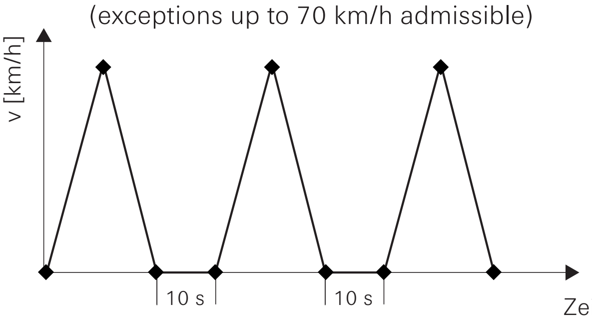
12.5 Temperature measurements in the vehicle

All vehicle applications are individually tested and measured by ZF when putting them into operation, and the permissible coolant temperatures are specified together with the OEM.

12.5.1 Release criteria for EcoLife transmissions

12.5.1.1 Measurement conditions / retarder test cycle

– 50 km/h for city bus
– 80 km/h for suburban buses and coaches (exceptions up to 70 km/h admissible)



- Open cooling system
  – Thermostat open blocked (no “empty” and/or dummy thermostat)
  – Vent/Fan fully active
- Ambient temperature min. 0 °C
- Roadway dry, no rain
- Consumer(s) (e.g. air-conditioning equipment) switched off
- Heating circuit closed via valve
- Retarder braking with 100 % retarder torque
- No vehicle or transmission-end limitation of the retarder torque
- Engine brake deactivated (if possible)

12.5.1.2 Retarder cycle measurement

Retarder cylces are to be run until persistent determination of temperatures, at least every 20 minutes.
In general, all measurement parameters can be measured via CAN if the positions of the measurement sensor are suitable for the process.

If no different arrangement can be established, the following three measurement parameters will suffice as a minimum:

Coolant temperature on transmission input	$T_{KM,Getr,ein}$ Engine temperature: Engine coolant temperature
Oil temperature Transmission sump	$T_{Getr,Sumpf}$ Transm. Fluids: Transmission oil temperature
Ambient-air temperature	T_{Amb} Ambient conditions: Ambient air temperature

In the case of recording via CAN SAE J1939, the following measurement parameters must be recorded (measurement parameters for other CAN systems can be sent upon request):

Temperature

Oil retarder outlet	RF: Hydraulic retarder oil temperature

Speed

Engine speed	EEC1: Engine speed
Turbine speed	ETC1: Input shaft speed
Output speed	ETC1: Output shaft speed

Retarder variables

Retarder request	TSC1 DR: Requested torque/ torque limit
Retarder reference torque	Ret Conf: Reference Retarder torque
Actual retarder torque	ERC1 DR: Actual retarder percent torque

Engine variables

Torque request engine	EEC2: Accelerator pedal position
Engine torque	EEC1: Actual engine percent torque

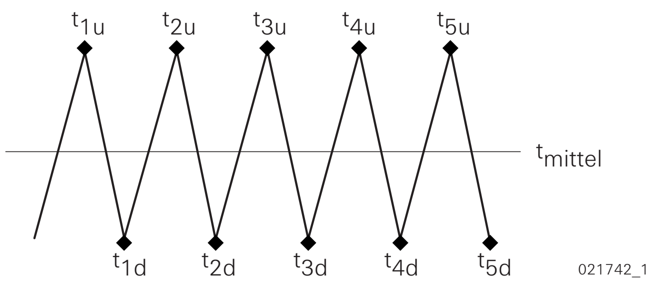
Other

Brake pedal position	EBC1: Brake pedal position (CCVS/EBC1: Brake switch)
Brake value Engine brake	ERC1 ER: Actual retarder percent torque
Vehicle speed	CCVS: Wheel-based vehicle speed
Current gear	ETC2: Current gear

12.5.1.3 Calculation

Determine mean values of coolant temperature at transmission inlet $T_{KM,Getr,ein}$, oil sump temperature $T_{Getr,Sumpf}$, and ambient temperature T_{Amb}.

If the temperatures change cyclically, the average temperature should be calculated based on the values of the last five cycles as follows:



$$t_{mittel} = \left(\frac{t_{1u} + t_{2u} + t_{3u} + t_{4u} + t_{5u}}{5} + \frac{t_{1d} + t_{2d} + t_{3d} + t_{4d} + t_{5d}}{5} \right) : 2$$

ΔT_{spec}
Difference between oil sump temperature and coolant temperature at the transmission output
$\Delta T_{spec} = T_{Getr,Sumpf} - T_{KM,Getr,ein}$

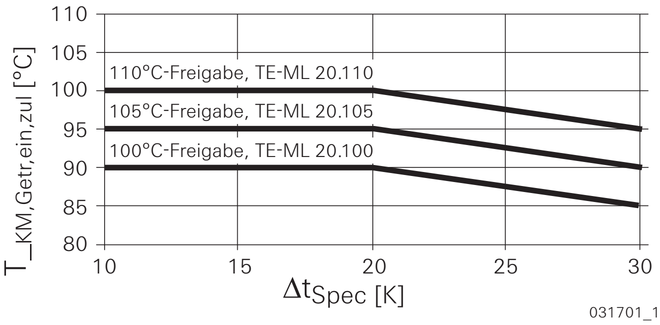
GKK (transmission cooling constant, also: TCC)
Difference between oil sump temperature and ambient temperature:
$GKK = T_{Getr,Sumpf} - T_{Amb}$

Max. admissible ambient-air temperature ($T_{Amb,zul}$)
The latter is calculated as follows:
$T_{Amb,zul} = T_{Getr,Sumpf\_xxx°C\_release\_TE\text{-}ML20.xxx} - GKK \bullet 0.8$

12.5.1.4 Determination of maximum permissible coolant temperature according to List of Lubricants TE-ML 20

- The maximum admissible coolant temperature $T_{KM,Getr,ein,zul}$ is determined on the basis of diagrams/charts, namely with the value determined ΔT_{spec} and the limit temperature according to the List of Lubricants.

Temperature release for EcoLife according to TE-ML 20.100 / TE-ML 20.105 / TE-ML 20.110



General ZF requirements:

- Calculated max. admissible ambient-air temperature ($T_{Amb,zul}$) ≥ 40 °C.
- A release for use with an ambient-air temperature >45 °C is to be agreed with our "Sales and Application" department and must be granted in writing by the department.
- Adherence to the maximum admissible coolant temperature, determined on the basis of the diagram/chart, is considered mandatory.
  The point of maximum thermostat opening must be attained at least 5K above the max. coolant temperature. Once the max. coolant temperature or, as an alternative, upon attaining the max. transmission oil sump temperature, the vehicle vent/fan must be fully active.

Example TE-ML 20.110:

- **Measurement values during retarder cycles**

  $T_{Getr,Sumpf}$ = 95 °C
  T_{Amb} = 25 °C
  $T_{KM,Getr,ein}$ = 70 °C

  } **ΔT_{Spec} = 25 K**
  GKK = 70 K

- **Determination of permissible coolant temperature from diagram**

- **Result**
  Coolant temperature at the transmission inlet ($T_{KM,Getr,ein}$) must be below **98 °C** under all conditions, i. e. this coolant temperature must not be exceeded, not even in a controlling system with a maximum ambient temperature.

- **Max. permissible ambient temperature ($T_{Amb,zul}$)**

  = $T_{Getr,Sumpf\_110\ °C\_release\_TE\text{-}ML\ 20.110}$ – GCC • 0.8

  = 110 °C – 70 K • 0.8
  = 110 °C – 56 K
  = 54 °C
  54 °C > 40 °C

13 Peripherals

13.1 CAN pushbutton switch with connection to the diagnosis unit and orifice 13-3

13.2 CAN pushbutton switch with connection to the diagnosis unit, without orifice 13-5

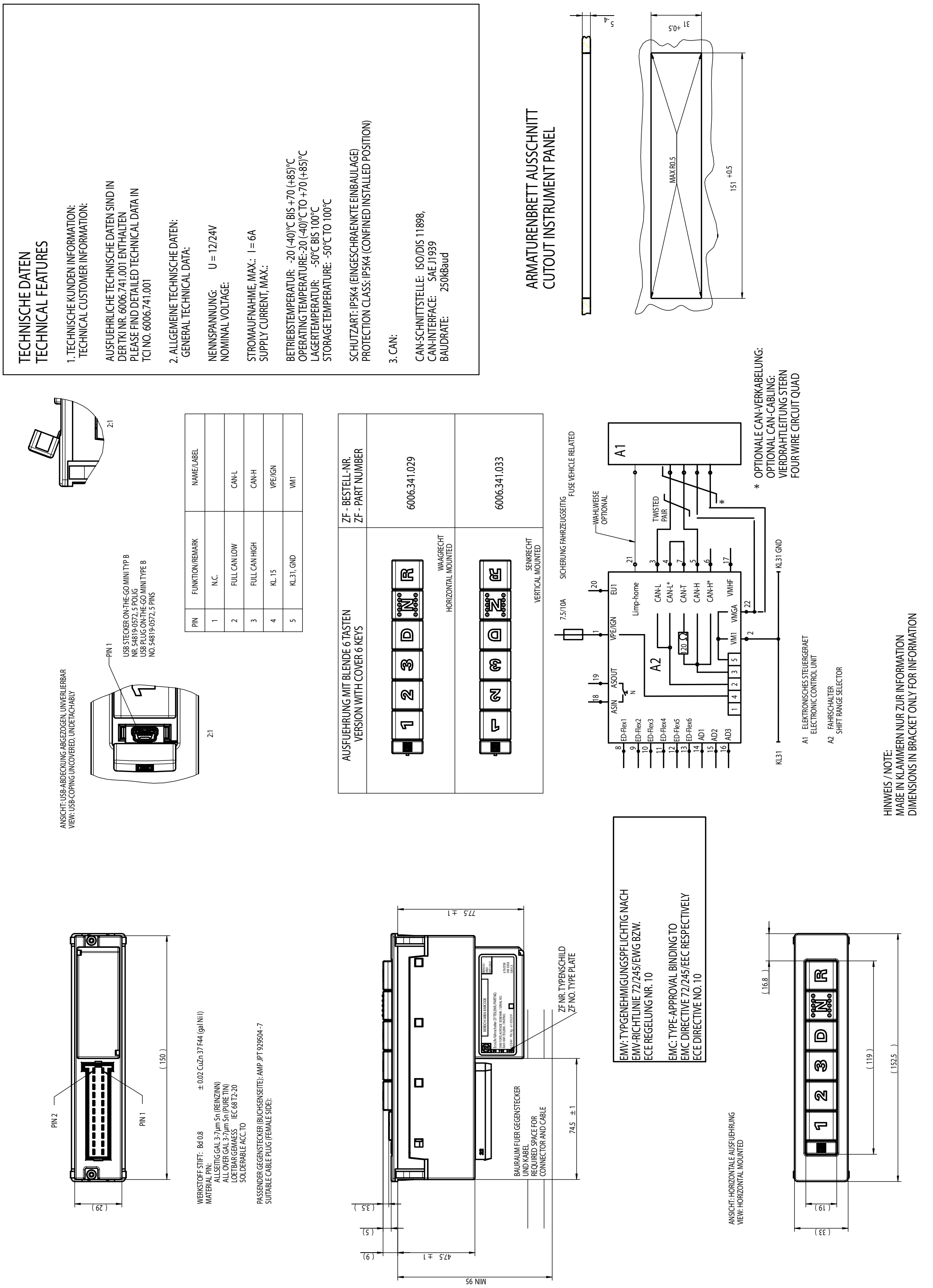
13.3 Optional equipment 13-7

13 Peripherals

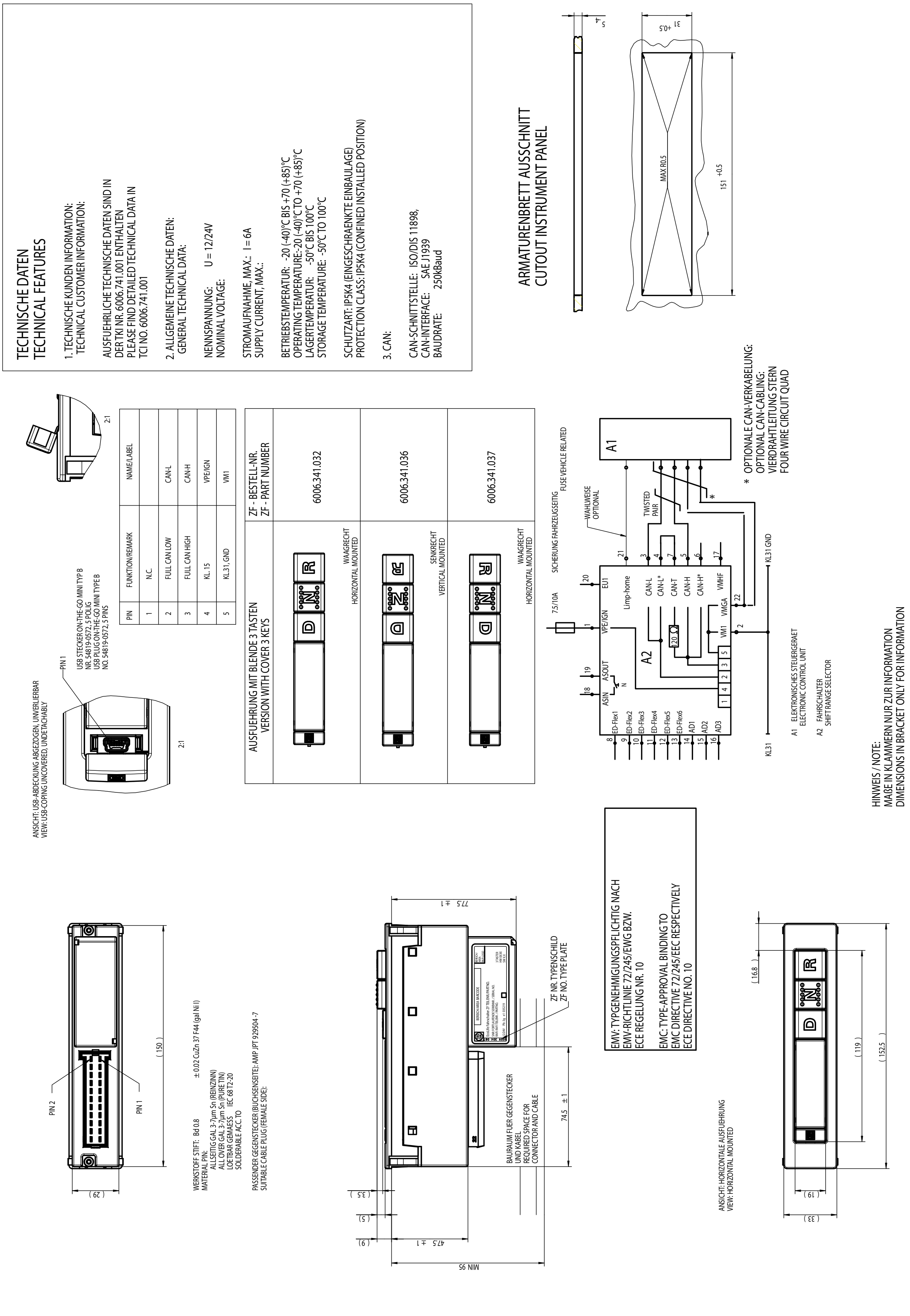
13.1 CAN pushbutton switch with connection to the diagnosis unit and orifice

Standard installation variants, horizontal and vertical with 3 and 6 pushbuttons

Installation variant with 6 pushbuttons **From drawing no.: 6006 641 009b**



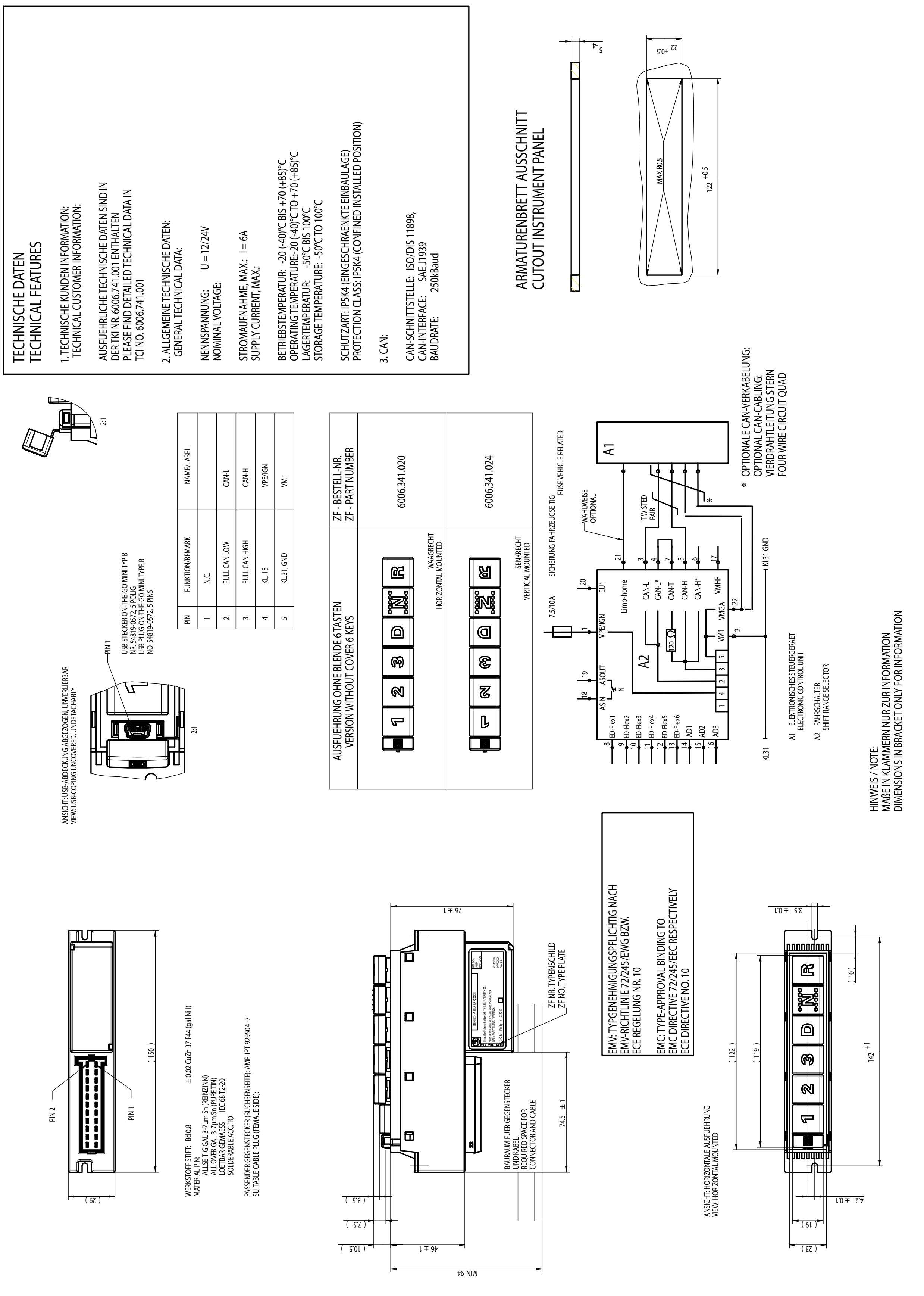
CAN pushbutton switch with connection to the diagnosis unit and orifice:
Installation variant with 3 pushbuttons From drawing no.: 6006 641 012b



13.2 CAN pushbutton switch with connection to the diagnosis unit, without orifice

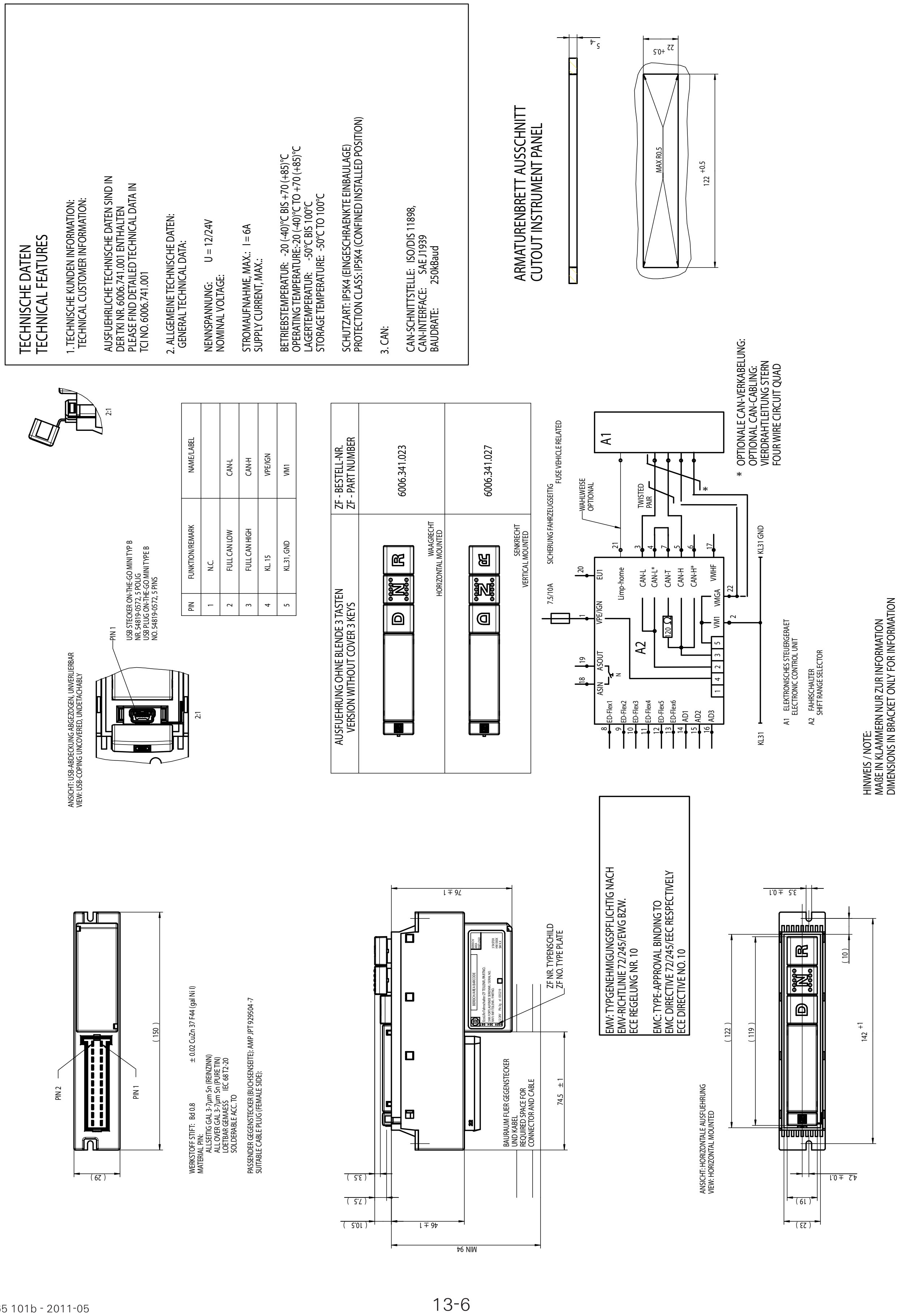
Standard installation variants, horizontal and vertical with 3 and 6 pushbuttons

Installation variant with 6 pushbuttons **From drawing no.: 6006 641 013b**



CAN pushbutton switch with connection to the diagnosis unit, without orifice:

Installation variant with 3 pushbuttons — From drawing no.: 6006 641 016b



13.3 Optional equipment

6007 603 007	Drawing	Kickdown switch	Parts list no.: 6007 203 105
6007 603 030	Drawing	Kickdown switch	Parts list no.: 6007 203 181
0501 207 847	Drawing Pressure Switch - AIS - 0.9 bar		
0501 311 584	Drawing Pressure Switch - AIS - 0.9 bar		
6029 205 557	Drawing	Cable connection	Kickdown, pressure switch, i. a.
6006 641 010	Drawing	CAN pushbutton switch	5 pushbuttons with orifice
6006 641 011	Drawing	CAN pushbutton switch	4 pushbuttons with orifice
6006 641 014	Drawing	CAN pushbutton switch	5 pushbuttons without orifice
6006 641 015	Drawing	CAN pushbutton switch	4 pushbuttons without orifice
0501 205 041	Drawing	Brake step switch	Length of lever 80 mm
0501 205 042	Drawing	Brake step switch	Length of lever 120 mm
0501 209 410	Drawing	Brake step switch	Length of lever: 160 mm 3-stage, blocked
0501 209 665	Drawing	Pedal brake valve	Parts list no.: 0501206 153, 3-stage

14 EcoLife ECU Control Unit, E-Module 2, and Wiring

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14.2 Provided standard functions . . . 14-4

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14 EcoLife ECU Control Unit, E-Module 2, and Wiring

14.1 Description of Function of ECU EcoLife

EcoLife ECU, the new electronic control unit, is needed for functions control and monitoring of the ZF-EcoLife transmission ranges. The EcoLife ECU communicates with other control units of the entire vehicle system via CAN interfaces.

These CAN interfaces allow for a simple integration of the transmission functions into new vehicle concepts. Sensors can be shared which means that costly components including connections by cables and connectors are not needed.

Different vehicle and transmission functions, such as direction of travel, speed ranges, engine load, various speeds, driving speeds, acceleration, temperature, etc. can be recorded and transformed into signals for controlling the hydraulic control elements of the transmission. Furthermore, transmission-specific information and requirements are communicated to the vehicle management system via CAN or vehicle electrical system interfaces. For this purpose, the ZF speed range selector and the ZF E-Module 2 provide digital inputs and outputs; communication with the EcoLife ECU happens via CAN.

The EcoLife ECU provides for a continuously variable shifting speed which is dependent on the vehicle acceleration. Upon request, 8 different driving program configurations and an analytical topography recognition (optional) are possible as well as a tractive force pre-calculation based on the engine torque.

The powerful ZF primary retarder can be integrated easily into modern brake management systems.

At each gear change, the electronic control unit controls the hydraulic shifting pressure on the clutches and brakes. Continuous shift quality over the entire transmission service life is achieved through adaptation. If the required shifting times and the required shifting pressure are not reached anymore, numerous backup and protective functions are available. The driver is informed about the the faults via a standard diagnosis interface.

The torque converter lock-up clutch installed in the hydrodynamic torque converter of the transmission is opened or closed depending on the engine load or engine speed.

The engine may be started only when “Neutral” is selected. The OEM is responsible for the engine start function.

The EcoLife ECU software includes a number of fail-safe mechanisms for faulty operation to increase driving safety.

The EcoLife ECU is capable of performing on-board diagnosis. The integration into on-board diagnosis systems is made possible by interfaces with UDS, KWP 2000, SAE J1587, IES diagnosis, and SAE J1939. New diagnosis systems with menu navigation allow for a quick and simple system check in the vehicle.

Thus, the EcoLife ECU makes a considerable contribution to the following characteristics:

- Increase in shift quality and safety
- Improved economy by reduced fuel consumption, among other things
- Increase in vehicle availability
- Simplified installation in the vehicle
- Flexible and application-specific maintenance intervals
- Integration into brake management systems

14.2 Provided Standard Functions

The EcoLife ECU software includes the following standard functions:

- Shifting programs which have been optimized in terms of operating cost reduction
- Statistics memory to record operating data
- High level of shift comfort thanks to shift pressure adaptation
- Reduction of fuel consumption when vehicle is stationary thanks to AIS
- Transmission protection through systematic engine torque intervention
- Increase of operating safety by means of various fail-safe mechanisms for faulty operation and malfunction of one or more components in the system.
- Saving of faults in the transmission system for fault analysis
- On-board diagnosis capability of the EcoLife ECU
- Diagnosis capability according to standard protocols, such as UDS, KWP 2000, IES diagnosis, SAE J1587, and SAE J1939
- End-of-line configuration of application parameters to reduce variety of versions and adjust to specific customer requirements
- Selection of suitable driving programs and speed range selector configurations
- Recording of operating data
- Special functions upon request

14.3 Technical Data of the EcoLife ECU

Technical Customer Information:

Detailed technical data are included in the Technical Customer Information, ZF Specification 6070 703 002, which can be requested whenever needed.

Installation drawing of EcoLife ECU 6070 603 001 see Chapter 14.4

General technical data of the electronic control unit:

- Nominal voltage: Us = 24V
- Maximum current consumption: I max = 5 A (2%ED)
- Operating temperature – 40 °C to +130 °C
- Storage temperature – 55 °C to +140 °C
- Protection class IP 69K

Typical characteristics:

The EcoLife ECU (hardware) is protected against:
- Reverse polarity
- Undervoltage
- Overvoltage
- Short circuit

In the event of an error/fault, it is possible to completely or partly deactivate the control unit outputs(protective function).

Communication interfaces:

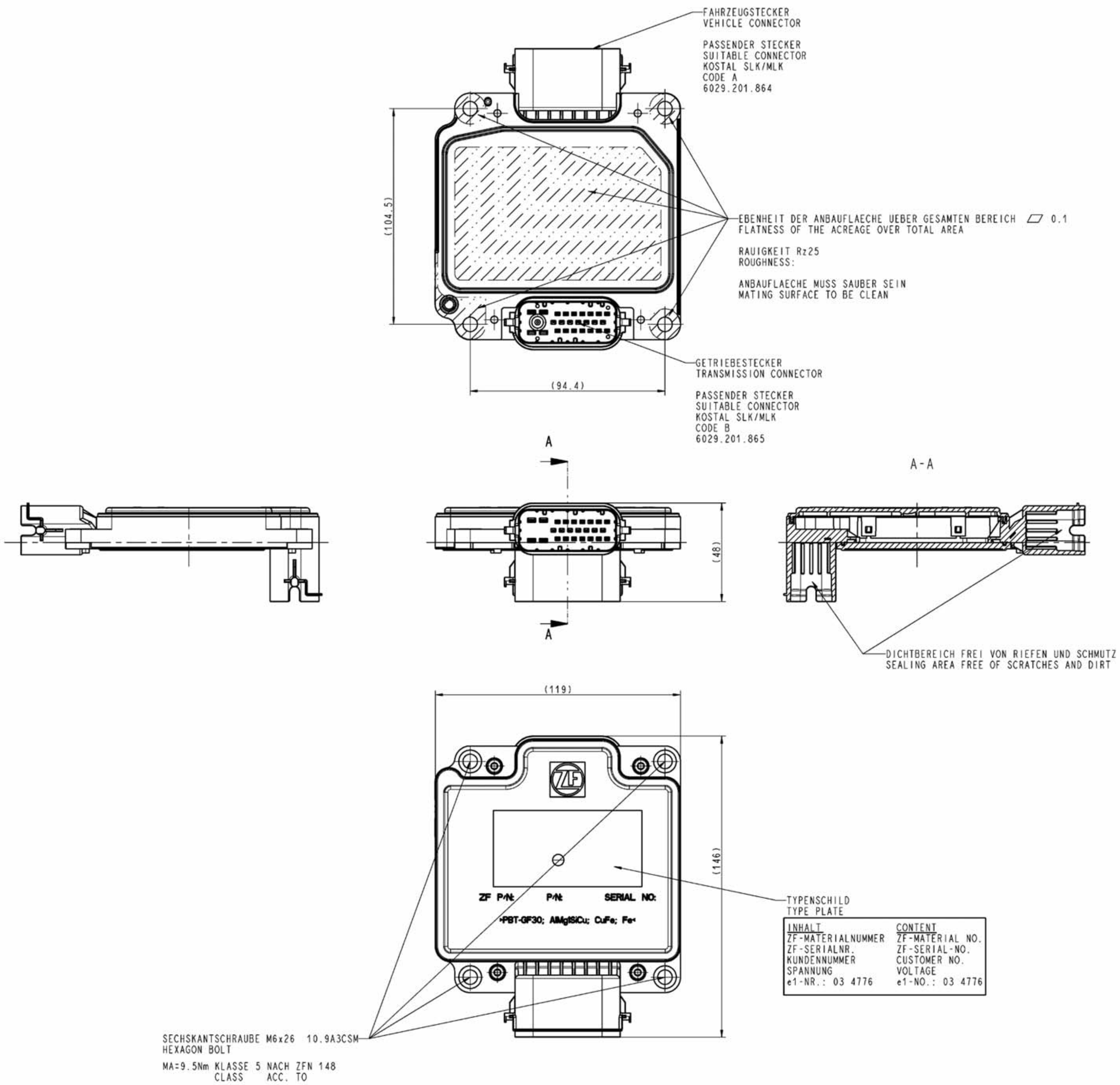
- 2 x CAN interface SAE J1939-11 / ISO 11898
- 1 x diagnosis interface SAE J1587

CAUTION
Battery cutoff (BCO) in the vehicle:
With BCO in "OFF" position, both battery and generator must be disconnected from the vehicle electric system! Otherwise voltage supply of the ECU via terminal 30 / battery must also be ensured with the master switch "OFF" (power consumption <1 mA, not critical!).
Operation of EcoLife ECU is not permitted without battery – risk of destruction through overvoltage!

14.4 Installation Drawing of EcoLife ECU

From drawing no.: 6070 603 001b/1

Note: For current e1 number, see order drawing



TECHNISCHE DATEN / KURZBESCHREIBUNG
TECHNICAL FEATURES / BRIEF DESCRIPTION

1. KUNDENSPEZIFIKATION :
CUSTOMER SPECIFICATION

AUSFUEHRLICHE TECHNISCHE DATEN FINDEN SIE
IN DER ZF-SPEZIFIKATION NR.: 6070 703 002
DETAILED TECHNICAL DATA IS CONTAINED IN ZF SPECIFICATION NO. 6070 703 002

2. ALLGEMEINE TECHN. DATEN DES ELEKTRONISCHEN STEUERGERAETES:
GENERAL ECU TECHNICAL DATA:

- NENNSPANNUNG NOMINAL VOLTAGE	: U_N = 24V
- MAX. STROMAUFNAHME SUPPLY CURRENT MAX.	: I_{MAX} = 5A(2% ED)
- BETRIEBSTEMPERATUR (AN MONTAGEPLATTE) OPERATING TEMPERATURE RANGE (AT MOUNTING PLATE)	: -40°C...+130°C
- LAGERTEMPERATUR STORAGE TEMPERATURE RANGE	: -55°C...+140°C
- GEWICHT WEIGHT	: 0.35 kg
- DICHTIGKEITSKLASSE (SCHUTZART) (STECKER MONTIERT) PROTECTION CLASS (WITH MOUNTED CONNECTOR)	: IP 69K

3. TYPISCHE EIGENSCHAFTEN :
TYPICAL PROPERTIES

- DAS ELEKTRONISCHE STEUERGERAET IST GESCHUETZT GEGEN:
THE ELECTRONIC CONTROL UNIT IS PROTECTED AGAINST:
  - VERPOLUNG
    CROSS-CONNECTION
  - UEBERSPANNUNG
    OVERVOLTAGE
  - KURZSCHLUSS
    SHORT-CIRCUITS
- IM FEHLERFALLE IST EINE TEILWEISE ODER KOMPLETTE ABSCHALTUNG DER STEUERGERAETE-AUSGAENGE MOEGLICH (SCHUTZFUNKTION)
IN CASE OF FAULTS, IT IS POSSIBLE TO COMPLETELY OR PARTIALLY SHUT DOWN THE CONTROL UNIT OUTPUT (PROTECTION FEATURE)

4. KOMMUNIKATIONSSCHNITTSTELLEN:
COMMUNICATION INTERFACES:

-2xCAN-SCHNITTSTELLE: 2xCAN-INTERFACE	SAE1939-11 / ISO 11898
-1xDIAGNOSE-SCHNITTSTELLE: 1xDIAGNOSTIC INTERFACE	SAE_J1708
-1xDIAGNOSE-SCHNITTSTELLE: 1xDIAGNOSTIC INTERFACE	ISO 9141

Fall-Test:
Die elektrische Funktion wurde auf Fallhoehe bis 1m geprueft.
Bei groesseren Fallhoehen oder sichtbarer aeusseren Beschaedigungen, ist das Geraet auszutauschen!

Drop Test:
The electrical function will be tested of a drop-hight up to 1m.
By higher drop-hight or external and viewable demaging, the ECU must be changed!

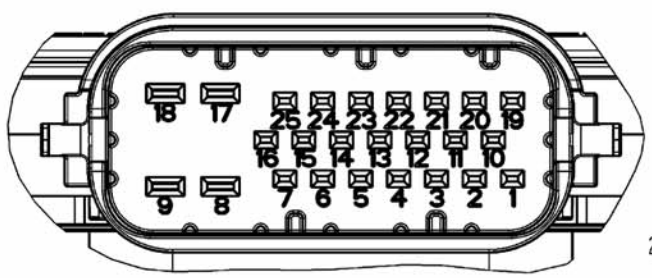
"EMV: Typengenehmigungspflichtig nach
EMV-Richtlinie 72/245/EWG bzw. ECE Regelung Nr. 10"
"EMV: type approval liability according
EMV-directive 72/245/EWG resp. ECE regulation no. 10"

From drawing no.: 6070 603 001b/2

Pin - Funktionsbeschreibung EcoLife, Steuergerät
Terminal Function-indication, EcoLife, ECU

Stecker-Pin Bordnetz *Plug-Terminal Vehicle-Interface*	Funktion-Bezeichnung *Function-indication*	Beschreibung	*Description*
1	-	-	-
2	CANF2L	CAN 2, Low (ZF-CAN)	CAN 2, low (ZF-CAN)
3	VMHF4	HF-Masse 4	Hi-frequence ground 4
4	VMHF2	HF-Masse 2	Hi-frequence ground 2
5	CANF1L	CAN 1, Low Triebstrang	CAN 1, low powertrain
6	-		
7	SD2	Schnittstelle Digital 2	Interface digital 2
8	VPE1	Versorgung (+) Kl.30	Power supply (+) Kl.30
9	VPE2	Versorgung (+) Kl.30	Power supply (+) Kl.30
10	SAE-J1708_A	Diagnoseschnittstelle J1708_A	Diagnosis interface J1708_A
11	CANF2H	CAN 2, High (ZF-CAN)	CAN 2, high (ZF-CAN)
12	VMHF5	HF-Masse 5	Hi-frequence ground 5
13	CANF1T	CAN 1-Abschluss-Widerstand	CAN 1 ending-resistor (terminal)
14	CANF1H	CAN 1, High, Triebstrang	CAN 1, high powertrain
15	-		
16	SD2	Schnitstelle Digital 1, (Limp home)	Interface digital 1, (limp home)
17	VM1	Versorgung Masse (-) Kl.31	Supply ground (-) Kl.31
18	VM2	Versorgung Masse (-) Kl.31	Supply ground (-) Kl.31
19	SAE-J1708_B	Diagnoseschnittstelle J1708_B	Diagnosis interface J1708_B
20	VMHF3	HF-Masse 3	Hi-frequence ground 3
21	VMHF1	HF-Masse 1	Hi-frequence ground 1
22	CANF1L	CAN 1, Low, Triebstrang	CAN 1, low powertrain
23	CANF1H	CAN 1, High, Triebstrang	CAN 1, high powertrain
24	ER3	Eingang Widerstand 3	Input resistor 3
25	VPI	Signal (+) Kl.15 (Zündung)	Signal (+) Kl.15 (Ignition)

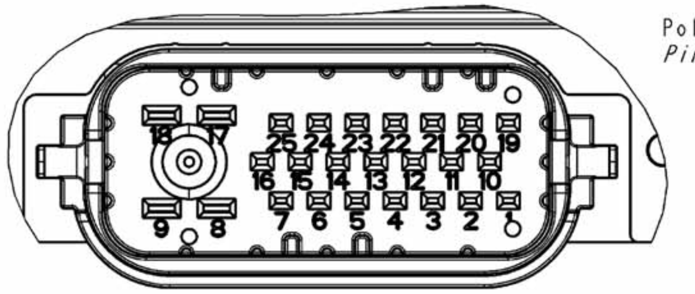
Polbild zum Bordnetz
pin pattern to Vehicle Interface



2:1

Stecker-Pin Getriebe *Plug-Terminal Transmission*	Funktion-Bezeichnung *Function-indication*	Beschreibung	*Description*
1	-		
2	EF1	Eingang Frequenz 1, Geber	Input frequency 1, sensor
3	AIM6	Ausgang, Strom-Masse 6 (-) , Y12	Output current 6, ground (-), Y12
4	AIM7	Ausgang, Strom-Masse 7 (-) , Y14	Output current 7, ground (-), Y14
5	AIM8	Ausgang, Strom-Masse 8 (-) , Y13	Output current 8, ground (-), Y13
6	AU1	Ausgang Spannung 1, (5V)	Output voltage 1, (5V)
7	ER4	Eingang Widerstand 4	Input resistor 4
8	VPS2	Versorgung plus (+) geschaltet 2	Voltage power (+) switched 2
9	VPS1	Versorgung plus (+) geschaltet 1	Voltage power (+) switched 1
10	EF2	Eingang Frequenz 2, Geber	Input frequency 2, sensor
11	AIM10	Ausgang, Strom-Masse 10 (-)	Output current 10, ground (-)
12	-		
13	-		
14	AIM4	Ausgang, Strom-Masse 4 (-) , Y19	Output current 4, ground (-), Y19
15	AU2	Ausgang Spannung 2, (5V)	Output voltage 2, (5V)
16	AIM3	Ausgang, Strom-Masse 3 (-) , Y13	Output current 3, ground (-), Y13
17	VMG1	Versorgung Masse Geber 1 (-)	Supply ground sensor 1 (-)
18	VMG2	Versorgung Masse Geber 2 (-)	Supply ground sensor 2 (-)
19	AIM9	Ausgang, Strom-Masse 9 (-)	Output current 9, ground (-)
20	AIM5	Ausgang, Strom-Masse 5 (-) , Y11	Output current 5, ground (-), Y11
21	ER2	Eingang Widerstand 2, Temp-Geber	Input resistor 2, temp-sensor
22	ER1	Eingang Widerstand 1, Temp-Geber	Input resistor 1, temp-sensor
23	ER3	Eingang Widerstand 3	Input resistor 3
24	AIM1	Ausgang, Strom-Masse 1 (-) , Y16	Output current 1, ground (-), Y16
25	AIM2	Ausgang, Strom-Masse 2 (-) , Y17	Output current 2, ground (-), Y17

Polbild zum Getriebe
Pin pattern to Transmission



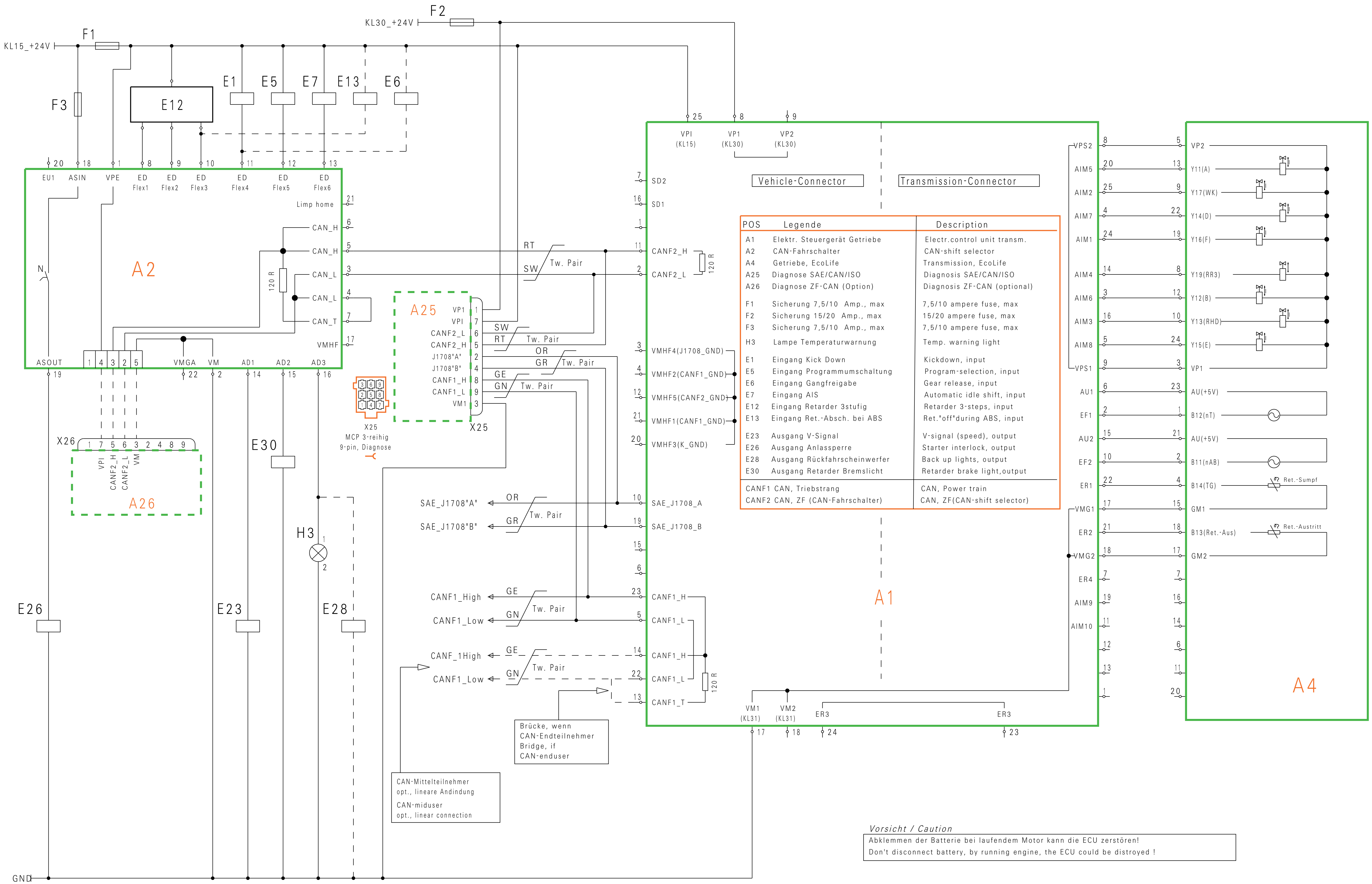
2:1

14.5 Circuit Diagrams and Terminal Connection Diagrams

The circuit diagram is the electrical wiring diagram of the ZF components in the system layout. It is used for wiring installation, which is why the connectors of the ZF components are also shown. If the wiring for connecting ZF components to the transfer connector (CAN speed range selector, E-Module 2) is supplied by ZF, then ZF also draws up a connection diagram.
For standard circuit diagrams, terminal connection diagrams, and functional description, see Chapters 14.5.1 to 14.5.5 below.

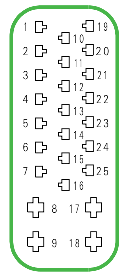
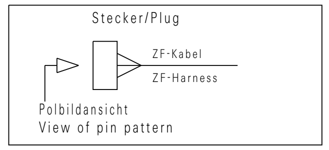
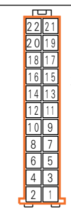
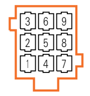
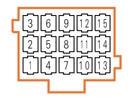
14.5.1 Circuit diagram, general, CAN-end / CAN-mid / SAE J1708/ISO 9141

From drawing no.: 6029 739 017a/1



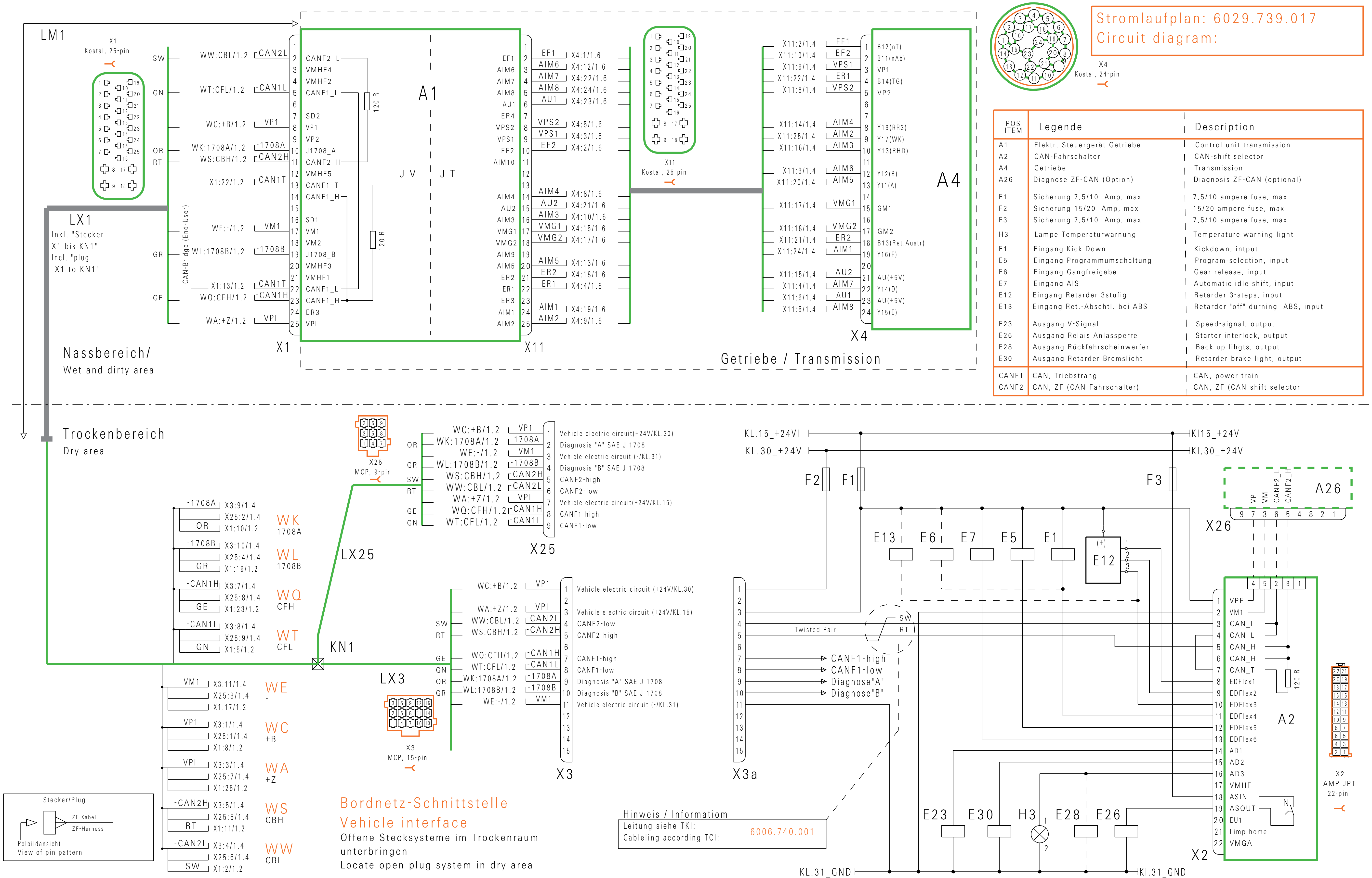
14.5.1 Circuit diagram, general, CAN-end / CAN-mid / SAE J1708/ISO 9141

From drawing no.: 6029 739 017a/2

Verkabelung-Anforderungen	Harness-requirements	
Stecker, ECU, fahrzeugseitig Typ: 25pol, Kostal, Buchse (SLK/MLK) ZF-Best-Nr.: 6029 199 156 Hersteller: Fa. Kostal Hersteller Best-Nr.: siehe TKI 0000 702 303 ZF-Verarbeitungspezifikation: 0501 700 453 ZF-Spezifikation: 6029 705 028 Kostal-Verarbeitungspez: DOK 000 860 29 (verbindlich) Achtung: Der Kabelabgang am ECU-Stecker muss nach ca. 100mm befestigt werden ! Hierzu ist eine Gewindebohrung (M8) am Getriebe-Wärmetauscher vorgesehen	**Plug, ECU, vehicle-part** Type: 25pin, Kostal, female (SLK/MLK) ZF-Order-no.: 6029 199 156 Manufacturer: Co. Kostal Manufacturer order-no: See TCI 0000 702 303 ZF-processing-specification: 0501 700 453 ZF-specification: 6029 705 028 Kostal-processing-specific: DOK 000 860 29 (binding) Attention: The cable must be fixed ca. 100mm after cable-out from the ECU-plug ! For this is designed a threaded hole (M8) at the transmission heat-exchanger	 Kostal 25-pin, ECU 
Stecker, CAN-Fahrschalter Typ: 22pol, Tyco, Buchse, Jun.P.T., 2reihig ZF-Best-Nr.: 6029 199 132 Hersteller: Fa. Tyco Hesteller Best-Nr.: 929504-7 (Stecker-Gehäuse) Herteller Best-Nr.: 927771-3 (Kontaktbuchse)	**Plug, CAN shift-seletor** Type: 22pin, Tyco, female, jun.p.t., 2-array ZF-Order-no.: 6029 199 132 Manufacturer: Co. Tyco Manufacturer order-no: 929504-7 (plug-housing) Manufacturer order-no: 927771-3 (female terminal)	 AMP JPT 22-pin, FS
Stecker, Diagnose Typ: 9pol, Tyco, Buchse, MCP, 3reihig ZF-Best-Nr.: 6029 199 157 Hersteller: Fa. Tyco Hesteller Best-Nr.: 8-968971-1 (Stecker-Gehäuse) Herteller Best-Nr.: 1-968849-1 (Kontaktbuchse)	**Plug, diagnoses** Type: 9pin, Tyco, female, MCP, 3-array ZF-Order-no.: 6029 199 157 Manufacturer: Co. Tyco Manufacturer order-no: 8-968971-1 (plug-housing) Manufacturer order-no: 1-968849-1 (female terminal)	 X25 MCP 3-reihig 9-pin, Diagnose
Stecker, Bordnetz (Vorschlag-ZF) Typ: 15pol, Tyco, Buchse, MCP, 3reihig ZF-Best-Nr.: 6029 199 161 Hersteller: Fa. Tyco Hesteller Best-Nr.: 8-968973-1 (Stecker-Gehäuse) Herteller Best-Nr.: 1-968849-1 (Kontaktbuchse, 1,0qmm) Herteller Best-Nr.: 1-968851-1 (Kontaktbuchse, 2,5qmm)	**Plug, vehicle interface (ZF proposel)** Type: 15pin, Tyco, female, MCP, 3-array ZF-Order-no.: 6029 199 161 Manufacturer: Co. Tyco Manufacturer order-no: 8-968973-1 (plug-housing) Manufacturer order-no: 1-968849-1 (female terminal, 1,0qmm) Manufacturer order-no: 1-968851-1 (female terminal, 2,5qmm)	 MCP, 3-reihig 15-pin, Bordnetz
Leitungen, CAN-Schnittstellen Schnittstellen nach: SAE J1939 / SAE J 1708 Verdrilltes Leitungspaar: Schläge 32mm (32 S/m) Empfohlener Leiterquerschnitt: 1,0qmm	**Wires, CAN-interface** Interfaces according: SAE J1939 / SAE J 1708 Twisted pair wires: Twisted 32mm (32 S/m) Recommended wire cross-section: 1,0qmm	
Leitungen, BN(+)Kl.30, BN(-)Kl.31 Empfohlener Leiterquerschnitt: 2,50qmm Kl.30 (VPE1/VPE2), Pin 8 / 9 Kl.31 (VM1/VM2), Pin 17 / 18	**Wires, power supply, Kl.30, Kl.31** Recommended wire cross-section: 2,5qmm Kl.30 (VPE1/VPE2), pin 8 / 9 Kl.31 (VM1/VM2), pin 17 / 18	
Leitungen, BN(+)Kl.15 und sonstige Empfohlener Leiterquerschnitt: 1,00qmm Kl.15 (VPI), Pin 25 und alle sonstigen Leitungen	**Wires, power(+)Kl.15 and miscellaneous** Recommended wire cross-section: 1,0qmm Kl.15 (VPI), pin 25 and all other wires	
Hinweis: Der Fahrzeughersteller (OEM) ist verantwortlich für die Auslegung der Verkabelung.	Notice The Vehicle manufacturer (OEM) is responsible for the construction of the harness.	

14.5.2 Terminal connection diagram, general, CAN-end, diagn.: SAE J1708

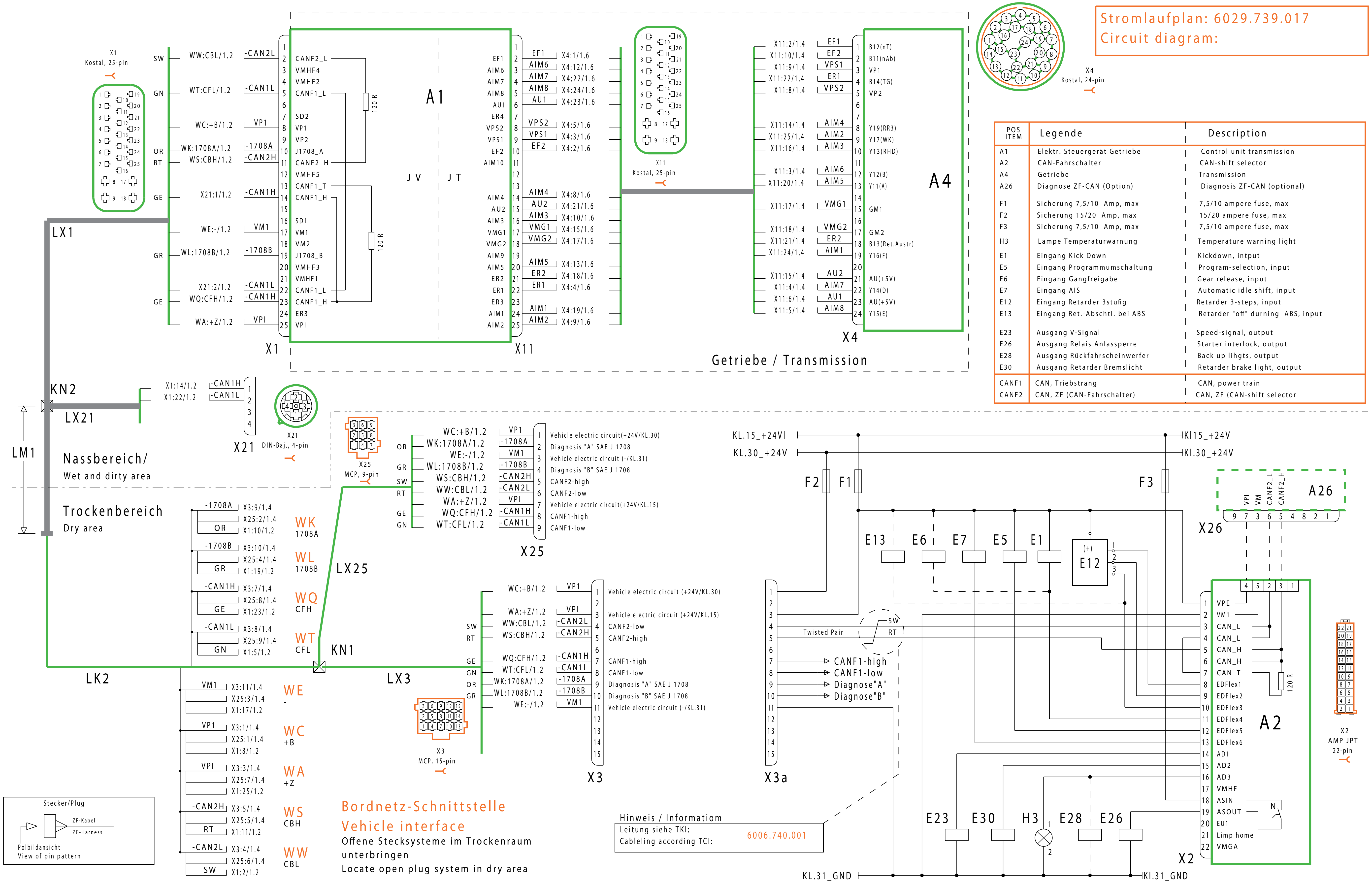
From drawing no.: 6029 739 018



POS ITEM	Legende	Description
A1	Elektr. Steuergerät Getriebe	Control unit transmission
A2	CAN-Fahrschalter	CAN-shift selector
A4	Getriebe	Transmission
A26	Diagnose ZF-CAN (Option)	Diagnosis ZF-CAN (optional)
F1	Sicherung 7,5/10 Amp, max	7,5/10 ampere fuse, max
F2	Sicherung 15/20 Amp, max	15/20 ampere fuse, max
F3	Sicherung 7,5/10 Amp, max	7,5/10 ampere fuse, max
H3	Lampe Temperaturwarnung	Temperature warning light
E1	Eingang Kick Down	Kickdown, intput
E5	Eingang Programmumschaltung	Program-selection, input
E6	Eingang Gangfreigabe	Gear release, input
E7	Eingang AIS	Automatic idle shift, input
E12	Eingang Retarder 3stufig	Retarder 3-steps, input
E13	Eingang Ret.-Abschtl. bei ABS	Retarder "off" durning ABS, input
E23	Ausgang V-Signal	Speed-signal, output
E26	Ausgang Relais Anlassperre	Starter interlock, output
E28	Ausgang Rückfahrscheinwerfer	Back up lihgts, output
E30	Ausgang Retarder Bremslicht	Retarder brake light, output
CANF1	CAN, Triebstrang	CAN, power train
CANF2	CAN, ZF (CAN-Fahrschalter)	CAN, ZF (CAN-shift selector

14.5.3 Terminal connection diagram, general, CAN-mid, SAE J1708

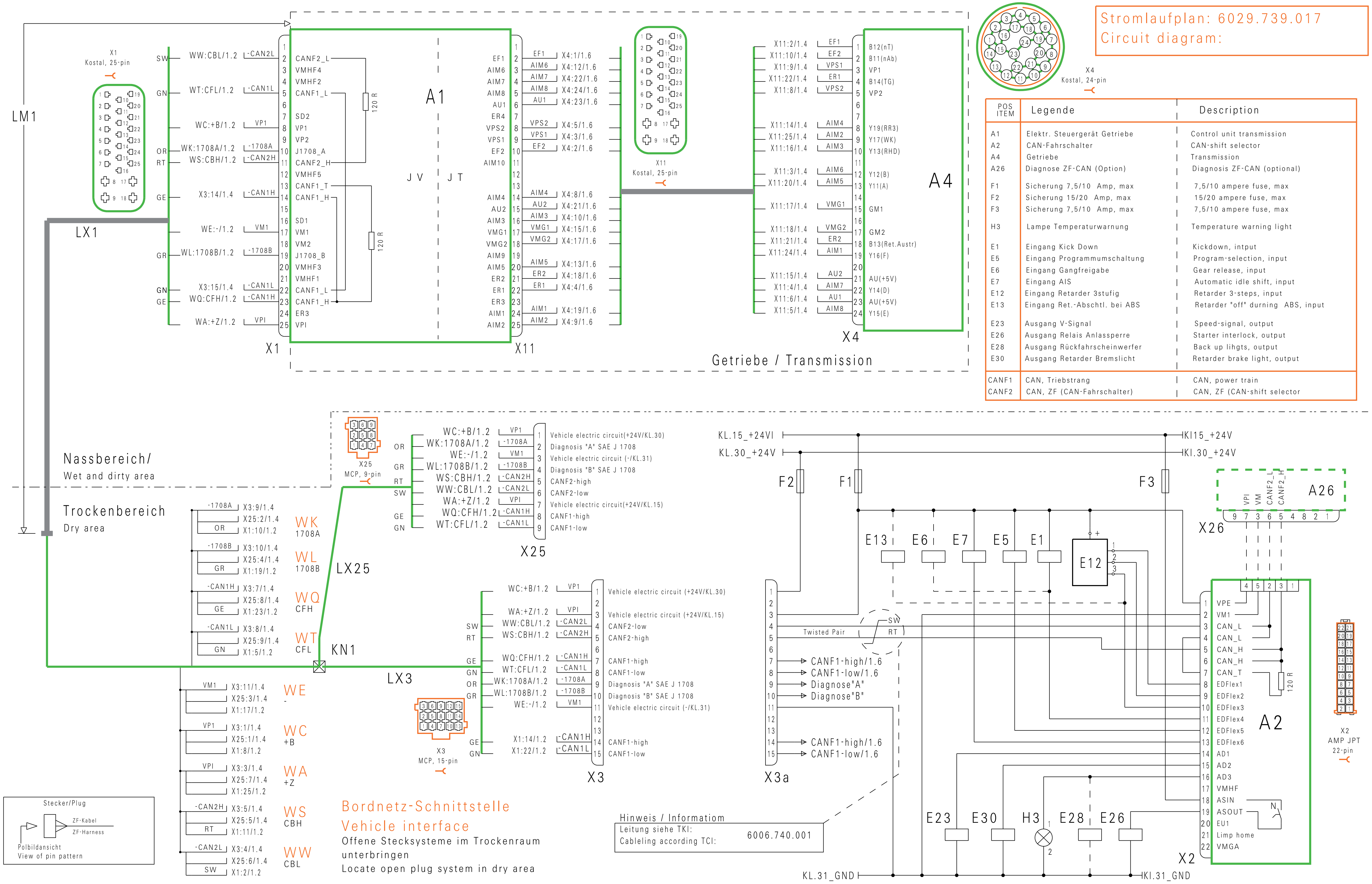
From drawing no.: 6029 739 021



POS ITEM	Legende	Description
A1	Elektr. Steuergerät Getriebe	Control unit transmission
A2	CAN-Fahrschalter	CAN-shift selector
A4	Getriebe	Transmission
A26	Diagnose ZF-CAN (Option)	Diagnosis ZF-CAN (optional)
F1	Sicherung 7,5/10 Amp, max	7,5/10 ampere fuse, max
F2	Sicherung 15/20 Amp, max	15/20 ampere fuse, max
F3	Sicherung 7,5/10 Amp, max	7,5/10 ampere fuse, max
H3	Lampe Temperaturwarnung	Temperature warning light
E1	Eingang Kick Down	Kickdown, intput
E5	Eingang Programmumschaltung	Program-selection, input
E6	Eingang Gangfreigabe	Gear release, input
E7	Eingang AIS	Automatic idle shift, input
E12	Eingang Retarder 3stufig	Retarder 3-steps, input
E13	Eingang Ret.-Abschtl. bei ABS	Retarder "off" durning ABS, input
E23	Ausgang V-Signal	Speed-signal, output
E26	Ausgang Relais Anlassperre	Starter interlock, output
E28	Ausgang Rückfahrscheinwerfer	Back up lihgts, output
E30	Ausgang Retarder Bremslicht	Retarder brake light, output
CANF1	CAN, Triebstrang	CAN, power train
CANF2	CAN, ZF (CAN-Fahrschalter)	CAN, ZF (CAN-shift selector

14.5.4 Terminal connection diagram, general, CAN-mid, SAE J1708, linear connection

From drawing no.: 6029 739 067



POS ITEM	Legende	Description
A1	Elektr. Steuergerät Getriebe	Control unit transmission
A2	CAN-Fahrschalter	CAN-shift selector
A4	Getriebe	Transmission
A26	Diagnose ZF-CAN (Option)	Diagnosis ZF-CAN (optional)
F1	Sicherung 7,5/10 Amp, max	7,5/10 ampere fuse, max
F2	Sicherung 15/20 Amp, max	15/20 ampere fuse, max
F3	Sicherung 7,5/10 Amp, max	7,5/10 ampere fuse, max
H3	Lampe Temperaturwarnung	Temperature warning light
E1	Eingang Kick Down	Kickdown, intput
E5	Eingang Programmumschaltung	Program-selection, input
E6	Eingang Gangfreigabe	Gear release, input
E7	Eingang AIS	Automatic idle shift, input
E12	Eingang Retarder 3stufig	Retarder 3-steps, input
E13	Eingang Ret.-Abschtl. bei ABS	Retarder "off" durning ABS, input
E23	Ausgang V-Signal	Speed-signal, output
E26	Ausgang Relais Anlassperre	Starter interlock, output
E28	Ausgang Rückfahrscheinwerfer	Back up lihgts, output
E30	Ausgang Retarder Bremslicht	Retarder brake light, output
CANF1	CAN, Triebstrang	CAN, power train
CANF2	CAN, ZF (CAN-Fahrschalter)	CAN, ZF (CAN-shift selector

14.6 Description of EcoLife ECU Interfaces

If the wiring of the ZF-EcoLife transmission system is part of the ZF scope of supply, the connector to the X3 speed range selector or X3a vehicle supply connector represents the transfer point to the vehicle wiring. The following interface description describes the function of the individual electric connections which are available at the X3 connector.

NOTE
The interface description merely lists the standard. The assignment of the digital inputs and outputs may vary according to customer specs. Depending on the application, additional functions can be implemented by means of an E-Module 2, e.g. when using an analog brake step plate.

Description of EcoLife ECU interfaces according to circuit diagram:
6029 739 017 (CAN-mid, CAN-end, J 1708)
- Application with ZF-CAN speed range selector

Terminal connection diagram:
6029 739 018 (CAN-End [end user], SAE J 1708)
6029 739 021 (CAN-Mit [intermediate user], SAE J1708)
All applications with ZF-CAN speed range selector

Voltage supply limits:
Fully functioning between 18 V and 32 V

NOTE
At voltages < 18 V (terminal 30) the control unit switches to safe condition, i. e. the transmission goes to “Neutral”.

RESET: By setting speed range selector to Neutral

Current consumption:

Standby:	< 1 mA at 28 V Term. 30
Idling speed:	< 250 mA
Full load:	< 5 A

A1 EcoLife ECU

PIN 1 unused
Function: none

PIN 2 (CAN2_L) CAN 2 Low
Function: Communication with CAN speed range selector, ZF diagnosis, ZF application

PIN 3 (VMHF4) Ground supply high frequency
Function: CAN to earth/ground, SAE J1708 Connection of the shield for wiring with shielded CAN wires

PIN 4 (VMHF2) Ground supply high frequency
Function: CAN to earth/ground, CAN1 Connection of the shield for wiring with shielded CAN wires

PIN 5 (CAN1_L) CAN 1 Low
Function: Communication, driveline

PIN 6 free
Function: none

PIN 7 (SD2) Digital interface
Function: Serial interface

PIN 8 (VP1) Positive supply, external
Function: Terminal 30 (continuous positive) also serves to backup a control unit after-running [hunting], i. e. for the entry of error and adaptation data after the deactivation of terminal 15. The EcoLife ECU automatically shuts down following the after-running of the power supply, i.e. the vehicle’s power supply is no longer charged.

NOTE

In order to guarantee faultless data saving (diagnosis) during deactivation, the EcoLife ECU requires overtravel to save the data. This means that after the ignition has been switched off (terminal 15), the EcoLife ECU must be supplied by terminal 30 (permanent +) for at least 10 seconds.

If voltage supply is not maintained during afterrunning, functions are not limited or impaired, but no error entry and no recording of statistical and adaptation data is made.

PIN 9 (VP2) Option for 2nd positive supply, external
Function: like Pin 8 (VP1)

PIN 10 (J1708_A) SAE J1708 "A" line
Function: Interface, diagnosis according to SAE J1708

PIN 11 (CAN2_H) CAN 2 High
Function: like PIN 2 (CAN2_L)

PIN 12 (VMHF5) Ground supply high frequency
Function: like PIN 4 (VMHF2)

PIN 13 (CAN1-T) CAN 1, termination
Function: Termination resistor of 120 Ohm
If EcoLife ECU is defined as end consumer, the termination resistor in the ECU must be activated by installing a bridge from Pin 22 or Pin 5 to Pin 13.

PIN 14 (CAN1_H) CAN 1 High
Function: Communication, driveline

PIN 15 free
Function: none

PIN 16 (SD1) Digital interface
Function: Serial interface

PIN 17 (VM1) Ground/earth supply, external
Function: Terminal 31, ground/earth supply (-) for ECU, vehicle to ground.

PIN 18 (VM2) Option for 2nd ground/earth supply, external
Function: like Pin 17 (VM1)

PIN 19 (J1708_B) SAE J1708 "B" line
Function: Interface, diagnosis according to SAE J1708

PIN 20 (VMHF3) Ground supply high frequency
Function: like PIN4 (VMHF2)

PIN 21 (VMHF1) Ground supply high frequency
Function: like PIN4 (VMHF2)

PIN 22 (CAN1_L) CAN 1 Low
Function: like PIN 5 (CAN1_L)

PIN 23 (CAN1_H) CAN 1 High
Function: like PIN 14 (CAN1_H)

PIN 24 (ER3) Resistor input
Function: E.g. for resistor input for external temperature sensors

PIN 25 (VPI) Positive supply, external
Function: Terminal 15 (positive pole connected) via ignition switch (key-operated switch), activated voltage supply.

NOTE

To assure zero-defect powering up and shutting down of the control units communicating with the EcoLife ECU, always ensure that e.g. engine, ABS, and transmission control units establish communication links within max. 3 seconds.
Reason: Diagnosis is activated after 4 seconds.

A2 CAN speed range selector (pushbutton range selector) by ZF

Short description:
Digital flex inputs can be configured as low-active or high-active. All functions controlled via inputs or outputs can also be requested via CAN (application-dependent).

PIN 1 (VPE) Positive supply, external
Function: Terminal 15 (positive pole connected) via ignition switch (key-operated switch), activated voltage supply

NOTE:
If the CAN speed range selector is not supplied by ZF, always ensure that e.g. engine, ABS, and transmission control units establish communication links within max. 3 seconds.

Reason: Diagnosis of EcoLife ECU is activated after 4 seconds.

PIN 2 (VM) Ground/Earth supply, external
Function: Terminal 31, ground/earth supply (-) for CAN speed range selector, vehicle to ground.

PIN 3 (CAN_L) CAN 2 Low
Function: Communication with CAN speed range selector, ZF diagnosis

PIN 4 (CAN_L) CAN 2 Low
Function: Communication with CAN speed range selector, ZF diagnosis

PIN 5 (CAN_H) CAN 2 High
Function: Communication with CAN speed range selector, ZF diagnosis

PIN 6 (CAN_H) CAN 2 High
Function: Communication with CAN speed range selector, ZF diagnosis

PIN 7 (CAN_T) CAN 2, termination
Function: Termination resistor of 120 Ohm; If CAN speed range selector is defined as end consumer, the terminator resistor in the CAN speed range selector must be activated by installing a bridge from Pin 6 to Pin 7.

PIN 8 (EDFlex1) Digital input, flexible
Function: Retarder request step 1, digital. If retarder step 1 (1/3 of retarder torque) is requested, (refer to Section 8 “Retarder”), vehicle electrical system (+ level), high-side, or vehicle electrical system (- level), low-side, must be connected.

PIN 9 (EDFlex2) Digital input, flexible
Function: Retarder request step 2, digital. If retarder step 2 (2/3 of retarder torque) is requested, (refer to Section 8 “Retarder”), vehicle electrical system (+ level), high-side, or vehicle electrical system (- level), low-side, must be connected.

PIN 10 (EDFlex3) Digital input, flexible
Function: Retarder request step 3, digital. If retarder step 3 (full retarder torque) is requested, (refer to Section 8 “Retarder”), vehicle electrical system (+ level), high-side, or vehicle electrical system (- level), low-side, must be connected.

Alternatively:
Function: Retarder deactivation when ABS is activated, digital retarder deactivation when ABS is active. In this case, vehicle electrical system (+ level), high-side, or vehicle electrical system (- level), low-side, must be connected.

PIN 11 (EDFlex4) Digital input, flexible
Function: Kickdown function digital
For the kickdown function, vehicle electrical system (+ level), high-side, or vehicle electrical system (-level), low-side, must be connected.

Alternatively:
Function: Shift/Gear release, digital
If a driving range is selected from “Neutral” (forwards or reverse), vehicle electrical system (+ level) highside, or vehicle electrical system (- level), low-side, must already be connected via switch in brake system or must be connected within 2 seconds. Otherwise, requested driving range must be selected again by means of “speed range selector to Neutral”.

PIN 12 (EDFlex5) Digital input, flexible

Function: Program changeover, digital
Here, vehicle electric system (+ level), high-side, or vehicle electrical system (- level), low-side, must be connected when changing over to 2nd driving program.

PIN 13 (EDFlex6) Digital input, flexible

Function: AIS (Automatic Idle Shift)
If "AIS" function is requested, vehicle electrical system (+ level), high-side, or vehicle electrical system (- level), low-side, must be connected.

PIN 14 (AD1) Digital output

Function: V signal.
Output by vehicle electrical system(+), when programmed speed has been reached.

PIN 15 (AD2) Digital output

Function: Retarder, active
Output by vehicle electrical system (+) durin retarder operation. E.g. to control brake light.

PIN 16 (AD3) Digital output

Function: Temperature warning
Output by vehicle electrical system (+), when certain temperature threshold value is exceeded at retarder output or in the transmission sump.

Alternatively:

Function: Backup light
Output by vehicle electrical system (+), when "R button" on CAN speed range selector is pressed.

PIN 17 (VMHF4) Ground supply high frequency

Function: CAN to earth/ground, CAN2
Connection of the shield for wiring with shielded CAN lines

PIN 18 (ASIN) Positive supply, starting interlock

Function: Terminal 15 (positive pole connected) via ignition switch (key-operated switch), activated voltage supply.

NOTE

ASIN (ignition interlock input) must be separately protected against short circuits in order to guarantee engine start also when fuse F / ECU or CAN fails.

PIN 19 (ASOUT) Digital output

Function: Ignition interlock
Output by vehicle electrical system (+), when "N button" on CAN speed range selector is pressed.
Due to the self-sufficient contact path in the CAN speed range selector, which has its own voltage supply (ASIN, pin18), it is possible to start to engine also when the ECU or the CAN fails.

PIN 20 (EU1) Voltage input

Function: Voltage input
Input of analog voltage signal of 0 - 5 V.
E.g.: Analog retarder control element (step plate 0 to 5 V). Pulse-generator voltage must be stabilized and supplied by the control element.

PIN 21 (SD1) Digital interface

Function: Serial interface

PIN 22 (VMGA) Ground/earth supply of analog sensor

Function: Analog ground/earth to sensor
Earth/Ground to sensor for analog resistance sensor, e,g.: temperature sensor at retarder outlet or analog retarder control element.

14.7 Wiring

14.7.1 Wiring quality requirements

A distinction is made between two fundamental installation situations:

1. Wiring which is routed in the cabin or other **dry areas**.
2. Wiring which is routed in **wet sections**, e. g. directly next to the ZF unit or engine. Here, more stringent requirements apply in terms of temperature, mechanical characteristics, and chemical resistance apply, which will be described below.

CAUTION
The vehicle manufacturer, OEM, is responsible for the wiring design; see circuit diagram 6029 739 017, Sheet 2.

14.7.2 General data

- Operating voltage: UB < 50 V
- Test voltage: UP = 28 V ± 1 V
- Nominal voltage: UN = 24 V

14.7.3 Temperature ranges

Wiring which is routed on the ZF unit or directly next to it **(wet parts):**
Wiring which is not routed close to the unit **(dry parts)**:

Lower temperature limit	– 40 °C
Normal operating temperature	+ 110 °C
Max. continuous temperature	+ 125 °C
Short-time, max. 30 min (e.g. after "Engine OFF")	+ 150 °C

Lower temperature limit	– 40 °C
Normal operating temperature	+ 80 °C
Short-time, max. 30 min. (max. 10 % of runtime)	+ 105 °C

14.7.4 Operating time

- Operating hours: 50000
- Service life: > 15 years

14.7.5 Types of protection

Plugs and electric connections in unprotected area:

- Protection class IP 67 according to DIN 40050, part 9 or IEC 133.

Plugs and electric connections in protected area:

- Protection class IP 20 according to DIN 40050, part 9 or IEC 133.

Protection system for wiring looms:

- In the transmission area: IP 69K
- In other areas: P 50

14.7.6 Electronic media durability

The following media must not damage the wiring:

- Lubricants according to ZF List of Lubricants TE-ML 20
- Commercially available cleaning agents
- Phosphatic cleaning agents
- Cold cleaner
- Saline solution
- Paints, varnishes, undercoatings, and preserving agents typically used in vehicle manufacturing (e.g. transmission varnish coat ZF item number 0670 290 253)
- Fuels: diesel, gasoline
- Brake fluid
- Splash water, water spray, dust, dirt

14.7.7 Electric conductors

Voltage supply lines, (+24V and ground):

- Soft-annealed, bare copper wires, resistance R = 7.5 mΩ/m at 20 °C
- Max. current load per wire: 20 A
- Conductor cross section: 2.5 mm^2

CAN and other wires:

- Soft-annealed, bare copper wires, resistance R ≤ 18´.5 mΩ/m at 20 °C
- Max. current loads per line: 10 A
- Conductor cross section: 1 mm^2
- CAN wires: bifilar, twisted
  Length of lay SL32 (32 lays / m), Z twist

Deviating conductor cross-sections are to be agreed with ZF on an individual basis.

14.7.8 Line insulation

Preferably halogen-free, self-extinguishing materials according to ZFB 889.
Smooth and even surface, without cracks, nodes, blisters, or other faults. The insulation diameter chosen must always correspond to the specs of the connector manufacturer regarding single-core insulation.

- Ømin. = 1.8 mm
- Ømax. = 2.1 mm

Wire insulation resistance:

- Min. R = 2 x 10^{10} Ω/m

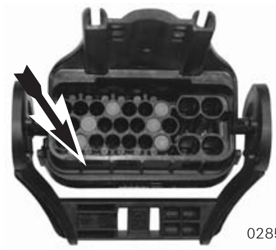
14.7.9 Plug connector

Both sides of a plug connection must always be fully compatible (protection system, contacts, etc.)

Plug-in frequency:
Min. 10 plug-in cycles for all connectors

Insulation resistance (connector):
Min. 100 MΩ, test voltage 500 V, between any two contact points or between contact point and metallic housing parts.

Water tightness of wiring and connectors:



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- Seal unused PINs in connector using welch plug (arrow).
- PINs must be sealed.

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If this is not observed, corrosion may occur in the connector and vehicle failure may be the result.

14.8 Wiring Running Instructions

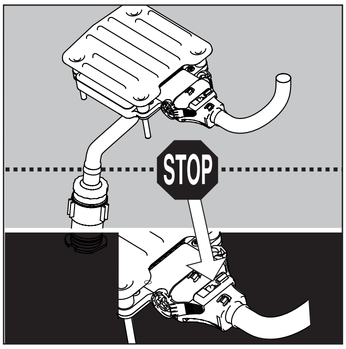
Wiring in the vehicle should be run so it:

a) is not damaged.

b) it is accessible at all times.

When routing and connecting the wires, the following points are to be observed in particular:

- The wires must be routed and fastened in a protected area in the vehicle. Wires must not be hanging loose.
- Damage to the wiring caused by relative movements must be ruled out. It is particularly important to keep a sufficiently large distance to moving parts (input shaft etc.).
- Wiring must be fastened in such a way as to prevent the wiring from being crimped or damaged.
- The wire on the 25-pin connector must be fastened to the transmission after approx. 10 cm using a suitable cable clip!



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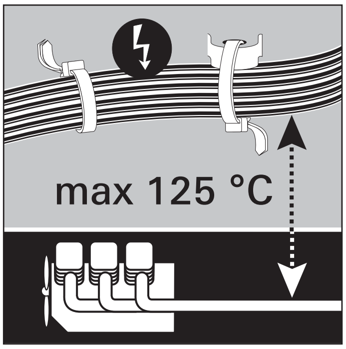
Mount the EcoLife ECU's connector correctly, i.e. locking shackle must have snapped into place.



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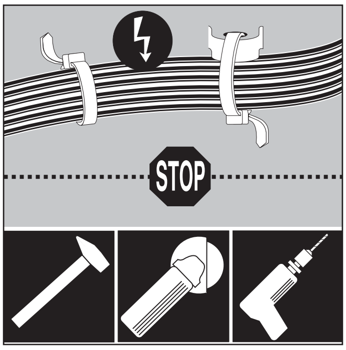
Install wiring harness at sufficient distance from the exhaust pipe.
The maximum permissible ambient temperature is 125 °C.



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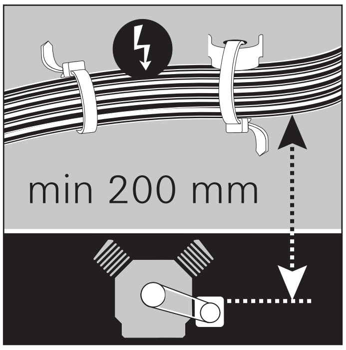
The wiring harness must not be damaged by boring, grinding, flying sparks during welding, or similar work.



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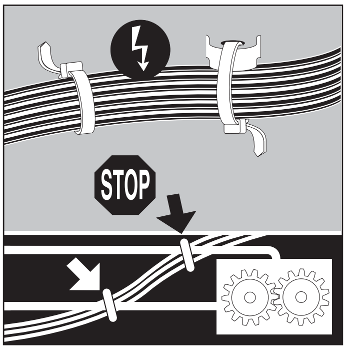
Minimum distance of the wiring harness to the alternator and to the starting motor must be 200 mm.



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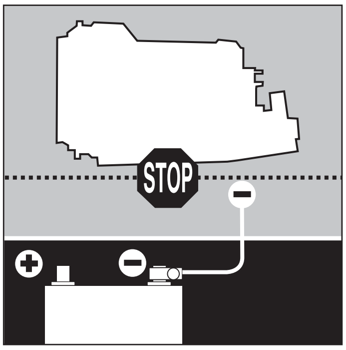
Do not fasten wiring harness to oil, water, or pressure hoses.



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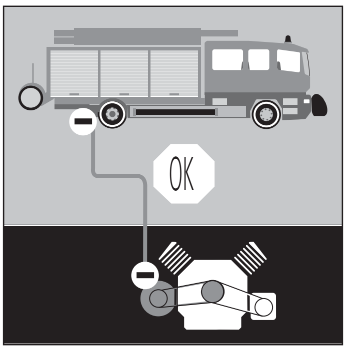
In principle, a ground cable on the transmission is not permitted. In exceptional cases, a ground cable is acceptable at the SAE 1 engine connecting bell if the electric connection between engine and transmission housing is perfect.



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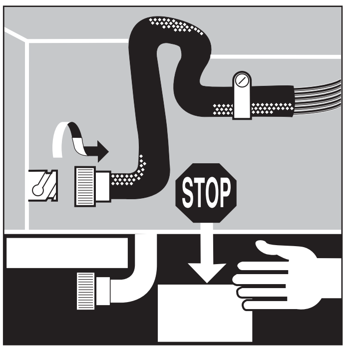
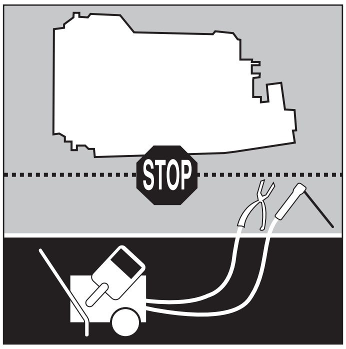
Negative pole of the electric starting motor must be connected via bonding jumper with the vehicle chassis.



006740

The plug-in connections must be removable for service purposes.



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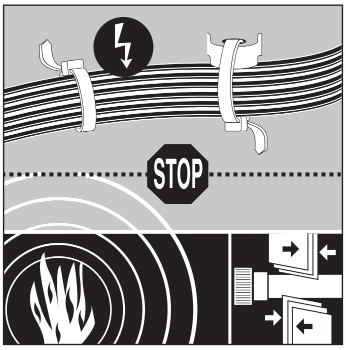
When doing electric repair work (welding), there must be no current flowing through the transmission.

005295

Do not place wiring directly next to high frequency lines.



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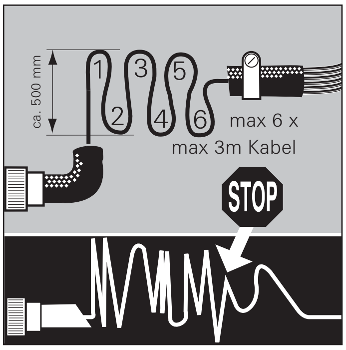
The wires must be routed in such a way as to protect them against influence of heat (possibly install heat shield) and against chafing.



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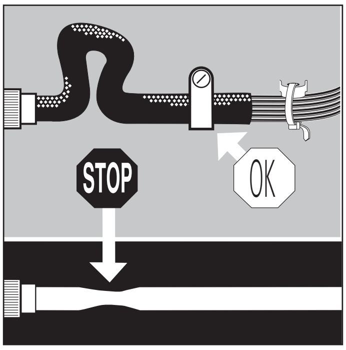
For length compensation, wires may be routed in loops.
For example:
Max. 3 m of wire length with 6 loops.



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Wiring must be routed in such a way as to absolutely prevent tensile load on the plug-in connections (particularly in the bending part of articulated buses).

005295

When routing wires, mind EMC compatibility.

- The following bending radii must be observed for routing in corrugated (metal) pipe (German abbreviation: WR):

Nominal width of WR (corrugated pipe)	Bending radius
Nominal width (NW) 10	r > 20 mm
Nominal width (NW) 13	r > 35 mm
Nominal width (NW) 17	r > 45 mm
Nominal width (NW) 22	r > 50 mm

The corrugated tube is to be routed in such as way that the connector is not subjected to any loads.

14.9 CAN Bus Installation

The OEM is responsible for CAN bus installation!
The vehicle-end connector on the EcoLife ECU allows to integrate the transmission into all known CAN bus topologies (linear CAN connection, non-linear CAN connection).
Practical experience has shown that the use of an unshielded twisted CAN wire (twisted pair) is sufficient for most applications.

Linear CAN connection
(no tap lines)

From today's point of view, an economically and technically (EMC aspects) good solution; the linear connection is relatively insensitive to faults, even with high transfer rates (500 kb).

The ZF transmission system supports this type of CAN connection. The CAN wires are looped through the control unit (2 connections each, for CAN_H and CAN_L respectively).

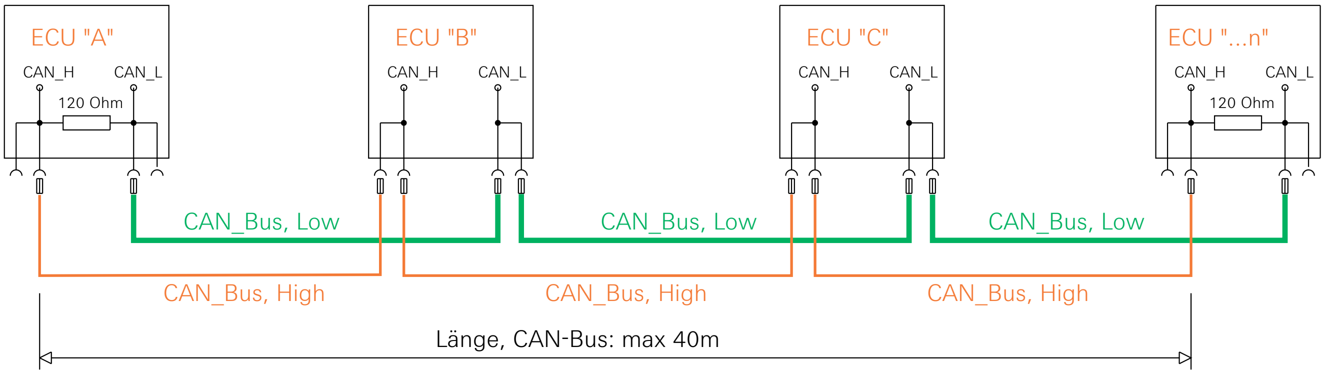
Non-linear CAN connection
(non-linear stub cable)

The non-linear connection is more sensitive to faults, but represents a simpler way of CAN networking. The result is a so-called stub cable, namely between the node point (point B) and the electronics (point A).

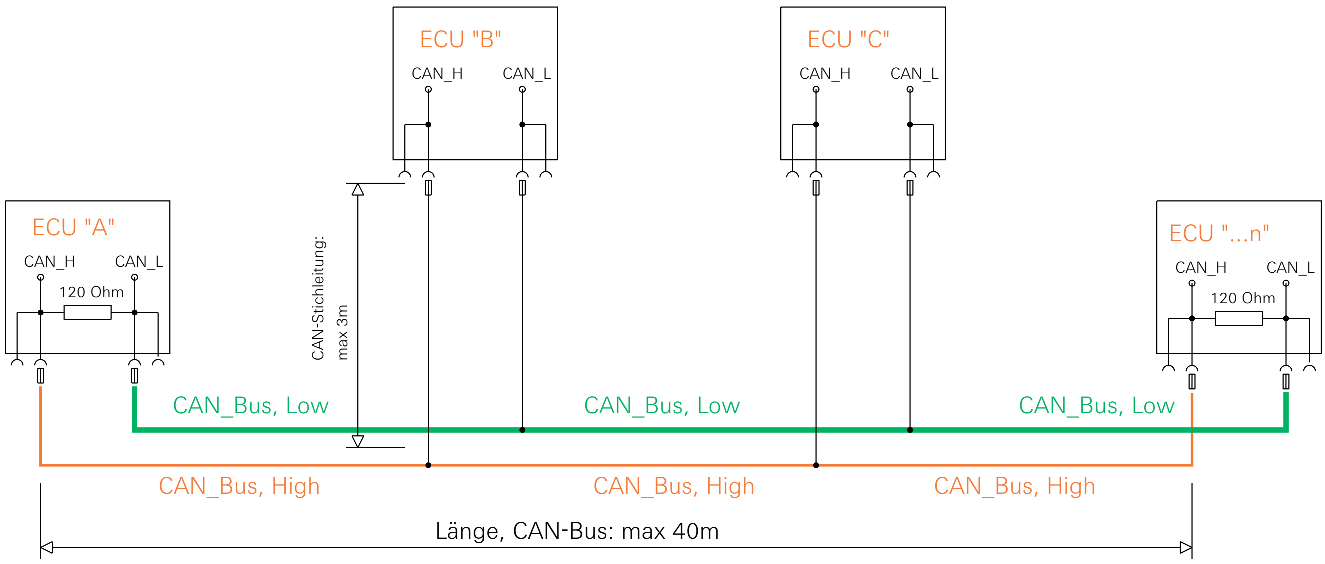
This stub cable must not exceed the maximum length defined in the standards SAE J 1939, ISO 11898).
In the case of deviations from the specified maximum lengths, communication faults can occur (e. g. when using terminal testers or intermediate wiring kits, etc.).

Line version
Line (wire) versions must also comply with the existing standards (SAE J 1939 and/or ISO/DIS 11898), which specify twisted or twisted + shielded.

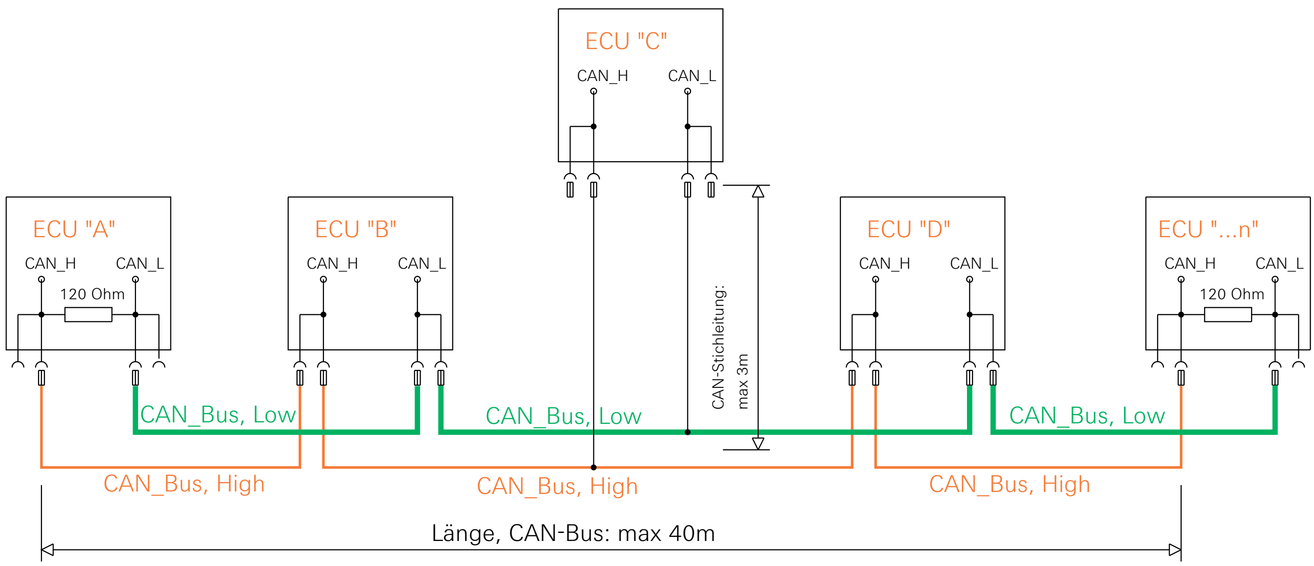
Lineare CAN-Anbindung



Nicht-Lineare CAN-Anbindung



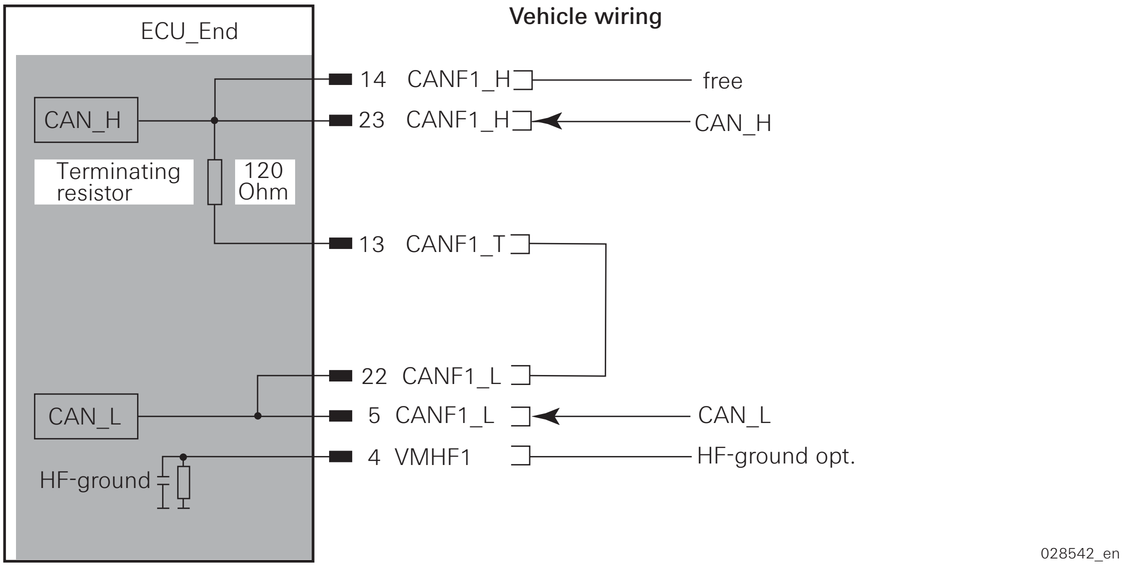
Lineare / Nichtlineare CAN-Anbindung



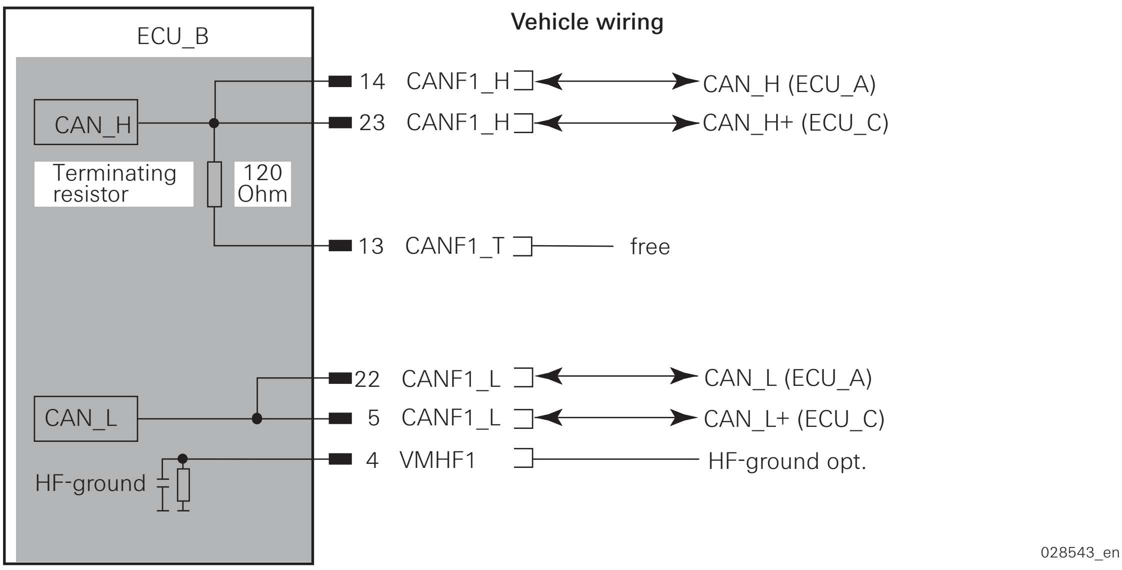
Terminating resistance
The transmission control unit has an integrated bus termination resistor which can be activated by the wiring on the electronics connector.
The electronics can therefore be used as CAN bus end user or as mid-user.

If the transmission electronics is designed as CAN bus end consumer, the power bridge must be fitted as closely as possible to the EcoLife ECU connector (bridge from PIN 22 to PIN 13).

If the transmission electronics are designed as CAN bus mid-user, this line bridge becomes obsolete.

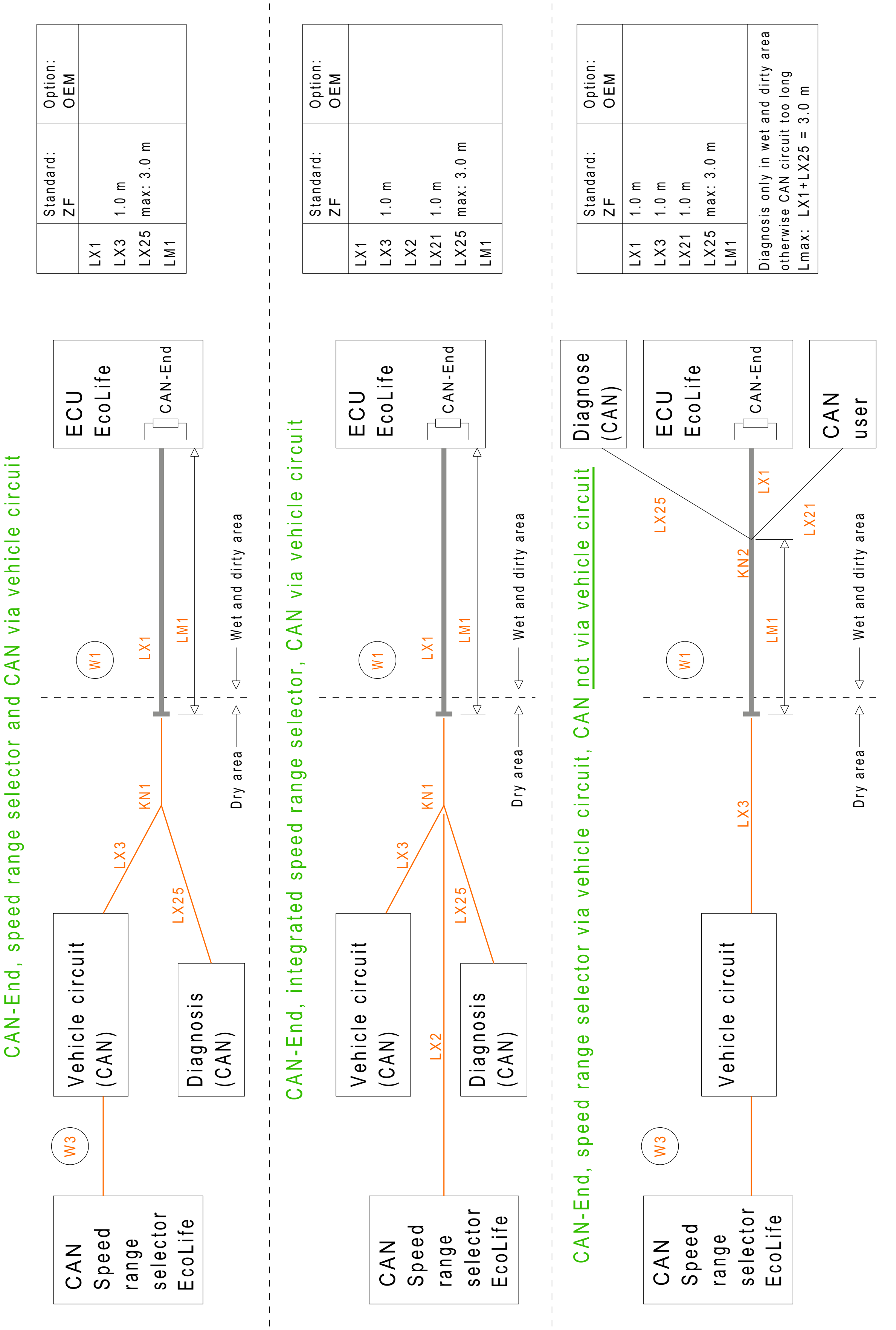


Transmission electronics as CAN bus end user



Transmission electronics as CAN bus mid-user

14.9.1 Wiring examples for CAN end users



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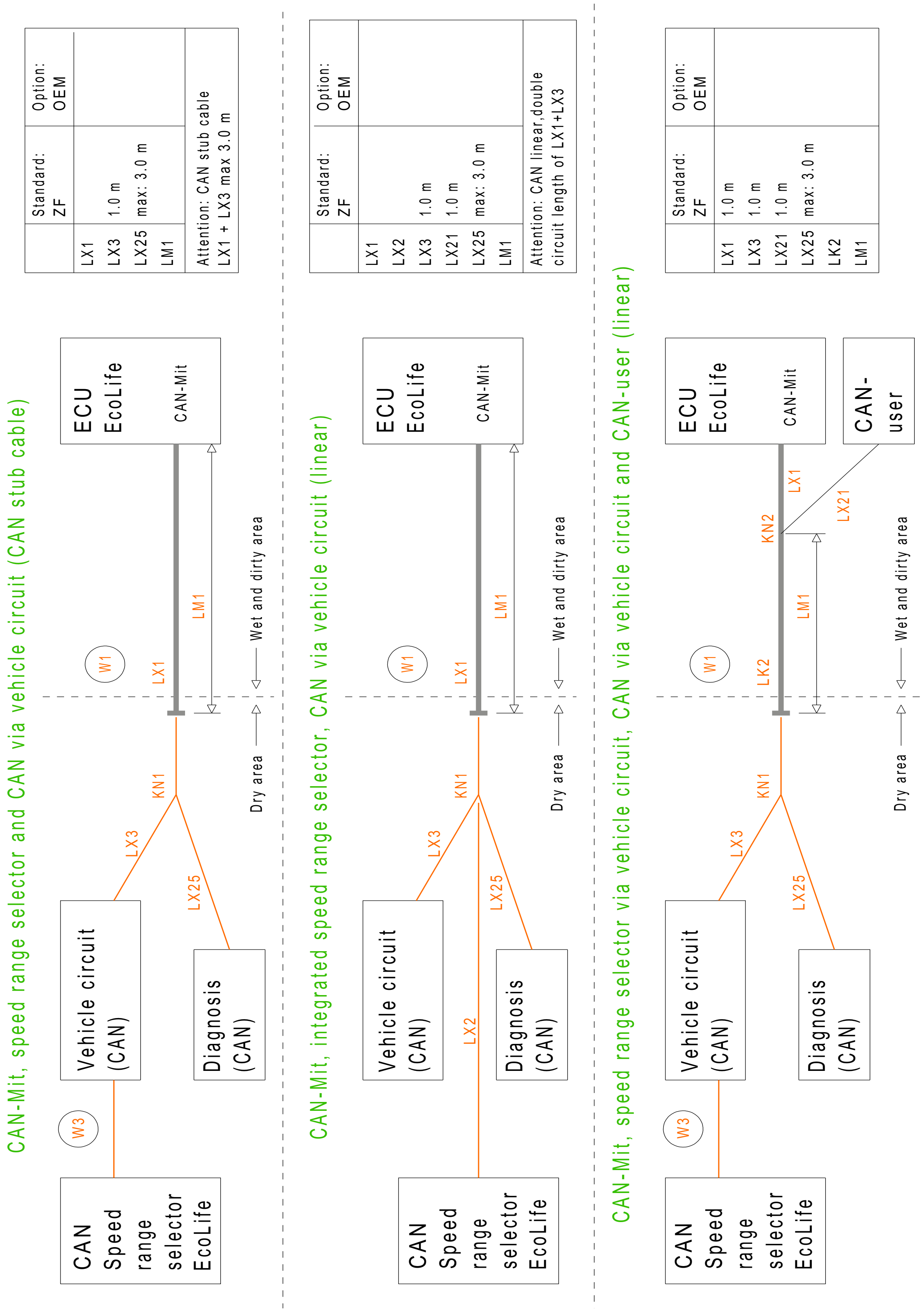
14.9.2 Wiring examples for CAN mid-users



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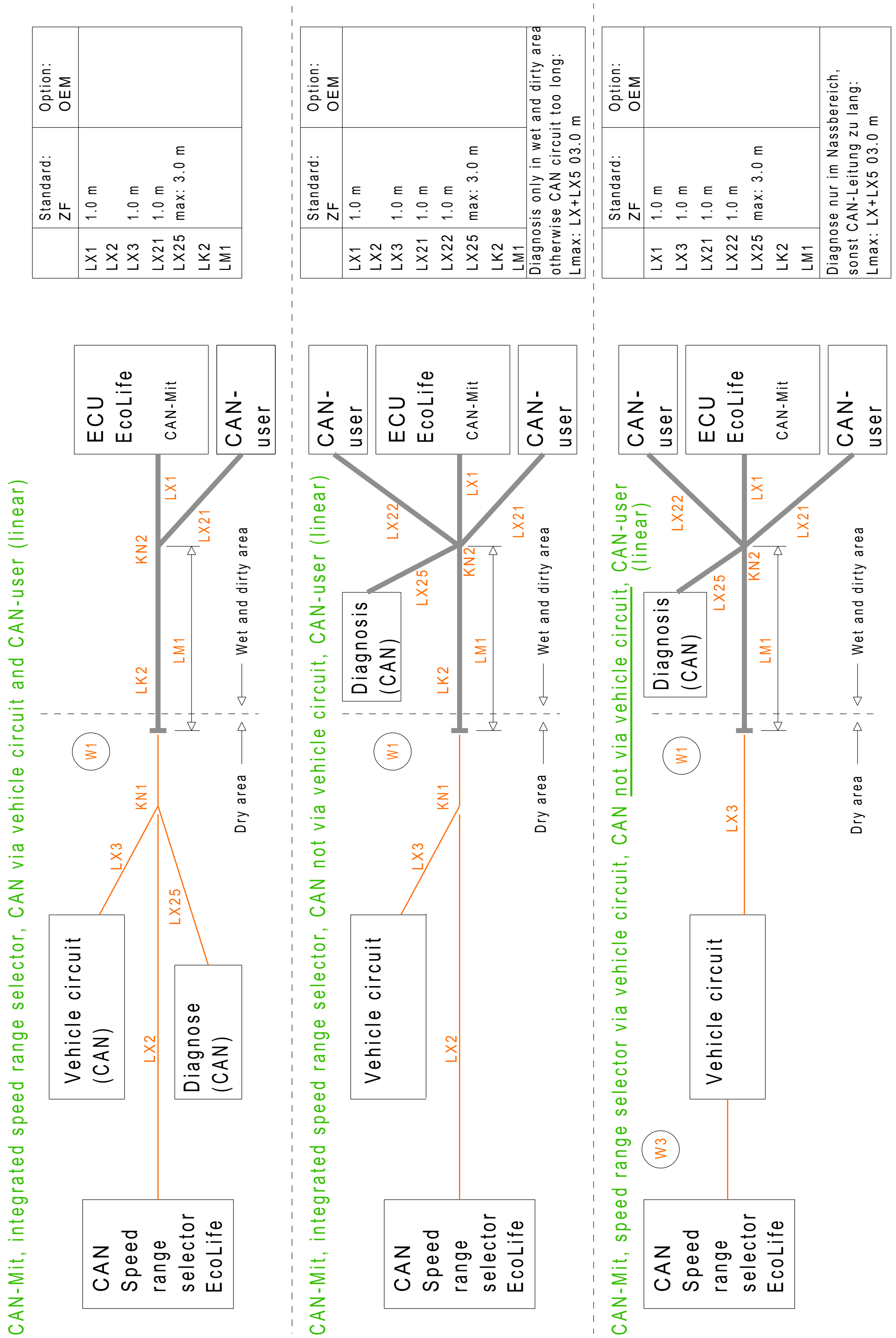
Wiring examples for CAN mid-users



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14.10 E-Module 2 6041 322 044 for digital output and digital input function (PIN description)

14.10.1 Description

The E-Module 2 has been designed to transmit peripheral signals to the transmission control unit via CAN.

The E Module 2 is used to enlarge the I/O scope of a transmission control unit. The module and transmission control unit communicate via a CAN interface. Up to four outputs can be controlled by the transmission control unit via the CAN interface. Consumers which are connected to one of the ground switching outputs can be deactivated by the central deactivation channel (two pins) in the event of an error/fault.

Another of the system's functions is to record up to 14 input signals which are then made available to the transmission control unit via CAN communication. These are e. g. speed range selector signals or program changeover switch signals.

14.10.2 Operating Conditions

Operating voltage:	12 V/24 V vehicle electrical system
Functional range:	9 V to 32 V
Permissible overvoltage:	36 V for 1 h
Permissible ambient temperature:	-40 to +85 °C
Permissible storage temperature:	-55 to +105 °C
Protection class:	IP20 when connected

EMC interference resistance:	Incoming interferences: 150 V/m according to 72/245/EEC in version 95/52/EC. Conducted interferences: according to ISO 7637, test pulses 1a to 5b, load dump together with ECU (172V-150ms-2O)
ESD resistance:	±8 kV on connector pins ±8 kV on housing
Vibration resistance:	5 g (10..2000 Hz)

14.10.3 Wiring Information

The CAN wires from E Module 2 to the transmission control unit must have twisted routing. See SAE J 1939-11, ISO-DIS 11898.

14.10.4 Type of Connector

15-pin connector:
Tyco AMP no. 8-968973-1 / ZF no.: 0501 319 837

Pin	Signal name	
1	ADVP	Digital output (high-side)
2	EDM1	Digital input to ground/protective earth 1 (low-side)
3	EDM2	Digital input to ground/protective earth 2 (low-side)
4	EDM3	Digital input to ground/protective earth 3 (low-side)
5	EDM4	Digital input to ground/protective earth 4 (low-side)
6	EDM5	Digital input to ground/protective earth 5 (low-side)
7	EDM6	Digital input to ground/protective earth 6 (low-side)
8	EDM7	Digital input to ground/protective earth 7 (low-side)
9	EDM8	Digital input to ground/protective earth 8 (low-side)
10	ED1	Digital input 1 (high-side)
11	ED2	Digital input 2 (high-side)
12	ED3	Digital input 3 (high-side)
13	ED4	Digital input 4 (high-side)
14	ED5	Digital input 5 (high-side)
15	VMG	Earth/Ground supply to sensor

18-pin connector:
Tyco AMP no. 8-968974-1 / ZF no.: 0501 319 838

Pin	Signal name	
1	EDVP	Digital input, positive supply, terminal 15
2	VPE	Plus supply, terminal 30
3	VPS1	Plus supply, switched
4	VPS2	Plus supply, switched
5	VPS3	Plus supply, switched
6	CANF1-H	CAN
7	CANF1-H+	CAN
8	CANF1-L	CAN
9	CANF1-L+	CAN
10	EU1	Voltage input (analog)
11	CANF1-T	CAN Full Terminating (activation of termination resistor)
12	VMHF1	Earth/Ground supply High frequency (CAN)
13	VMHF2	Earth/Ground supply High frequency (CAN)
14	ADM1	Digital output, ground/protective earth 1
15	ADM2	Digital output, ground/protective earth 2
16	ADM3	Digital output, ground/protective earth 3
17	VM1	Supply to ground/earth 1
18	VM2	Supply to ground/earth 2

14.10.5 Supply

The E Module 2 (VPE/EDVP) can be connected irrespectively of the transmission control unit’s current path.
The EDVP is designed as redundant supply path.

CAUTION
If the EDVP is not connected to terminal 15, but to the voltage supply output of a control unit, the output’s current carrying capacity must not be exceeded.

14.10.6 Digital Inputs

The module has 8 digital inputs, ground switching, and 5 digital inputs, positive switching (PNP). All inputs are short-circuit and overload-proof.

Switching threshold low to high	U >= +3.1 V
Switching threshold high to low	U = +9.0 V
Hysteresis	>1.0 V
Input resistance	<2.4 kΩ

Special attention should be paid to the following restrictions when using digital inputs. Depending on the ambient temperature, only a certain number of inputs can be permanently active at the same time (see table).

Temperature	Number of active inputs
<= 25 °C	13 Inputs
35 °C	11 Inputs
45 °C	9 Inputs
55 °C	8 Inputs
55 °C	7 Inputs
75 °C	5 Inputs
85 °C	4 Inputs

14.10.7 Analog input

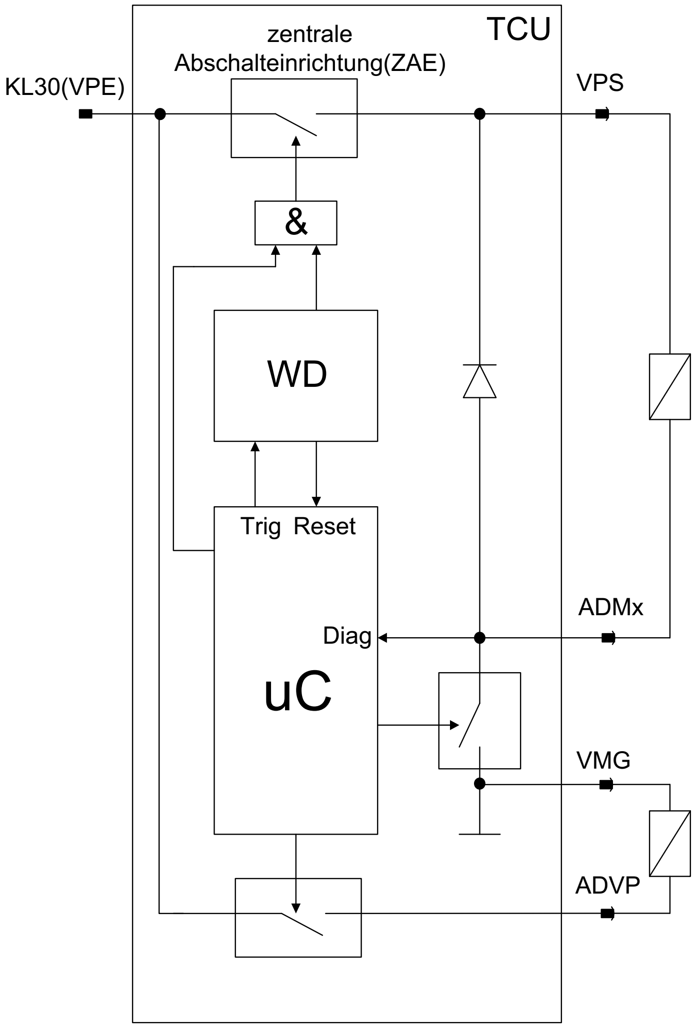
The module has one analog input, EU1. Terminal 15 is to be used as reference voltage and the E Module 2 (VM1, VM2, VMG) as reference potential.

Voltage range	0 - 36 V
Resolution	8 bit
Input resistance	>100 kΩ

14.10.8 Digital Outputs

In total, 4 digital outputs are integrated in the module. Three of these are low-side (ADM1 through ADM3) and one output is high-side (ADVP) switching. When using the low-side outputs, they must always be supplied by the central deactivation channel (VPS1 through VPS3). This switching allows for bipolar deactivation of the outputs in the event of an error. Loads which are operated via ADVP always have to be connected to the ground wire of the e-module (VMG). Bipolar deactivation of loads is not possible with the ADVP!

Max. output current	±1.5 A
Extinction of inductive loads	Integrated
Max. interrupt resistance	1 - 5KΩ
Maximum short circuit resistance:	1 W



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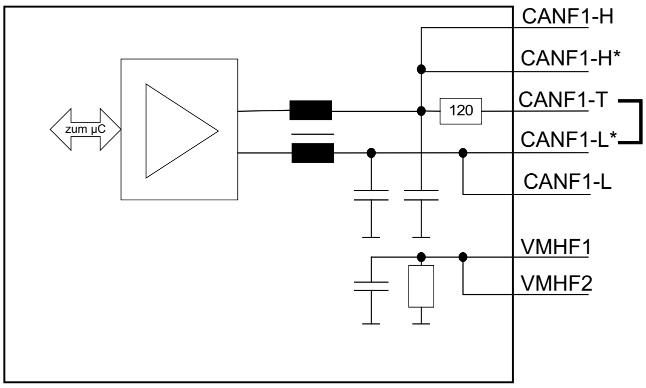
14.10.9 CAN Interface

CAN communication parameter

- Interface according to ISO 11898 High-Speed
- Transfer rate 250/500kBit/s
- Integrated 120 Ω termination resistor can be used through appropriate energization

The E Module 2 can be operated both at the system CAN and the ZF CAN. The following communication parameters can be parameterized:
- Sending ID/ Received ID
- Baud rate 250/500 kBit/s
- Bus OFF behavior
- Cycle time of 'Sending ID' /'Received ID'

Connector energization when using termination resistor



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14.10.10 Description of Function

When the system is started, the E Module 2 performs self-test. After correct start-up of the module, all inputs are cyclically read in and transferred to the transmission control unit. Connected loads at the outputs are switched depending on the transmission control unit requirements and are checked continuously for short circuit and line disconnection.

In the event of terminal 30 drop-out or error at the ADMs, E Module 2 responds immediately by bipolar deactivation. Both the central deactivation channel (ZAE) and the faulty ADM are deactivated. Reactivating is possible only by a signal of the transmission control unit.
Depending on the application, the ADVP is deactivated or not in the event of terminal 30 drop-out.

In case of an error at the ADVP, the supply voltage output is deactivated and the error is reported to the transmission control unit which must then deactivate control.

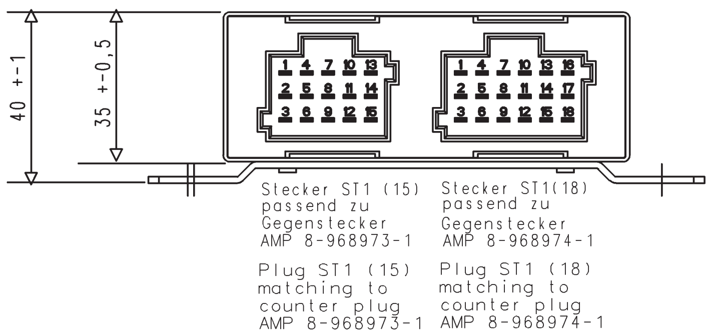
In case of an error at the ADVP, the loads ADM1 through ADM3 and ZAE are not deactivated.

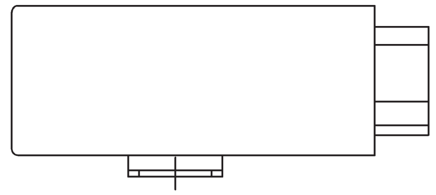
This means that no loads which have safety-relevant functions must be connected to the ADVP. This output is mainly used as switchable voltage supply for external components, such as e. g. a rotary switch.

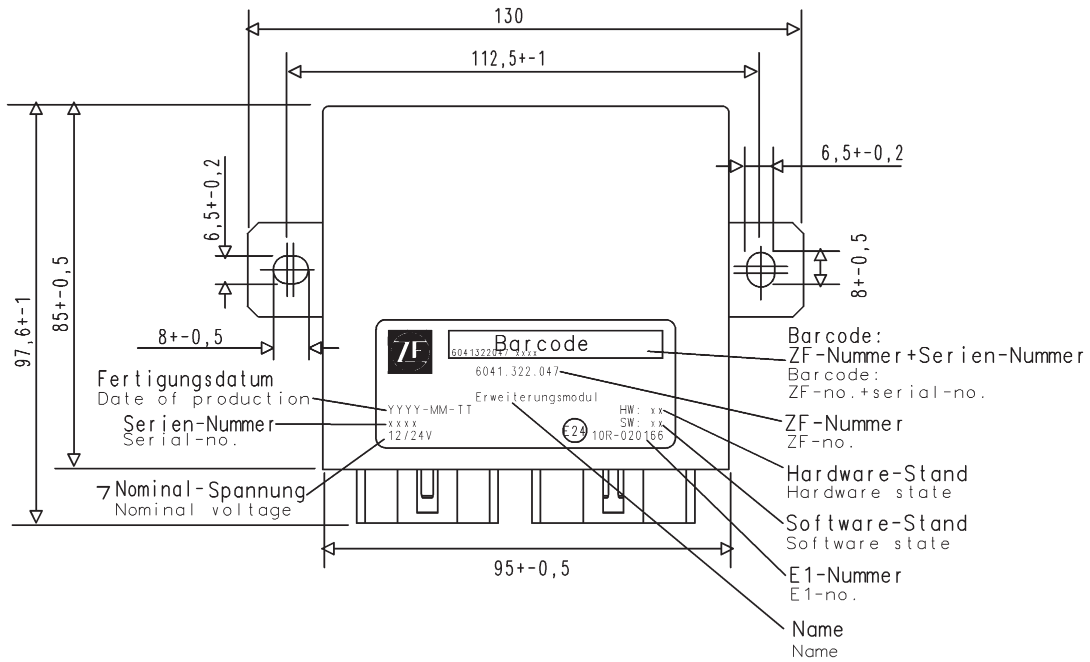
14.10.11 Installation Drawing of E-Module 2 6041 322 044

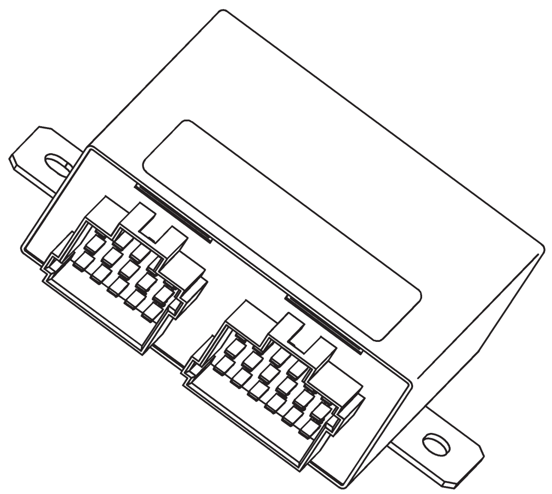
From drawing no.: 6041 622 026b

NOTE: For current e1 number, see order drawing









Material

Gehaeuse	PA6.6GF30 schwarz
Blende	PA6.6GFK30 schwarz
Stecker ST1(18)(2.8x0.8)	Cu Sn 6 bleifrei verzinnt
Stecker ST1(15)(2.8x0.8)	Cu Sn 6 bleifrei verzinnt
Halter	St 12 blau verzinkt

Housing	PA6.6GF30 black
Cover	PA6.GFK30 black
Plug ST1(18)(2.8x0.8)	CuSn6 unleaded tin coated
Plug ST1(15)(2.8x0.8)	CuSn6 unleaded tin coated
Bracket	St12 blue zinc coated

Technische Daten

Nennspannung	12/24V
Betriebsspannung	9V....32V
Betriebstemperatur	-40....+85°C
Ruhestrom	<1mA
Schutzklasse	IP20
ZF Spezifikation	Nr. 6041 722 041

Technical data

Nominal voltage	12/24V
Operating voltage	9V....32V
Operating temperature	-40....+85°C
Stall current	<1mA
Protection class	IP20
ZF Specification No.	6041 722 041

ZF SACH-NR./ ZF PART-NO.	Benennung / Description
6041 322 044	Fahrschaltermodul / Shift Lever Module

15 AIS - Automatic Idle Shift

15.1 Description 15-3

15.2 AIS during travel 15-3

15.3 AIS at standstill 15-3

15 AIS - Automatic Idle Shift

15.1 Description

The AIS transmission function was developed to reduce fuel consumption in stop-and-go traffic and/or stopping at bus stops, traffic lights, etc. With an active AIS during travel, braking against the torque converter is prevented. If a vehicle is being stopped and the stop request is clear (service brake is active), the system changes to AIS while the vehicle is still moving, i.e. the driveline is opened.

15.2 AIS during travel

The following conditions have to be met:

- Accelerator pedal in idle position
- Service brake activated by the driver

15.3 AIS at standstill

The following conditions have to be met:

- Accelerator pedal in idle position
- One brake is active
- Vehicle standstill is detected
- 1st forward gear detected

Once all of these conditions are met, the system changes automatically to AIS after some delay time. Delay time can be set according to the application.

If one of the AIS conditions is not met, a gear will be engaged again.

NOTE
The AIS function is quit in the event of speed increases (e.g. due to air conditioning systems). Speed increase is permissible only when the speed range selector is in neutral position.

⚠ **DANGER**
The pneumatic pressure in the braking system must be set in such a way as to make sure that the vehicle is safely decelerated on uphill or downhill gradients.
It is essential to advise the driver and vehicle manufacturer of correct vehicle operation on uphill and downhill gradients.
Rolling back on uphill gradients must be prevented as usual by using the parking brake or the bus stop brake.
Starting: Carefully accelerate, transmission closes, release brake.
If the AIS and the door-closing mechanism are coupled, it must be ensured that the vehicle can never start moving in an uncontrolled manner.
Releasing the bus stop brake may be made possible by the driver's "active" intervention only, e.g. by accelerating or manually releasing the brake

16 TopoDyn Life

16.1 Intelligent shift strategy: TopoDyn Life 16-3

16 TopoDyn Life

16.1 Intelligent shift strategy: TopoDyn Life

TopoDyn Life is the designation of a flexible shift program, adjusted to the terrain pattern, with a speed range covering everything from Eco via Normal to Power.
Latest information on the road gradient (uphill or downhill angle) is an important decision element for controlling the transmission's shift points.
Based on vehicle and transmission parameters and by analyzing the latest acceleration and active torque values, the electronic control unit constantly calculates the road resistance.
The impact of a laden versus an empty vehicle is also considered.

Advance traction calculation prevents gear hunting on long uphill grades.

In **EcoLife** transmissions, the optimum shifting speed is adjusted to the topography in a **dynamic** and continuously variable manner:

- Consumption-oriented, whenever possible
- Performance-oriented, only as long as necessary

Also on downhill gradients, the shift points are controlled in a continuously variable manner by the shift point function.
During downhill travel with active retarder, raised downshift points are selected; thus, maximum retarder and engine brake torques are made available.

Advantages:

- Optimization of fuel consumption
- Increase in driving comfort on uphill gradients
- Stability of shift program compared to gear hunting
- Increased retarder performance and thus preservation of service brake
- Noise reduction thanks to economically optimized drive program

TopoDyn Life, the intelligent shift strategy, relies on tried and tested shifting software without using sensors or GPS route information.

NOTE
For order number of “TopoDyn Life” video
Refer to Chapter 4.9 Document overview

17 ZF Diagnosis

17.1 ZF-Testman diagnosis system 17-3
17.1.1 Range of functions 17-3
17.1.2 System requirements 17-3
17.1.3 Scope of supply 17-4
17.1.4 Accessories, optional 17-4

17.2 Information on user interface 17-4

17.3 Safety instructions 17-4

17.4 Sections of the user interface 17-5

17.5 Contents 17-6

17 ZF Diagnosis

17.1 ZF-TESTMAN DIAGNOSIS SYSTEM

The new generation of PC diagnosis software.

Testman, the ZF diagnosis system, can be used for all diagnosable ZF vehicle systems, such as e.g. Intarder, AS Tronic, Ecomat, **EcoLife**; ECCOM construction machinery transmissions, T7000 tractor transmissions, steering systems, etc.

All necessary transmission-specific data required for rapid and comprehensive diagnosis can be retrieved using the ZF-Testman diagnosis system. Data are supplied on CD and saved on the hard disk using an installation routine.

Targeted troubleshooting allows staff trained by ZF to rapidly find the error in the transmission system. After identifying the error, the diagnosis system will propose remedial measures.

Communication between the transmission electronics and the interface adapter (DPA 05) is performed via CAN. Communication between interface adapter and PC is performed via USB, serial line, or online using mobile telephony. Each screen page can be printed out or saved for error documentation. The diagnosis software is available in several different languages.

17.1.1 Range of functions

Statistics Data
All statistical data which are saved in the control unit are displayed on screen.

Diagnosis
Current fault display; read error memory; delete error memory; read identification data

Monitoring
Test device (displays all digital inputs and outputs); display of digital and analog parameters, e.g. speeds, amperage, and voltage levels.

Repair aid
Tightening torques; settings; special tools; test equipment.
Maintenance; repairs.
Pressures, circuit diagrams, electrical measuring values.
As a PDF file.

ZF phone directory
Phone directory of all ZF service centers.

Vehicle configuration
This is where all vehicle-specific data can be set for each product and drive programs can be selected and adapted, respectively.

Programming (flashing)
Available programming files can be installed.

17.1.2 System requirements

- Operating system Windows 2000 SP4, XP SP2, Vista (32Bit), Windows 7 (32Bit)
- Internet Explorer 5.01 or new
- Windows Installer 3.0 or new
- MDAC 2.8 Sp1
- Processor min. 1 GHz
- RAM min. 512 MB
- Free hard disk capacity, min. 1GB
- Screen resolution min. 800x600 pixels
- High color
- CD-ROM drive
- RS232 interface COM1 to COM4 or USB interface
- Modem connection (if telemetry is used)
- Internet connection for software updates and synchronization (only with support contract)

17.1.3 Scope of supply

1 T adapter 9-/6-/3-pins
2 ZF diagnosis adapter DPA 05
3 USB cable
4 CAN universal cable
5 RS232 cable
6 ZF-Testman diagnostic software on CD (without PC)

17.1.4 Accessories, optional

Additional accessories required in line with the respective vehicle installation:

- Diagnosis at the ZF speed range selector: Cable 6008 207 043
- Diagnosis at the control unit: Adapter 6008 206 042

Contact for detailed information: testmanpro@zf.com

17.2 Information on user interface

The TESTMAN diagnosis tool can be operated by keyboard and mouse.
Thus, a comfortable working environment is ensured at all times, be it in the workshop or in the vehicle (depending on the application).

In the following, you will find a brief description of the user interface and operating instructions for mouse and keyboard.
Please refer to 17.5 for an overview of keyboard shortcuts.

NOTE
Starting the diagnostic tool may take up to 30 seconds.

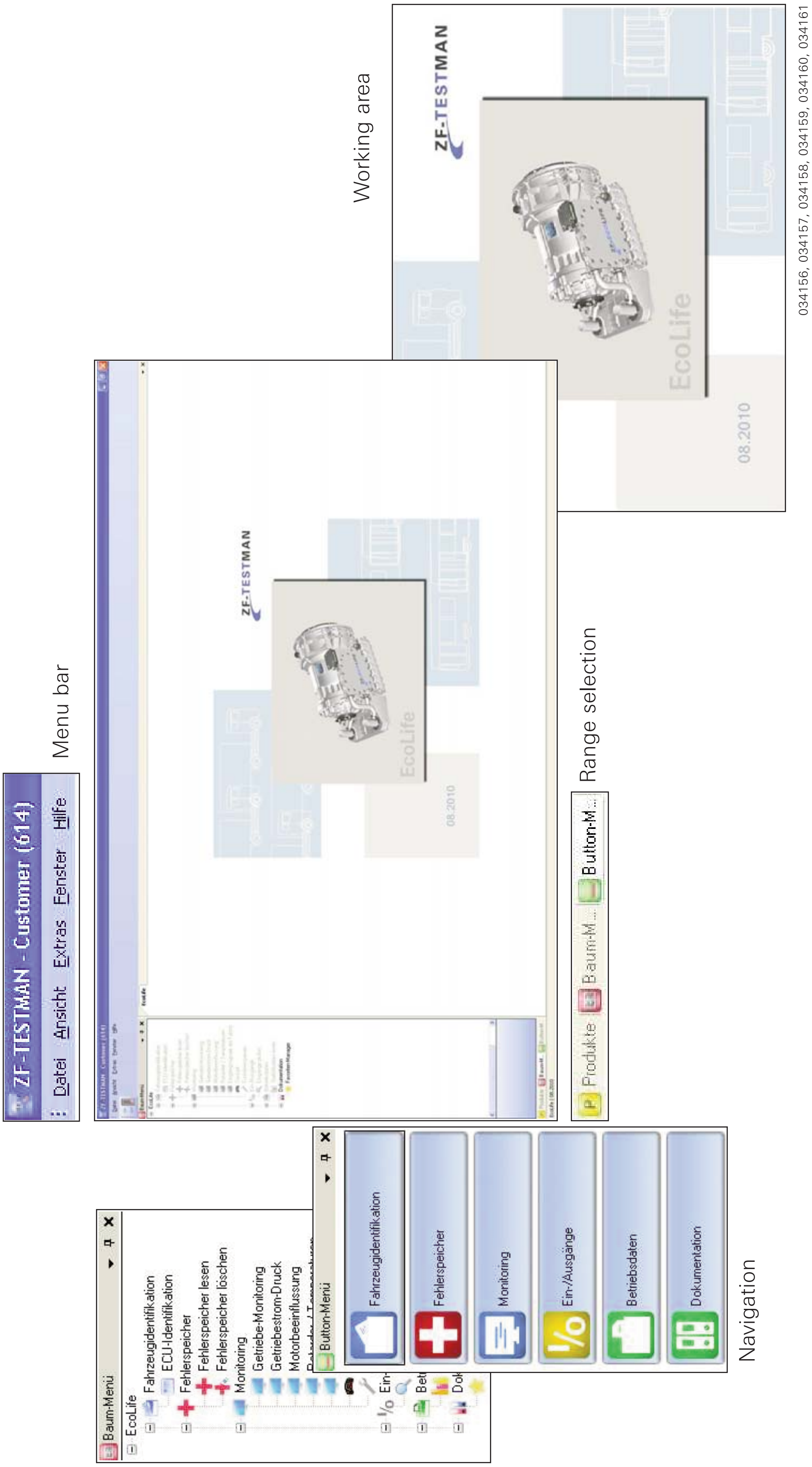
17.3 Safety instructions

As a rule, mechanics repairing ZF units are responsible for their own work safety.
To avoid injury to personnel and damage to products, all safety regulations and legal requirements which apply to repair and maintenance work must be adhered to.

Repairers must familiarize themselves with these regulations before they start working.

Personnel required to carry out repairs on ZF products must receive appropriate training in advance. It is the responsibility of each mechanic to seek proper training.

17.4 Sections of the user interface



17.5 Contents

Identification data of TCU

- Read fault memory
- Clear error memory

Display of
vehicle variables

Datalogger
Record measurements

Test of digital
inputs and outputs

Vehicle configuration
Content depends on
application

- EOL programming
- Save EEPROM
- Save flash

Operating data/
statistics memory

Additional documentation
depends upon application

- Test bench acceptance run
- System check
- Main pressure calibration
- Torque converter lock-up clutch check
- Retarder check
- Main pressure check
- Temperatures

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18 Transmission Storage, Oil-Related Topics

18.1 Transmission storage . . . 18-3

18.2 Oil grade, according to List of Lubricants TE-ML 20 . . . 18-3

18.3 Purity of the agent . . . 18-3

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18 Transmission Storage, Oil-Related Topics

18.1 Transmission storage

The transmissions may be stored at temperatures between 40 °C and 80 °C. Standard corrosion protection is effective for 6 months.

18.2 Oil grade, according to List of Lubricants TE-ML 20

- The specifications contained in the ZF List of Lubricants TE-ML 20 are binding

The latest List of Lubricants can be obtained from all ZF Sales & Service Centers or downloaded from the Internet under: www.zf.com (Product & Services / Services / Technical Information / Lists of Lubricants).

NOTE
The maximum permissible oil sump temperature is specified together with the vehicle manufacturer (e.g. 100 °C, 105 °C, or 110 °C).
The upper limit for the specification is at 120 °C. This predefinition is crucial for the allocation of the respective vehicle application to the classification according to the List of Lubricants TE-ML 20 (e.g. TE-ML 20.100, TE-ML 20.105, or TE-ML 20.110). This means that approved oil grades according to lubricant class 20E or 20F as well as oil and pressure filter change intervals are clearly defined. These data are to be copied into the vehicle manual.

18.3 Purity of the agent

NOTE
The oil must not contain any visible solid impurities.

18.4 Oil filter

Only genuine ZF oil filters may be used.

18.5 Oil quantity

- For oil change (draining time approx. 10 min.) approx. 24 liters
- For the initial fill of the transmission, not filled with oil

6 AP 1000 B / 1200 B / 1400 B	approx. 38 liters
6 AP 1700 B / 2000 B	approx. 42 liters
6 AP 1203 B / 1403 B	approx. 40 liters

NOTE
These values are reference values! The oil quantity after the oil level check at operating temperature (90 °C) is definitive.

18.6 Oil level check

CAUTION
It is absolutely necessary to maintain the correct oil level!

- **Insufficient oil quantities lead to malfunctions and damage of the transmission.**
- **Excessive oil quantities lead to overheating of the transmission.**

⚠ **DANGER**
Insufficient oil quantities lead to partial or complete failure of the retarder, i.e. results in reduced braking effect or no braking effect at all.

The following general rules apply:

- Transmission delivered with status 'not oil-filled' must be filled with the specified oil volumes prior to initial operation.
- In order to ensure minimum oil volumes for initial operation, an initial check is to be conducted with cold transmission oil, refer to Chapter 18.6.1.
- The relevant oil level check is to be conducted at operating temperature (90 °C), also refer to Chapter 18.6.2.
- For further options to heat up the transmission oil, refer to Chapter 18.6.3.
- Oil level check at least quarterly
- Conduct regular visual inspections of the transmission for signs of leakage.

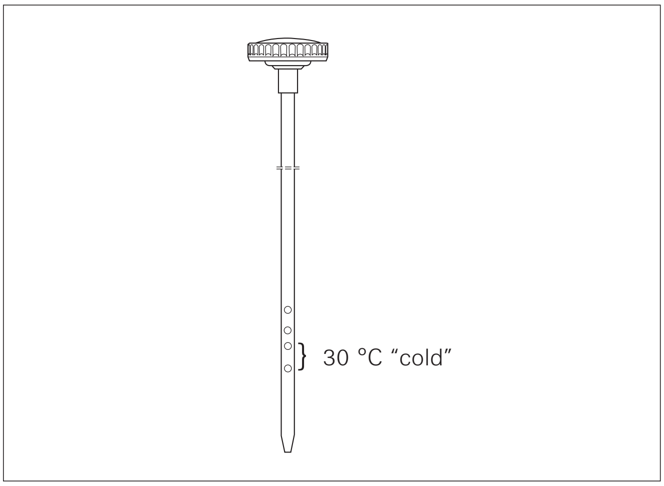
18.6.1 Initial check after engine start in order to ensure minimum oil quantities for initial operation

Oil level check with cold transmission oil (30 °C):

- Vehicle must be parked on level ground.
- Shift speed range selector (pushbutton range selector) to "Neutral"
- Let engine run at 1 200 - 1 500 rpm for 15 to 20 seconds.
- Let engine run at idling speed.

CAUTION
The idling speed should be set to 500 up to 700 rpm. It must not, under any circumstances, drop below 400 rpm.

- Oil level must be within **"30 °C (cold)" range**



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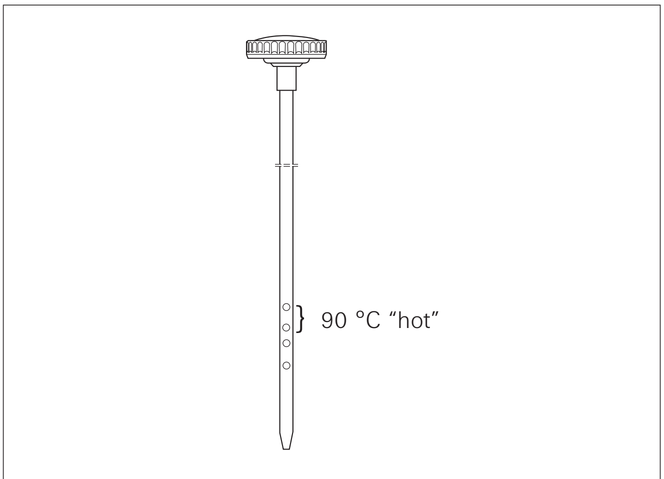
18.6.2 Relevant oil level check at operating temperature

Oil level check when transmission oil is hot (90 °C):

- Vehicle must be parked on level ground.
- Shift speed range selector (pushbutton range selector) to "Neutral"
- Let engine run at 1200 - 1500 rpm for 15 to 20 seconds.
- Let engine run at idling speed.

CAUTION
The idle speed should be set to 500 - 700 rpm^{-1}. It must never fall below 400 rpm^{1}.

- Oil level must be within **"90 °C (hot)"** range.



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18.6.3 Option for heating up transmission oil

The transmission oil can be heated up to the specified operating temperature for oil level check purposes by normal driving operation with retarder cycles until the oil sump temperature reaches 90 °C.

CAUTION
Max. permissible oil temperature in oil sump is 120 °C and must not be exceeded.

When the operating temperature is reached **carry out "Check at operating temperature 90 °C"** (Chapter 18.6.2).

18.7 Oil change intervals

- The specifications contained in the **ZF List of Lubricants TE-ML 20 are binding.**

CAUTION
The pressure filter must be renewed each time the oil is changed - refer to Chapter 18.4.

18.8 Oil drain

NOTE
Drain only at operating state temperature and at least for 10 minutes:

- Engine standstill
- Unscrew oil drain plug **(1)** and drain oil
- Unscrew oil drain plug **(2)** on filter cover **(3)** and drain oil from filter compartment
- Unscrew filter cover **(3)**
- Replace filter cartridge (pressure filter) and O-ring on filter cover and on oil drain plug

NOTE
Pressure filter must be replaced when oil is changed.

ZF angle drive 80° RHD
The angle drive does not have its own oil drain plug. Drain oil through main transmission's oil drain plug as described in Chapter 18.8.

18.9 Oil fill

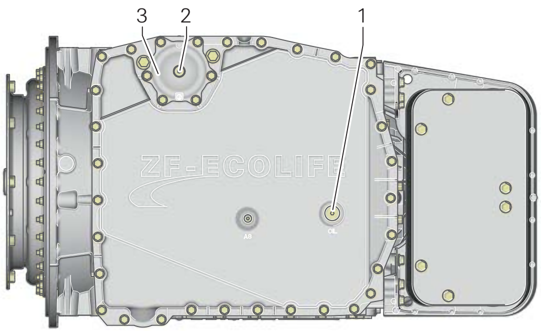
- Screw filter cover **(3)**, tightening torque: **29 Nm**

  NOTE
  Be aware of different screw lengths.
- Screw screw plug **(2)** into filter cover **(3)**. Tightening torque: **25 Nm**
- Screw in oil drain plug **(1)**: Tightening torque: **35 Nm**

CAUTION
Always use genuine ZF oil drain plugs. The torque converter drain valve is operated by oil drain plug.

- Fill in oil at oil filler pipe according to Chapter 18.5 **(4)**.
- Check oil level at oil dipstick **(5)**; refer to Chapter 18.6.
- Oil grade, refer to Chapter 18.2.

Coaxial transmission



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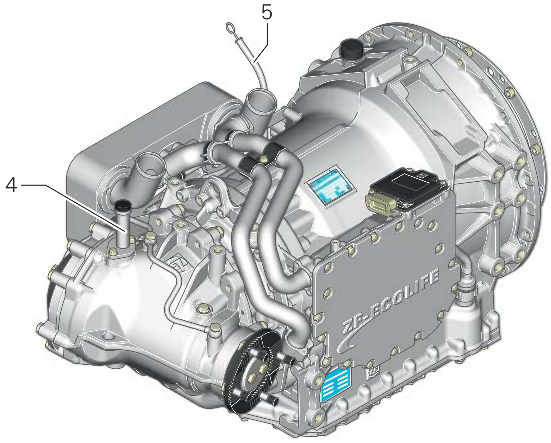
Transmissions with angle drive of 80°, RHD



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19 Formulary and Conversion Tables

19.1 Driveline design

The driveline can be designed with the following formulas for performance calculation.

The hill-climbing performance in 1st mechanical gear is to be one criterion, as the torque converter is used as roll control (starting traction control) only. The reference value is S > 15 %.
If the topography conditions are unfavorable, the value S is to be specified higher.

Calculation formula:

Road speed v_F

$$v_F\,[km/h] = \frac{0.377 \cdot r_{dyn}\,[m] \cdot n_T\,[rpm]}{i_G \cdot i_H}$$

$$v_F\,[mph] = \frac{0.0714 \cdot r_{dyn}\,[ft] \cdot n_T\,[rpm]}{i_G \cdot i_H}$$

Max. hill climbing performance S_{max} [%] in mechanical gears (in hydraulic gear, torque conversion μ recorded)
(air resistance $W_L \approx 0$ at < 30 km/h)

$$S_{max} = 100 \cdot \tan\left[\arc\sin\left(\frac{T_T\,[lbft] \cdot i_G \cdot i_H \cdot \eta_{tot}}{G\,[lbf] \cdot r_{dyn}\,[ft]} - f_R\right)\right]$$

Hill-climbing performance S [%] at higher speed v_F in mechanical gears
For uphill gradients S ≤ 10% is sin α ≈ tan α; error ≤ 0.5 % (for conversion to angular degrees)

$$S = 100\left[\frac{1}{m\,[kg] \cdot 9.81} \cdot \left(\frac{T_T\,[Nm] \cdot i_G \cdot i_H \cdot \eta_{tot}}{r_{dyn}\,[m]} - 0.0473 \cdot C_W \cdot A \cdot V_F^2\,[(km/h)^2]\right) - f_R\right]$$

S = 45 ° ≙ 100%

$$S = 100\left[\frac{T_T\,[lbft] \cdot i_G \cdot i_H \cdot \eta_{tot}}{G\,[lbf] \cdot r_{dyn}\,[ft]} - \frac{0{,}002529 \cdot C_W \cdot A\,[ft^2] \cdot V_F^2\,[(mph)^2]}{G\,[lbf]} - f_R\right]$$

r_{dyn} [m], [ft]	Rolling radius	
m [kg]	Vehicle weight	
G [lbf]	Vehicle weight	
9.81 [m/s^2]	Gravitational acceleration	
n_T [rpm]	Turbine wheel speed	
T_T [Nm], [lbft]	Turbine wheel torque	
i_G [–]	Transmission ratio	
i_H [–]	Axle ratio	
η_{tot} [–]	Overall efficiency	$\eta_{tot} = \eta_G \cdot \eta_H \approx 0.9$
f_R [–]	Rolling resistance (commercial vehicle tires) Asphalt, concrete,	f_R = 0,007 – 0,010
C_W [–]	Drag coefficient	Bus $C_W \approx 0.55$ Truck $C_W \approx 0.8$
A [m^2], [ft^2]	Frontal area	Bus A ≈ 6 m^2 Truck A ≈ 8 m^2
V_F [km/h], [mph]	Road speed	

Performance calculations can be made at ZF upon request.

19.2 Example for calculation of braking performance

1. Braking performance P_{Br} on downhill gradient S [%]

$$P_{Br}\,[kW] = \frac{G\,[kg] \cdot 9{,}81\,[m/s^2] \cdot v\,[km/h]}{3600}\,[\sin(\arctan \frac{S\,[\%]}{100}) - f_R]$$

2. Engine speed $n_{Mot} = n_{Ret}$ (applies only when torque converter lock-up clutch is closed)

$$n_{Ret}\,[rpm] = n_{Mot}\,[rpm] = \frac{v\,[km/h] \cdot i_G \cdot i_H}{0{,}377 \cdot r_{dyn}\,[m]}$$

3. Retarder performance P_{Ret} for n_{Ret}

$$P_{Ret}\,[kW] = \frac{T_{Ret}\,[Nm] \cdot n_{Ret}\,[rpm]}{9550}$$

Sample calculation

Braking performance of city bus with EcoLife 6 AP 1200 B and retarder

Data: G = 18000 kg; f_R = 0.01; v = 30 km/h; S = 7 %

$$\text{Braking performance } P_{Br} = \frac{18000 \cdot 9.81 \cdot 30}{3600}\,[\sin(\arctan \frac{7}{100}) - 0{,}01]$$

Braking performance P_{Br} = 88 kW = 120 PS

Calculation of engine or retarder speed at v = 30 km/h with 2nd gear engaged
(only if torque converter lock-up clutch is closed, the following applies $n_{Mot} = n_{Ret}$); tires 275/70 R 22,5;
r_{dyn} = 0.466 m; axle ratio i_H = 5.27

$$n_{Ret}\,[rpm] = n_{Mot}\,[rpm] = \frac{30 \cdot 1.909 \cdot 5.27}{0.377 \cdot 0.466} = 1718\,[rpm]$$

Braking performance S_{Br} [%] with max. permissible braking torque T_{Br} = 1400 Nm with 2nd gear engaged (6 AP 1200 B) at v = 30 km/h

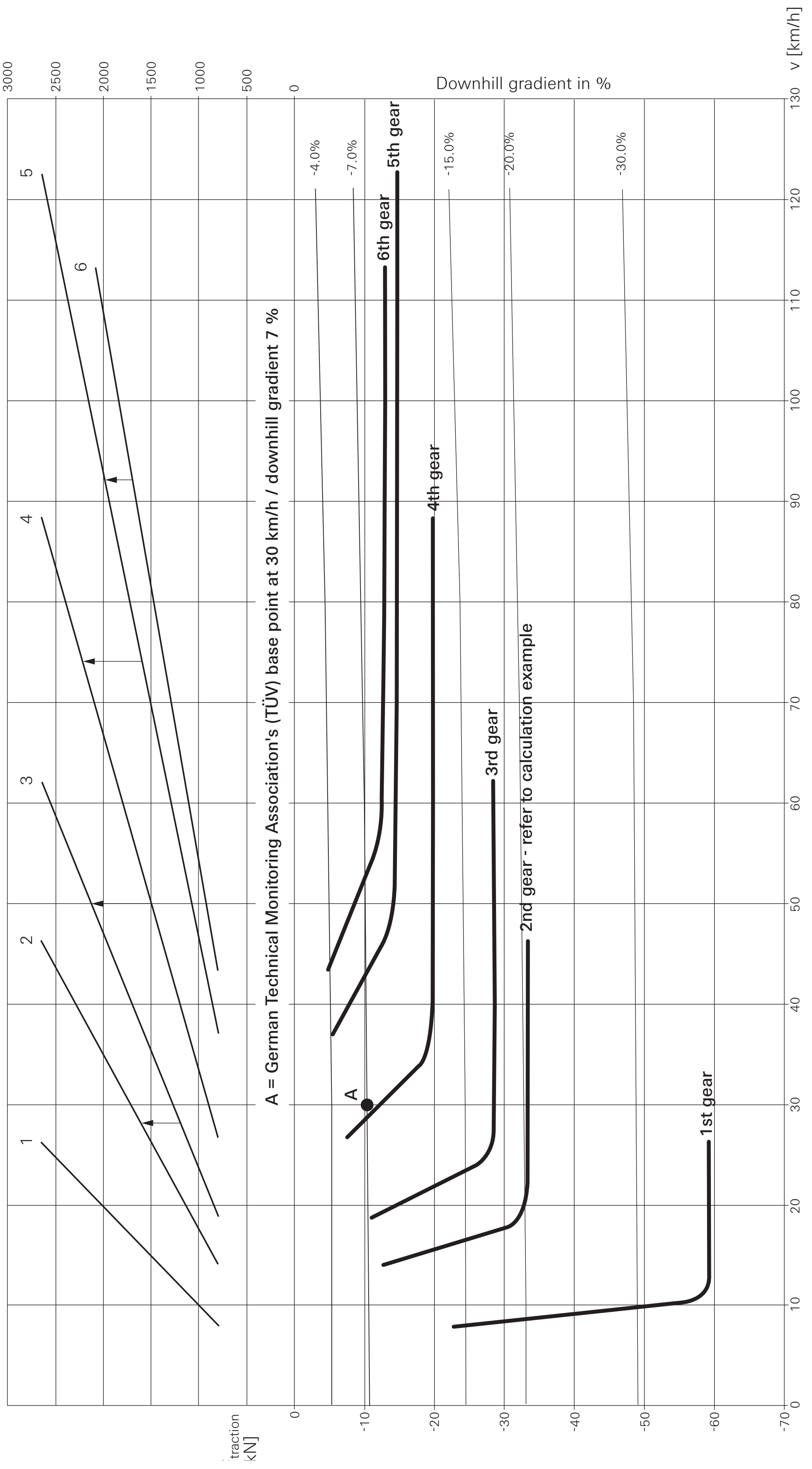
$$S_{Br} = 100 \tan[\arcsin(\frac{T_{Br}\,[Nm] \cdot i_G \cdot i_H}{m\,[kg] \cdot 9.81\,[m/s^2] \cdot r_{dyn}\,[m] \cdot \eta_{tot}} + f_R)]$$

T_{Br} = 1400 Nm
at n_{Ret} = 1718 rpm (30 km/h)

$$S_{Br} = 100 \tan[\arcsin(\frac{1400 \cdot 1.909 \cdot 5.27}{18000 \cdot 9.81 \cdot 0.466 \cdot 0.9} + 0.01)] = 20.4\%$$

NOTE: Rolling resistance f_R and overall efficiency η_{tot} support braking and need to be included in the formula for S_{Br}!

Max. possible braking power for vehicle (also refer to vehicle data) with the 6 AP 1200 B EcoLife



Vehicle:
Bus
m = 18000 [kg] i_A = 5.27
r_{Dyn} = 0.466 [m] fr = 0.010
A_{front} = 6.30 [m^2] cw = 0.550

Engine:
210 kW, 2200 rpm, 1120 Nm, 1200 rpm
210.0 [kW] (2200 rpm)
1120.0 [Nm] (1200 rpm)

Transmission: 6 AP 1200 B
Converter: W 370
Retarder: EcoLife
i_{gmax} = 3.36 mue0 = 1.00
i_{vm} = 1.00 i_{vgin} = 1.00 i_{vgout} = 1.00

Braking power graph 15. Apr 2008
No.:4168.781.XXX Ind.: --
Task: Bus 210 kW, 12 m, 18 to, 5.27, 6 AP 1200 B
In charge: Hess
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19.3 Conversion tables

19.3.1 Length units

Unit in		in	ft	yd	mile	n mile[1)]	mm	m	km
1 in	=	1	0.08333	0.02778	–	–	25.4	0.0254	–
1 ft	=	12	1	0.33333	–	–	304.8	0.3048	–
1 yd	=	36	3	1	–	–	914.4	0.9144	–
1 mile	=	63360	5280	1760	1	0.86898	–	1609.34	1.609
1 n mile[1)]	=	72913	6076.1	2025.4	1.1508	1	–	1852	1.852
1 mm	=	0.03937	$3.281 \cdot 10^{-3}$	$1.094 \cdot 10^{-3}$	–	–	1	0.001	10^{-6}
1 m	=	39.3701	3.2808	1.0936	–	–	1000	1	0.001
1 km	=	39370	3280.8	1093.6	0.62137	0.53996	10^{6}	1000	1

in = inch, ft = foot, yd = yard, mile = statute mile, n mile = nautical mile

[1)] 1 n mile = 1 sm = 1 international sea mile = 1 arc minute of meridian

In Great Britain 1 n mile (UK) = 6 080 ft ≈ 1 853 m.

1 knot = 1 n mile/h = 1.852 km/h

19.3.2 Surface units

Unit		in^2	ft^2	yd^2	$mile^2$	cm^2	dm^2	m^2	a	ha	km^2
1 in^2	=	1	–	–	–	6.452	0.06452	–	–	–	–
1 ft^2	=	144	1	0,1111	–	929	9.29	0.0929	–	–	–
1 yd^2	=	1296	9	1	–	8361	83.61	0.8361	–	–	–
1 $mile^2$	=	–	–	–	1	–	–	–	–	259	2.59
1 cm^2	=	0.155	–	–	–	1	0.01	–	–	–	–
1 dm^2	=	15.5	0.1076	0.01196	–	100	1	0.01	–	–	–
1 m^2	=	1550	10.76	1.196	–	10000	100	1	0.01	–	–
1 a	=	–	1076	119.6	–	–	10000	100	1	0.01	–
1 ha	=	–	–	–	–	–	–	10000	100	1	0.01
1 km^2	=	–	–	–	0.3861	–	–	–	10000	100	1

in^2 = square inch (sq in),
ft^2 = square foot (sq ft),
yd^2 = square yard (sq yd),
$mile^2$ = square mile (sq mile).

19.3.3 Volume units

Unit		in^3	ft^3	yd^3	gal (UK)	gal (US)	cm^3	dm^3 1)	m^3
1 in^3	=	1	–	–	–	–	16.3871	0.01639	–
1 ft^3	=	1728	1	0.03704	6.229	7.481	–	28.3168	0.02832
1 yd^3	=	46656	27	1	168.18	201.97	–	764.555	0.76456
1 gal (UK)	=	277.42	0.16054	–	1	1.20095	4546.09	4.54609	–
1 gal (US)	=	231	0.13368	–	0.83267	1	3785.41	3.78541	–
1 cm^3	=	0.06102	–	–	–	–	1	0.001	–
1 dm^3 1)	=	61.0236	0.03531	0.00131	0.21997	0.26417	1000	1	0.001
1 m^3	=	61023.6	35.315	1.30795	219.969	264.172	10^6	1000	1

in^3 = cubic inch (cu in),
ft^3 = cubic foot (cu ft),
yd^3 = cubic yard (cu yd),
gal = gallon,
1) dm^3 = 1 (liter).

19.3.4 Energy units

Unit		J	kw h	kp m	PS h	kcal 1)	ft lbf	Btu 2)
Legal units								
1 J	=	1	$277,8 \cdot 10^{-9}$	0.10197	$377.7 \cdot 10^{-9}$	$238.8 \cdot 10^{-6}$	0.73756	$947.8 \cdot 10^{-6}$
1 kWh	=	$3.6 \cdot 10^6$	1	367098	1.3596	859.84	$2.6553 \cdot 10^6$	3412.14
Units to be converted								
1 kp m	=	9.80665	$2.724 \cdot 10^{-6}$	1	$3.704 \cdot 10^{-6}$	$2.342 \cdot 10^{-3}$	7.2330	$9.295 \cdot 10^{-3}$
1 PS h	=	$2.6476 \cdot 10^6$	0.73550	269980	1	632.369	$1.9528 \cdot 10^6$	2509.4
1 kcal 1)	=	4186.8	$1.163 \cdot 10^{-3}$	426.93	$1.581 \cdot 10^{-3}$	1	3088	3.9683
Anglo-American units								
1 ft lbf	=	1.3558	$376.6 \cdot 10^{-9}$	0.13826	$512.1 \cdot 10^{-9}$	$323.8 \cdot 10^{-6}$	1	$1.285 \cdot 10^{-3}$
1 Btu 2)	=	1055.06	$293.1 \cdot 10^{-6}$	107.59	$398.6 \cdot 10^{-6}$	0.252	778.17	1

1) 1 kcal = amount of heat which is needed to heat up 1 kg of water by 1 °C starting from 15 °C.
2) 1 Btu = amount of heat which is needed to heat up 1 lb of water by 1 °F.
1 therm = 10^5 Btu

19.3.5 Mass units

Mass units

Avoirdupois system (in UK and US generally used commercial weight)

Unit		gr	dram	oz	lb	long cwt	sh cwt	long tn	sh tn	g	kg	t
1 gr	=	1	0.03657	0.00229	1/7000	–	–	–	–	0.064799	–	–
1 dram	=	27.344	1	0.0625	0.00391	–	–	–	–	1.77184	–	–
1 oz	=	437.5	16	1	0.0625	–	–	–	-	28.3495	–	–
1 lb	=	7000	256	16	1	0.00893	0.01	–	0.0005	453.592	0.45359	–
1 long cwt[1)]	=	–	–	–	112	1	1.12	0.05	–	–	50.8023	–
1 sh cwt[1)]	=	–	–	–	100	0.8929	1	0.04464	0.05	–	45.3592	–
1 long tn[1)]	=	–	–	–	2240	20	22.4	1	1.12	–	1016.05	1.01605
1 sh tn[1]	=	–	–	–	2000	17.857	20	0.8929	1	–	907.185	0.90718
1 g	=	15.432	0.5644	0.03527	–	–	–	–	–	1	0.001	–
1 kg	=	–	–	35.274	2.2046	0.01968	0.02205	–	–	1000	1	0.001
1 t	=	–	–	–	2204.6	19.684	22.046	0.9842	1.1023	10^6	1000	1

UK = Great Britain, US = United States of America

gr = grain, oz = ounze, lb = pound
long cwt = long hundredweight, sh cwt = short hundredweight,
long tn long ton, sh tn = short ton.

1 slug = 14.5939 kg = mass which is accelerated by 1 ft/s^2 by a force of 1 lbf.
1 st (stone) = 14 lb = 6.35 kg (only UK)
1 qr (quarter) = 28 lb = 12.7006 kg (only UK, used rarely).
1 quintal = 100 lb = 1 sh cwt = 45.3592 kg
1 tdw (ton dead weight) = 1.016 t. tdw specifies the load capacity of cargo boats (load + ballast + fuel + food)
.

1) When cwt and tn are used without ‘long’ or ‘sh’ in front of it, this means ‘long cwt’ and ‘long tn’ in the UK, ‘cwt’ and ‘sh tn’ in the US.

19.3.6 Force units

Force units

1 kp = 9.80665 N ^{2} 10N
1 lbf (pound-force) = 4.44822 N
1 pdl (poundal) = 0.138255 N = force which is needed to accelerate mass of 1 lb by 1 ft/s^2
1 sh (sthène)* = 10^3 N

1 N = 0.101972 kp ^{2} 0.1 kp
1 N = 0.224809 lbf
1 N = 7.233011 pdl

Pressure units and units of stress

Unit	N/m^2	µbar	mbar	bar	N/mm^2	kp/mm^2	at	kp/m^2	Torr	atm	lbf/in^2	lbf/ft^2	tonf/in^2
Legal units													
1 N/m^2 = 1 Pa =	1	10	0.01	10^{-5}	10^{-6}	–	–	0.10197	0.0075	–	–	–	–
1 µbar =	0.1	1	0.001	10^{-6}	10^{-7}	–	–	0.0102	–	–	–	–	–
1 mbar =	100	1000	1	0.001	0.0001	–	–	10.197	0.7501	–	0.0145	2.0886	–
1 bar =	10^5	10^6	1000	1	0,1	0.0102	1.0197	10197	750.06	0.9869	14.5037	2088.6	–
1 N/mm^2 =	10^6	10^7	10000	10	1	0.10197	10.197	101972	7501	9.8692	145.037	20886	0.06475
Units to be converted													
1 kp/mm^2 =	–	–	98066.5	98.0665	9.80665	1	100	10^6	73556	96.784	1422.33	–	0.63497
1 at = 1 kp/cm^2 =	98066.5	–	980.665	0.98066	0.0981	0.01	1	10000	735.56	0.96784	14.2233	2048.16	–
1 kp/m^2 = 1mmWS =	9.80665	98.0665	0.0981	–	–	10^{-6}	10^{-4}	1	–	–	–	0.2048	–
1 Torr = 1mmHg =	133.322	1333.22	1.33322	–	–	–	0.00136	13.5951	1	0.00132	0.01934	2.7845	–
1 atm =	101325	–	1013.25	1.01325	–	–	1.03323	10332.3	760	1	14.695	2116.1	–
Anglo-American units													
1 lbf/in^2 =	6894.76	68948	68.948	0.0689	0.00689	–	0.07031	703.07	51.715	0.06805	1	144	–
1 lbf/ft^2 =	47.8803	478.8	0.4788	–	–	–	–	4.8824	0.35913	–	–	1	–
1 tonf/in^2 =	–	–	–	154.443	15.4443	1.57488	157.488	–	–	152.42	2240	–	1

lbf/in^2 = pound-force per square inch (psi), lbf/ft^2 = pound-force per square foot (psf), tonf/in^2 = (long) ton-force per square inch
1 pdl/ft^2 (pound per square foot) = 1.48816 N/m^2
1 barye* = 1 µbar; 1 pz (pièce)* = 1 sn/m^2 (sthène/m^2)* = 10^3; 1 dyn/cm = 1 µbar.

Standards: DIN 66 034 kilopond – newton, newton – kilopond, conversion tables DIN 66 037 kilopond/cm^2 – bar, bar – kilopond/cm^2, conversion tables, DIN 66 038 torr – millibar, millibar – torr, conversion tables

* French units

19.3.7 Power units

Unit		W	kW	kpm/s	PS	kcal/s	kcal/h	hp[1)]	Btu/s
Legal units									
1 W	=	1	0.001	0.10197	$1.360 \cdot 10^{-3}$	$238.8 \cdot 10^{-6}$	0.86	$1.341 \cdot 10^{-3}$	$947.8 \cdot 10^{-6}$
1 kW	=	1000	1	101.97	1.3596	$238.8 \cdot 10^{-3}$	860	1.341	$947.8 \cdot 10^{-3}$
Units to be converted									
1 kpm/s	=	9.80665	$9.807 \cdot 10^{-3}$	1	$13.33 \cdot 10^{-3}$	$2.342 \cdot 10^{-3}$	8.434	$13.15 \cdot 10^{-3}$	$9.295 \cdot 10^{-3}$
1 PS [1)]	=	735.499	0.7355	75	1	0.17567	632.53	0.98632	0.69712
1 kcal/s	=	4186.8	4.1868	426.935	5.6925	1	3600	5.6146	3.9683
Anglo-American units									
1 hp[1)]	=	745.70	0.7457	76.0402	1.0139	0.17811	641.302	1	0.70678
1 Btu/s	=	1055.06	1.05506	107.586	1.4345	0.252	907.35	1.4149	1

1 ft lbf/s = 1.35582 W
1 ch (cheval vapeur) (French) = 1 PS = 0.7355 W
1 poncelet (French) = 100 kpm/s = 0.981 kW

Standards:		
	DIN 66035	calorie-joule, joule-calorie, conversion tables
	DIN 66036	horsepower-kilowatt, kilowatt-horsepower conversion tables
	DIN 66039	large calorie-watt-hour, watt-hour-large calorie conversion tables

[1)] Note the difference in testing conditions in line with SAE and DIN when power data of automotive engines are in hp or PS.
hp = horsepower [1)]
bhp = brake horsepower (brake power), dhp = drawbar horsepower (power at draw hook).

19.3.8 Conversion of temperatures

Unit		Conversion to			
		°F	°F	°R	K
degree Celsius	°C	1	$°F = \frac{9}{5}\,°C + 32$	$°R = \frac{9}{5}\,°C + 491.7$	$K = 273 + °C$
Degree Fahrenheit	°F	$°C = (°F - 32) \cdot \frac{5}{9}$	1	$°R = °F + 459.7$	$K = (°F - 32)\,\frac{5}{9} + 273$
Degree Rankine	°R	$°C = (°R - 491.7) \cdot \frac{5}{9}$	$°F = °R - 459.7$	1	$K = \frac{5}{9}\,°R$
Kelvin	K	$°C = K - 273$	$°F = \frac{9}{5}\,(K - 273) + 32$	$°R = \frac{9}{5}\,K$	1

19.3.9 Conversion factors of moments of inertia

1 kg m^2 = $(3.2808)^2$ kg sq.ft = $(3.2808)^2$ • (2.2046 lb) sq.ft = 23.73 lb sq.ft
1 kg m^2 = $(39.3701)^2$ kg sq.inch = $(39.3701)^2$ • (2.2046 lb) sq.inch = 3417 lb sq.inch
1 kg m^2 = $(1.0936)^2$ kg sq.yard = $(1.0936)^2$ • (2.2046 lb) sq.yard = 2.636 lb sq.yard

19.4 Torque

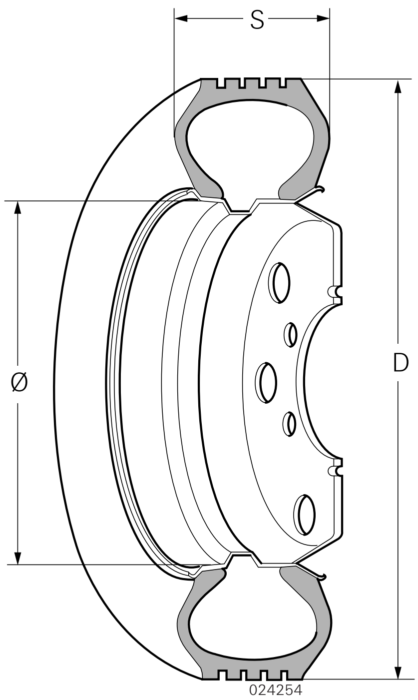
1 Nm = 0.738 lbft

$$P\,[kW] = \frac{T\,[Nm] \cdot n\,[rpm]}{9550}$$

$$P\,[kW] = \frac{T\,[lbft] \cdot n\,[rpm]}{7045}$$

19.5 Tire sizes

Dimensions of the tires



S section width
D outer diameter
Ø rim diameter

NOTE
Conversion to Anglo-American unit **[rev/mile]**

$$r_{dyn}\,[\textbf{rev/mile}] = \frac{5280}{2 \cdot \pi \cdot r_{dyn}\,[\textbf{ft}]}$$

Standard tires

European Standard / E.T.R.T.O.- standard dimensions			
Tire size	Width S (mm)	Outer dia. D (mm)	Rolling circumference (mm)
6.00 R 9	166	553	1647
225/75 R 10	234	606	1806
7.00 R 12	200	687	2050
205/80 R 15	213	723	2162
7.50 R 15	220	787	2355
8.25 R 15	243	855	2550
10.00 R 15	286	939	2800
7.00 R 16	205	800	2391
7.50 R 16	218	818	2446
8.25 R 16	239	878	2623
9.00 R 16	256	932	2782
205/65 R 17.5	212	721	2154
205/75 R 17.5	212	765	2297
215/75 R 17.5	219	779	2339
225/75 R 17.5	235	797	2388
235/75 R 17.5	242	811	2431
245/70 R 17.5	258	803	2406
265/70 R 17.5	272	831	2492
8 R 17.5	216	797	2391
8.5 R 17.5	224	817	2446
9.5 R 17.5	250	857	2568
10 R 17.5	264	875	2617
225/70 R 19.5	223	816	2490
245/70 R 19.5	258	853	2559
265/70 R 19.5	272	881	2644
285/70 R 19.5	293	911	2730
305/70 R 19.5	317	941	2815
425/55 R 19.5	438	981	2918
445/45 R 19.5	453	911	2712
445/65 R 19.5	472	1097	3252
8 R 19.5	216	867	2611
9.5 R 19.5	250	930	2794
7.00 R 20	206	908	2721
7.50 R 20	218	944	2830
8.25 R 20	234	980	2934
9.00 R 20	268	1038	3105
10.00 R 20	286	1074	3209
11.00 R 20	297	1104	3300
12.00 R 20	319	1146	3422
365/80 R 20	379	1116	3331
14.00 R 20	377	1260	3776

European Standard / E.T.R.T.O.- standard dimensions			
Tire size	Width S (mm)	Outer dia. D (mm)	Rolling circumference (mm)
8 R 22.5	216	950	2855
9 R 22.5	239	986	2958
10 R 22.5	264	1038	3111
255/70 R 22.5	265	944	2837
275/70 R 22.5	287	974	2922
275/80 R 22.5	287	1030	3087
11 R 22.5	290	1070	3203
12 R 22.5	312	1104	3306
295/60 R 22.5	304	940	2824
295/80 R 22.5	310	1062	3184
305/70 R 22.5	317	1018	3050
315/60 R 22.5	326	966	2879
315/70 R 22.5	318	1032	3093
315/80 R 22.5	318	1096	3282
13 R 22.5	326	1146	3428
385/55 R 22.5	401	1012	3044
385/65 R 22.5	405	1092	3248
425/65 R 22.5	447	1146	3406
445/65 R 22.5	472	1174	3485
12.00 R 24	319	1244	3739
305/75 R 24.5	320	1098	3294

$$\text{Rolling circumference [mm]} = \frac{\text{Rolling circumference [mm]}}{2\,\pi}$$