		Calculation of force couplings of shafts with hubs

i	Calculation: A = OK; B = OK
ii	☐ Project information

1.0	☐ Common input data

A	Interference fit

2.0	☑ Design of coupling dimensions

2.1	**Coupling parameters**			
2.2	System of fit	Hole basis system ▼		
2.3	Assembly method	Transverse press (shrink fit) ▼		
2.4	Purity of contact areas	Degreased surfaces ▼		
2.5	Plating of contact areas	Unplated surfaces ▼		
2.6	Friction coefficient	μ	0,12	0,12	☑
2.7	Desired safety against gliding		1,40	
2.8	Desired strength safety		1,40	
2.9	**Loading of the coupling**			
2.10	Service factor	K_S	1,00	1,00	☑
2.11	Service torque	T_S	78,78	[lb ft]
2.12	Total service loading	F_S	1 264,47	[lb]

2.13 **Preliminary design**

ID.	d	D	L	Fit
1.	1.5000	3.3750	2.0000	FN 1 ▼

2.14	**Coupling dimensions**			
2.15	Hollow shaft inner diameter	d_0	0,5	[in]
2.16	Minimum shaft diameter	d_{min}	0,905	[in]
2.17	Shaft diameter	d	1,500	[in]
2.18	Hub outer diameter	D	3,375	[in]
2.19	Shaft roughness	R_{aS}	16,00	[μin] ☑
2.20	Hub roughness	R_{aH}	32,00	[μin] ☑
2.21	Functional coupling length	L	2,000	[in]
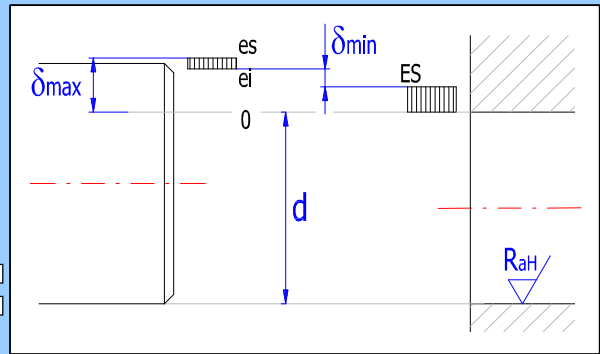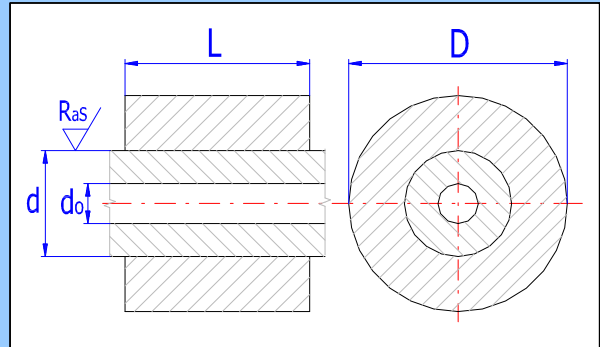
2.22	**Design and selection of the fit**
2.23	Automatic design of the fit

2.24	Recommended fits	FN 1 ▼ ☑		2.30	Coupling subsidence		0,04	[10^{-3} in]
2.25	Upper deviation of hub	ES	0,60	[10^{-3} in]	2.31	Min. required assembly interference		0,28	[10^{-3} in]
2.26	Lower deviation of hub	EI	0,00	[10^{-3} in]	2.32	Minimum fit interference	δ_{min}	0,30	[10^{-3} in]
2.27	Upper deviation of shaft	es	1,30	[10^{-3} in]	2.33	Max. allowable assembly interference		1,56	[10^{-3} in]
2.28	Lower deviation of shaft	ei	0,90	[10^{-3} in]	2.34	Maximum fit interference	δ_{max}	1,30	[10^{-3} in]

2.29 *Limit deviations and range of assembly interference of selected fit*

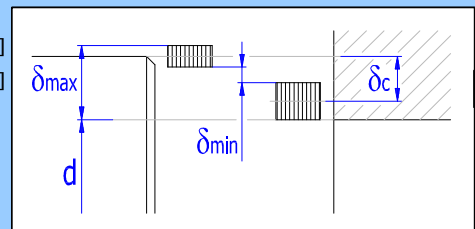Legend: Min. required assembly interference / Max. allowable assembly interference / Fit interference
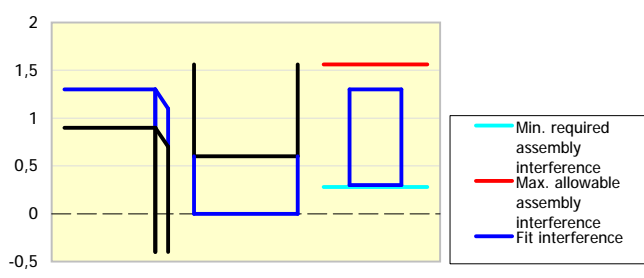
2.35 *Range of assembly interferences for recommended fits*
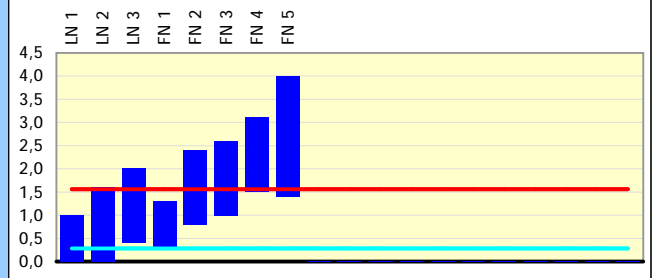
| 3.0	☑ Loading capacity, strength checks and mounting parameters of the coupling

3.1	**Loading capacity of the coupling**		dc	dmin	dmax	
3.2	Assembly interference	δ	0,80	0,30	1,30	[10^{-3} in]
3.3	Effective interference	Δd	0,76	0,26	1,26	[10^{-3} in]
3.4	Contact pressure	p	4,9	1,7	8,2	[ksi]
3.5	Frictional force	F_f	5583	1920	9247	[lb]
3.6	Safety against gliding		4,42	1,52	7,31	
3.7	**Strength check of hub**					
3.8	Outside diameter increase	ΔD	0,33	0,11	0,55	[10^{-3} in]
3.9	Allowable stress in tension	σ_A	30			[ksi]
3.10	Comparative stress outside		2,4	0,8	4,0	[ksi]
3.11	Comparative stress inside		10,7	3,7	17,8	[ksi]
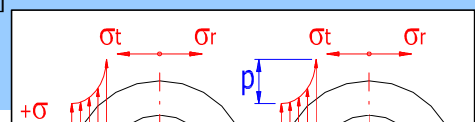
3.12	Safety		2,80	8,14	1,69	
3.13	**Strength check of shaft**					
3.14	Inside diameter decrease	Δd_0	0,18	0,06	0,30	$[10^{-3}$ in]
3.15	Allowable stress in tension	σ_A		34,8		[ksi]
3.16	Comparative stress outside		5,7	1,9	9,4	[ksi]
3.17	Comparative stress inside		11,1	3,8	18,4	[ksi]
3.18	Safety		3,13	9,11	1,89	
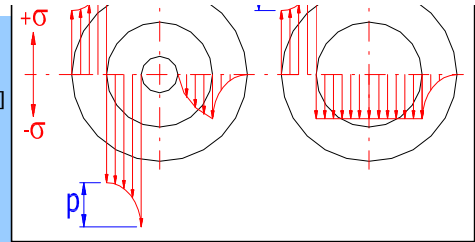
3.19	**Check of coupling for deformation**				3.23	**Check of shaft for torsion**			
3.20	Allowable contact pressure	p_A	13,5	[ksi]	3.24	Allowable stress in shear	τ_A	24,4	[ksi]
3.21	Max. contact pressure	p_{max}	8,2	[ksi]	3.25	Comparative stress	τ	2,9	[ksi]
3.22	Safety		1,65		3.26	Safety		8,45	

3.27	**Mounting parameters of the coupling**							
3.28	*Transverse press (shrink fit)*				3.41	*Longitudinal press (force fit)*		
3.29	Fit		With maximum interference ▼		3.42	Fit	With maximum interference ▼	
3.30	Assembly clearance	c	0,0015	[in]	3.43	Necessary pressing force	F_p	0	[lb]
3.31	Heat expansion coefficient :							
3.32	- Hub material (warming)	α_H	5	$[10^{-6}/°F]$				
3.33	- Shaft material (warming)	α_S	6,5	$[10^{-6}/°F]$				
3.34	- Shaft material (cooling)	α_{Sc}	5	$[10^{-6}/°F]$ ☑				
3.35	Determination of necessary hub heating temperature							
3.36	Shaft temperature	T_S	68,0	[°F]				
3.37	Necessary hub temperature	T_H	441,3	[°F]				
3.38	Determination of necessary shaft cooling temperature							
3.39	Hub temperature	T_H	200,0	[°F]				
3.40	Necessary shaft temperature	T_S	-173,3	[°F]				

4.0	☑ **Check of the coupling strained by additional load**

4.1	**Loading of the coupling**				
4.2	Additional radial force	F_R	500,00	[lb]	
4.3	Additional bending moment	M	20,00	[lb ft]	
4.4	Amplitude of the pressure	Δp	0,26	[ksi]	
4.5	**Check of the coupling**		dc	dmin	dmax	
4.6	Medium contact pressure	p	4,9	1,7	8,2	[ksi]
4.7	Max. allowable contact pressure	p_{maxA}		13,8		[ksi]
4.8	Maximum contact pressure	p_{max}	5,2	2,0	8,4	[ksi]
4.9	Safety		2,66	7,06	1,64	
4.10	Min. allowable contact pressure	p_{minA}		0,4		[ksi]
4.11	Minimum contact pressure	p_{min}	4,7	1,4	7,9	[ksi]
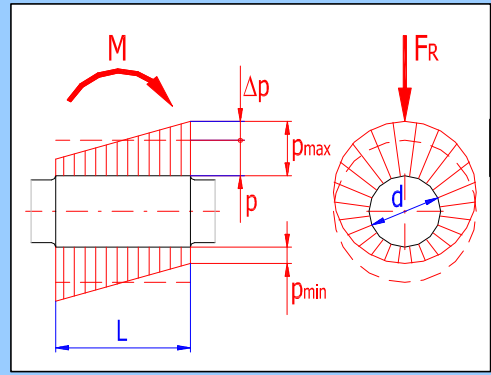
5.0	☑ **Check of the coupling at specific working temperature**

5.1	Service temperature	T	300,0		[°F]	

5.2	**Properties of the material**		Shaft		Hub		☑
			68 °F	300 °F	68 °F	300 °F	
5.3	Modulus of elasticity in tension	E	30500	28530,0	24700	22790,0	[ksi]
5.4	Heat expansion coefficient	α	6,5	6,90	5	5,50	$[10^{-6}/°F]$
5.5	Poisson number	ν	0,3	0,30	0,28	0,28	
5.6	Allowable stress in tension	σ_A	34,8	29,6	30	28,5	[ksi]

5.7	**Loading capacity of the coupling**		dc	dmin	dmax	
5.8	Assembly interference	δ	0,80	0,30	1,30	$[10^{-3}$ in]
5.9	Effective interference	Δd	0,76	0,26	1,26	$[10^{-3}$ in]
5.10	Service interference	Δd_T	1,25	0,75	1,75	$[10^{-3}$ in]
5.11	Contact pressure	p_T	7,5	4,5	10,5	[ksi]
5.12	Frictional force	F_{fT}	8480	5086	11875	[lb]
5.13	Safety against gliding		6,71	4,02	9,39	
5.14	**Strength check of hub**					
5.15	Outside diameter increase	ΔD_T	4,85	4,63	5,07	$[10^{-3}$ in]
5.16	Allowable stress in tension	σ_{AT}		28,5		[ksi]
5.17	Comparative stress outside		16,3	9,8	22,8	[ksi]
5.18	Comparative stress inside		3,7	2,2	5,2	[ksi]
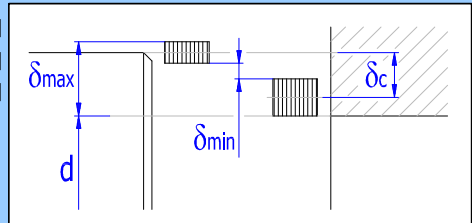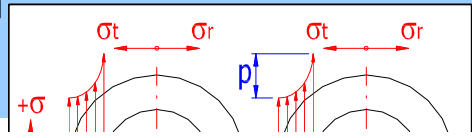
5.19	Safety		1,75	2,92	1,25	
5.20	**Strength check of shaft**					
5.21	Inside diameter decrease	Δd_{0T}	-0,50	-0,62	-0,39	[10^{-3} in]
5.22	Allowable stress in tension	σ_{AT}		29,6		[ksi]
5.23	Comparative stress outside		8,6	5,2	12,0	[ksi]
5.24	Comparative stress inside		16,9	10,1	23,6	[ksi]
5.25	Safety		1,75	2,93	1,25	
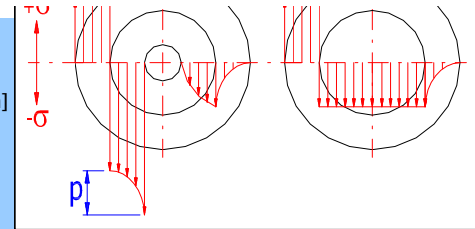
6.0 ☑ Extended fit selection according to ISO 286

6.1	**Desired parameters of the fit**			6.6	**Selection of the fit**			
6.2	Basic size	38,10	[mm]	6.7	Hub tolerance zone	H ▼ 6 ▼		
6.3	Min. required assembly interference	7,10	[µm]		**H6** Upper deviation	ES	16	[µm]
6.4	Max. allowable assembly interference	39,64	[µm]		Lower deviation	EI	0	[µm]

| 6.5 | **Automatic search of the fit** | | | | 6.8 | Shaft tolerance zone | p ▼ 5 ▼ | | |

ID	Min. interfer.	Max. interfer.	Fit
1.	10	37	H6/p5
2.	15	37	H5/p5
3.	10	33	H6/p4
4.	15	33	H5/p4
5.	10	24	H4/n4
6.	19	33	H4/p4
7.	15	30	H5/p3
8.	23	38	H5/r3

	p5 Upper deviation	es	37	[µm]
	Lower deviation	ei	26	[µm]

6.9	**Parameters of the selected fit**			
	H6/p5	Minimum interference	10	[µm]
		Maximum interference	37	[µm]

6.10

B	Clamping connection

7.0 ☑ Design of coupling dimensions

7.1	**Coupling parameters**				
7.2	Hub design	A ... Separated hub ▼			
7.3	Purity of contact areas	Degreased surfaces ▼			
7.4	Friction coefficient	µ	0,12	0,12	☑
7.5	Form factor	K_F	0,75		
7.6	Desired safety against gliding		1,70		
7.7	Desired strength safety		1,70		
7.8	**Loading of the coupling**				
7.9	Service factor	K_S	1,00	1,00	☑
7.10	Service torque	T_S	78,78	[lb ft]	
7.11	Total service loading	F_S	1 515,91	[lb]	
7.12	**Coupling dimensions**				
7.13	Hollow shaft inner diameter	d_0	0,5	[in]	
7.14	Minimum shaft diameter	d_{min}	0,905	[in]	
7.15	Shaft diameter	d	1,250	[in]	
7.16	Min. functional coupling length	L_{min}	1,224	[in]	
7.17	Functional coupling length	L	1,250	[in]	☑
7.18	**Mounting prestressing, design of connecting bolt**				
7.20	Number of connecting bolts	i	4		
7.21	Allowable mounting prestressing		2278,6 ~ 2326,5	[lb]	
7.22	Mounting prestressing	F_0	2300,0	[lb]	☑
7.23	Material of connecting bolt	S_Y	92,0 SAE 5 ▼	[ksi]	
7.24	Min. recommended thread size		5/16		
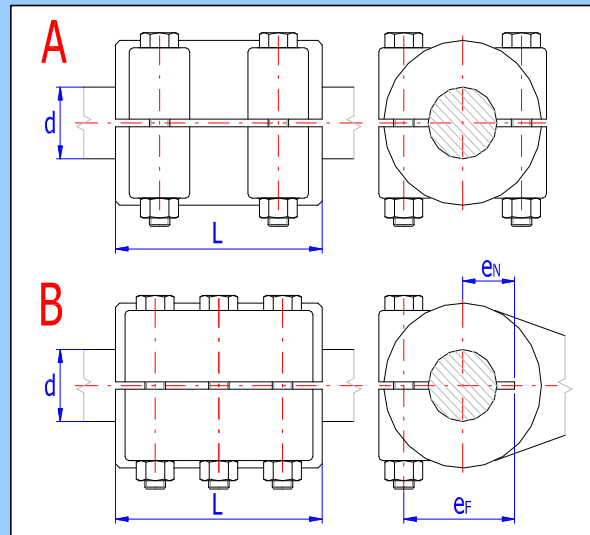
8.0 ☑ Loading capacity and strength checks of the coupling

8.1	**Loading capacity of the coupling**				8.13	**Check of coupling for deformation**			
8.2	Total clamping (normal) force	N	9200,0	[lb]	8.14	Allowable contact pressure	p_A	13,5	[ksi]
8.3	Contact pressure	p	5,89	[ksi]	8.15	Max. contact pressure	p_{max}	7,9	[ksi]
8.4	Frictional force	F_f	2601,2	[lb]	8.16	Safety		1,72	
8.5	Total service loading	F_S	1515,9	[lb]	8.17	**Check of shaft for torsion**			
8.6	Safety against gliding		1,72		8.18	Allowable stress in shear	τ_A	24,4	[ksi]
8.7	**Check of connecting bolt**				8.19	Comparative stress	τ	5,1	[ksi]
8.8	Yield point of the bolt material	S_Y	92	[ksi]	8.20	Safety		4,82	
8.9	Thread size	d	0,3125	[in]	8.21	**Check of hollow shaft**			
8.10	Tightening torque	M	11,6	[lb ft]	8.22	Allowable stress in tension	σ_A	34,8	[ksi]
8.11	Comparative stress in bolt core	σ	66,9	[ksi]	8.23	Comparative stress	σ	18,7	[ksi]
8.12	Safety at yield point		1,38		8.24	Safety		1,86	

	Additions section

9.0	☑ Comparative table						

9.1	**Interference fit**				9.10	**Clamping connection**			
9.2	Shaft diameter	d	1,5	[in]	9.11	Shaft diameter	d	1,25	[in]
9.3	Functional coupling length	L	2	[in]	9.12	Functional coupling length	L	1,25	[in]
9.4	Loading capacity of the coupling :				9.13	Loading capacity of the coupling :			
9.5	Min. frictional force	F_f	1919,7	[lb]	9.14	Frictional force	F_f	2601,2	[lb]
9.6	Safety against gliding		1,52		9.15	Safety against gliding		1,72	
9.7	Strength checks of the coupling :				9.16	Strength checks of the coupling :			
9.8	Max. contact pressure	p_{max}	8,2	[ksi]	9.17	Max. contact pressure	p_{max}	7,9	[ksi]
9.9	Safety		1,69		9.18	Safety		1,72	