ZEISS Gear Metrology

Specifications

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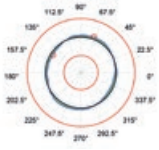
Seeing beyond

Gear types and variants

Gear types	Variants		Software solution
Cylindrical gears 	Involute profiles and splines Spur and helical gears External and internal gears Gear segments		GEAR® PRO involute basis
Special involute gears 	Conical gears Beveloids Sector shafts		GEAR® PRO involute advanced [1]
Non-involute gears 	Linear profiles and non-involute splines Serrations Parallel key splines Straight transversal profiles (e.g. cycloids, sprockets)		GEAR® PRO involute advanced [1]
Bevel gears 	Spiral and straight bevel gears Pinions and ring gears Bevel dies	Nominal data based on Master gear method (digitalization) or CAD model	GEAR® PRO bevel basis
		Nominal data imported via interface Gleason interface Klingelnberg interface DMG MORI interface	GEAR® PRO bevel advanced [1]
Worm gears 	Worm shafts with flank forms ZI ZA ZN ZK		GEAR® PRO worm basis
Rotors/ Screw compressors 	Male rotors Female rotors Straight rotors		GEAR® PRO rotor basis
Gear hobs 	One- and multiple-thread gear hobs for production of involute gears Fullprofile gear hobs (with or without turning plates technology)		GEAR® PRO hob basis
	Gear hobs with separated cutting edge geometry for right and left flank Gear hobs with additional tip turning plates		GEAR® PRO hob advanced [1]
Special gears 	Topographical evaluation of e.g. hirth gearings, worm wheels by nominal data based on Master gear method (digitalization) or CAD model		GEAR® PRO bevel basis
GPS evaluation 	GPS evaluations (geometrical product specifications) e.g. diameter, roundness, runout		CALYPSO basis
Other gears and tools	Customized solutions for e.g. gear racks on request		CALYPSO basis CALYPSO curve [1]

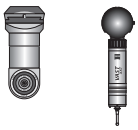
1) Option, requires related basis package.

Features of the GEAR® PRO product family from ZEISS

Evaluation parameters (in extracts for cylindrical gears)	Profile (F_{α}, $f_{f\alpha}$, $f_{H\alpha}$) Helix (F_{β}, $f_{f\beta}$, $f_{H\beta}$) Pitch (F_p, f_p, f_u, $F_{pz/8}$) Runout (F_r) Tooth thickness parameters (S_s, M_{rK}, M_{dR}, M_{dK}, W_k) Diameters (d_a, d_f) Reliefs ($C_{\alpha a}$, $C_{\alpha f}$, $C_{\beta I}$, $C_{\beta II}$) Crownings (C_{α}, C_{β}) Slope modifications ($C_{H\alpha}$, $C_{H\beta}$) K-Diagram/Tolerance band Design profile, Design helix
Navigation (travel paths)	Automatic generated travel paths/navigation and stylus selection for measurement with and without rotary table (also for horizontal orientation)
Evaluation standards	ISO, DIN, ANSI, AGMA, JIS, several company standards
CAD capability	Visualization, software simulation, nominal data definition for e.g. bevel gears, rotors, special gears
Offline version	GEAR® PRO offline basis for creating offline measurement programs, simulation, later evaluation
Interfaces (all types)	PDF export, ASCII export, Q-DAS ASCII transfer format export [1], CAD import/export (SAT, STEP, IGES)
Interfaces (cylindrical gears) [1]	GDE import/export
Interfaces (bevel gears) [1]	Gleason, Klingelnberg, DMG MORI
Non-contact evaluations	VOXEL data, STL data
Simulations	Virtual gauging effective tooth thickness/gap width, Actual-Actual comparison, single flank composite testing, order spectrum [1]

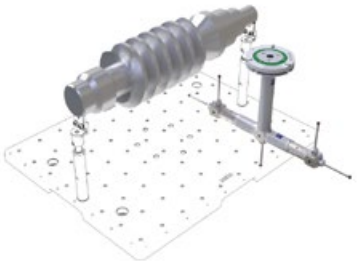
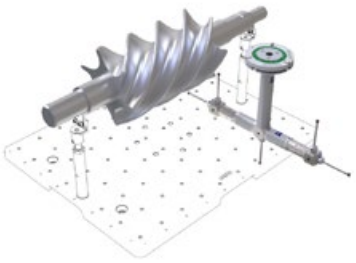
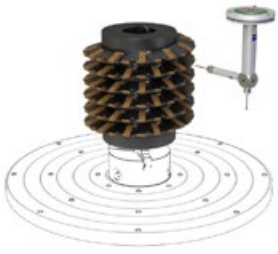
Supported systems and measuring methods of the GEAR® PRO product family from ZEISS

Systems	Bridge CMMs	ZEISS CONTURA, ZEISS MICURA, ZEISS SPECTRUM, ZEISS SPECTRUM plus, ZEISS PRISMO, ZEISS PRISMO fortis, ZEISS PRISMO ultra, ZEISS PRISMO verity, ZEISS XENOS
	Shop Floor CMMs	ZEISS DuraMax
	Large CMMs	ZEISS MMZ G, ZEISS MMZ M, ZEISS MMZ T
	Multisensor CMMs	ZEISS O-INSPECT
	Systems for Computed Tomography	ZEISS METROTOM (VOXEL-data, STL-data)
	Systems for 3D digitizing	e.g. ZEISS ATOS (STL-data)
Gear measuring methods	**Without rotary table** 3-axis scanning Various active and passive probing systems as well as articulating probing systems supported [2] Horizontal orientation supported [3] Pallet measurement supported [3]	**With rotary table** 3-axis and 4-axis scanning Various active and passive probing systems supported [2] Clamping between centers with tailstock ZEISS TS supported [2]

Probing systems	Active probing systems	Passive probing systems	Non-contact probing systems
	ZEISS VAST gold 	ZEISS VAST XXT 	ZEISS DotScan at ZEISS RDS [5] 
	ZEISS VAST XT gold 	ZEISS VAST XXT at ZEISS RDS [4] 	
	ZEISS VAST XTR gold 		

1) Option, requires related basis package.
2) Depending on CMM type.
3) Not available for GEAR® PRO hob.
4) Only rotational axis (A axis) supported.
5) Non-contact measurement with chromatic confocal probing system only in combination with rotary table possible. Only available for GEAR® PRO involute.

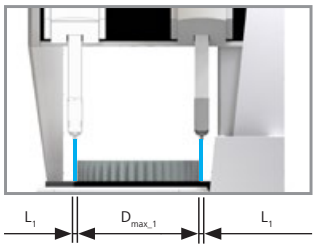
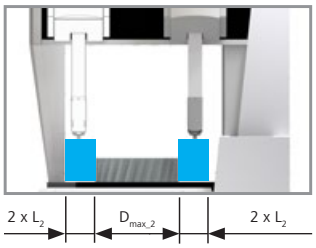
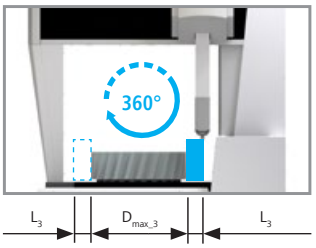
Application examples

Gear measuring methods	Without rotary table		With rotary table
	Stylus system with single stylus (-Z orientation)	Stylus system with multiple styli or probing system with rotational axis and stylus system with single stylus	Stylus system with single stylus (side styli X/Y orientation)
Cylindrical gears			
Bevel gears			
Worm gears	Not applicable		
Rotors/ Screw compressors	Not applicable		
Gear hobs	Not applicable	Not applicable	

Gear geometry specifications

Min. module	≥ 0.5 mm [1]		
Max. workpiece weight	Without rotary table	See CMM specifications (workpiece weight)	
	With rotary table	See rotary table specifications (permissible loading (axial) and max. mass moment of inertia) [2]	
		External gears	Internal gears
Max. workpiece length [3]	Vertical orientation	≤ Measuring range Z axis (G106)	≤ 0.5 x Measuring range Z axis (G106)
	Horizontal orientation	≤ Measuring range Y axis (G105)	≤ 0.5 x Measuring range Y axis (G105)
Max. workpiece diameter [3]	Vertical orientation	≤ Measuring range X axis (G104) - $L_{StylusSystem}$	≤ Measuring range X axis (G104)
	Horizontal orientation	≤ Measuring range Z axis (G106) - $L_{StylusSystem}$	≤ Measuring range Z axis (G106)

Comparison maximum workpiece diameter in relation to the different gear measuring methods

Gear measuring methods	Without rotary table		With rotary table
	Stylus system with single stylus (-Z orientation)	Stylus system with multiple styli or probing system with rotational axis and stylus system with single stylus	Stylus system with single stylus (side styli X/Y orientation)
Example	$D_{max\_1} \leq$ (G104) - $L_{StylusSystem\_1}$ $L_{StylusSystem\_1} = 2 \times L_1$ $L_1 \geq 5$ mm for module 3.5 mm [5]	$D_{max\_2} \leq$ (G104) - $L_{StylusSystem\_2}$ $L_{StylusSystem\_2} = 4 \times L_2$ $L_2 \geq 100$ mm for module 3.5 mm [5]	$D_{max\_3} \leq$ (G104) - $L_{StylusSystem\_3}$ [4] $L_{StylusSystem\_3} = 2 \times L_3$ $L_3 \geq 100$ mm for module 3.5 mm [5]
			

1) No software limitation, smallest/largest module is depending on each individual gear geometry and the smallest/largest permissible stylus tip diameter of the selected probing system. Module ≥ 0.5 mm normally always measureable, module < 0.5 mm has to be verified regarding accessibility and permissible stylus tip diameter.
2) Values of permissible loading and max. mass moment of inertia have to be considered incl. clamping fixtures (e.g. chuck) and faceplate.
3) G 104 (measuring range X axis), G 105 (measuring range Y axis), G 106 (measuring range Z axis) acc. to the CMM specifications. Stylus system dimensions and clamping fixtures (e.g. chuck) have to be considered for max. workpiece dimensions. Typically the stylus system for the measurement without rotary table requires more measuring range of the CMM than the measurement with rotary table.
4) The max. diameter of a workpiece on a system with rotary table has to be less or equalt to the faceplate of the rotary table.
5) Typical values for stylus system. May vary in individual cases.

Gear Accuracy

Measuring-instrument group VDI/VDE 2612 part 6:2022-05	A+ [1]	A	B		C			D		
Tolerance class to be tested according to ISO 1328-1:2013-09	≤ 3	4	5	6	7	8	9	10	11	12
Recommended systems with active probing systems [2]	ZEISS PRISMO ultra ZEISS XENOS	ZEISS PRISMO ZEISS PRISMO fortis ZEISS PRISMO verity ZEISS MICURA	ZEISS CONTURA ZEISS MMZ G ZEISS MMZ M ZEISS MMZ T ZEISS SPECTRUM plus							
Recommended systems with passive probing systems [2]					ZEISS CONTURA ZEISS DuraMax ZEISS MMZ G ZEISS MMZ M ZEISS MMZ T ZEISS O-INSPECT ZEISS SPECTRUM ZEISS SPECTRUM plus					

1) For the measuring-instrument group (A+), no recommendations for maximum permissible errors (MPE) can be established according to the current state of the art, taking into account the measurement uncertainty. For accuracies in tolerance class 3 (ISO 1328-1:2013-09), it is currently not possible to consistently assign a measuring-instrument group. Individual maximum permissible errors shall be defined separately here between the manufacturer and the purchaser.

2) Profile and helix acceptance test can be performed with a gear artifact z = 30, m = 3.5 mm, d = 105 mm, α = 20°, β = 0° / 20° r / 20° l, b = 70 mm (or similar gear artifact).
Pitch and runout acceptance test can be performed with a gear artifact z = 30, m = 3.5 mm, d = 105 mm, α = 20°, β = 0°, b = 30 mm (or similar gear artifact).

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