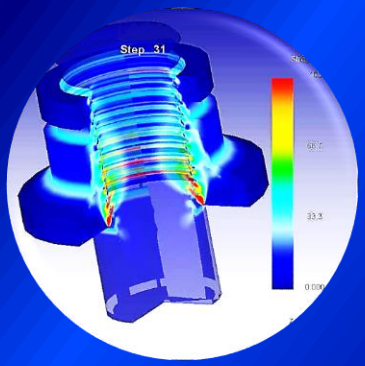
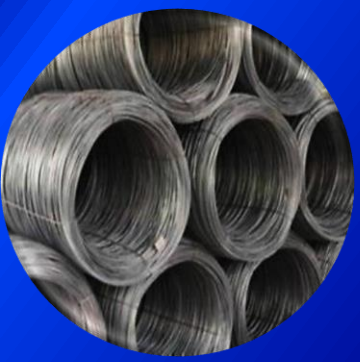
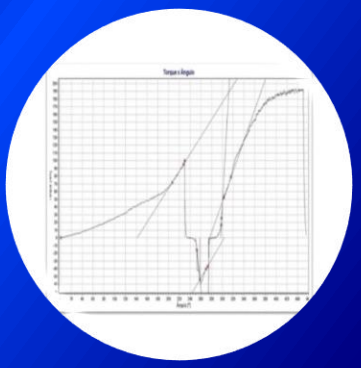
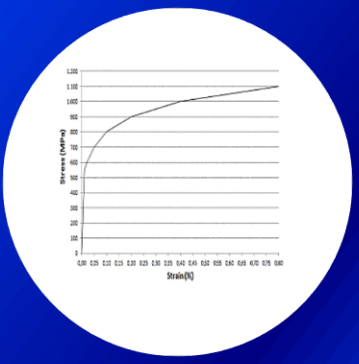


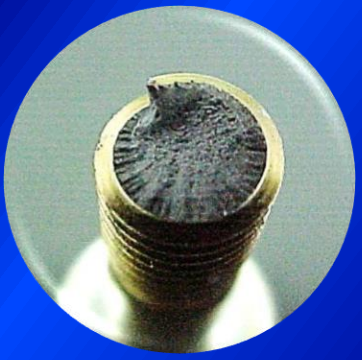


The Technology Center of Fixation (CTF) aims, along with its clients, to keep a solid cooperation in engineering, research and development and technological innovation in the area of bolted connections, including:

- *Calculation and design of bolted connections*
- *Acting at all stages of the manufacturing process, from the definition of materials, tooling, forging sequence, thread rolling, heat treatment, surface treatment up to the definition of quality control parameters*
- *Assembly techniques applied to the production line and specification of tightening parameters/control*
- *Analysis of assembly problems, field failures and recalls of various types of bolted connections*







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BCT , now renamed CTF ,operates since 2005 providing consulting and advice in the area of bolted connections.

- *It's a leader in understanding and developing solutions applicable to the whole universe of threaded fasteners, from design through manufacturing and assembly to the analysis of possible failures.*
- *BCT holds patents and extensive knowledge in all areas. The Patents and papers published by the CTF team are used as reference worldwide. Our tightening patent based on the torsion angle control EP1922179A1 / US20080209707A1 is mentioned by European and Japanese researchers as well as by the aircraft manufacturer AIRBUS.*
- *BCT technical staff has performed hundreds of fasteners projects, including tightening methods and control plans for companies located in the USA, Brazil and Europe for critical applications (cylinder heads, connecting rods , main bearings, wheels, brakes, suspensions, etc.).*
- *It has conducted over the last 12 years a large number of failure analysis, identifying root cause, proposing solutions and establishing the conditions for the decision of eventual recalls, for both Brazilian companies and abroad, in applications such as suspension and brake systems, gasoline and diesel engines, transmissions, large structures, fans for thermal power plants' cooling, wind turbines blades and other applications.*

❑ *Expertise in all manufacturing steps:*

- ➢ *Definition of the chemical composition and dimensional characteristics of steels involved in the manufacturing of fasteners.*
- ➢ *Tool Design, manufacturing sequence and definition of adequate equipment.*
- ➢ *Definition of procedures and parameters' controls for thread rolling process.*
- ➢ *Determination of heat treatment process parameters and controls according to the products' performance requirements and characteristics of the raw material.*
- ➢ *Support in choosing the surface treatment type depending on performance requirements (Coefficient of friction, corrosion resistance, etc.) along with definition of the surface finish application process control parameters.*

❑ *Calculation and design of bolted connections*

- ➢ *Analysis of forces and tensions (required clamp load, acting fatigue stress)*
- ➢ *Verification of the project's limiting factors (surface pressure, thread fillets' resistance)*
- ➢ *Definition of the fasteners/mating parts characteristics (thread size, pitch, tensile strength, friction coefficients, etc.)*

❑ *Definition of assembly parameters, process control and quality, establishing acceptance windows considering assemblies with:*

- ➢ *Plain Torque Control*
- ➢ *Torque x Angle or Yield Point Control*

❑ *Failure analysis:*

- ➢ *Failures on the assembly line*
- ➢ *Field Failures*
- ➢ *RECALLS*
- ➢ *Definition of root cause in highly complex joints' analysis with presentation of suggestions for modifications in materials, manufacturing processes, assembly and control in order to solve the various failure modes in bolted connections.*

❑ *Coaching, lectures, specific training and development of software and apps*

❑ *Standard and specific tests:*

- ➢ *Interpretation and analysis of international standards and/or specific customer requirements.*
- ➢ *Manufaturing of testing devices.*
- ➢ *Testing.*
- ➢ *Analysis of results.*
- ➢ *Definition of the necessary changes to meet standard's requirements.*

❑ *Development of specific equipment for bolted joints' routine analysis and fasteners' quality control.*

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Estimated M_A tightening torques (Nm) for standard metric screws (μ_{GES} = 0,12)

Thread size	Property Class		
	8.8	10.9	12.9
M6 x 1,00	10,1	14,9	17,4
M8 x 1,25	24,6	36,1	42,2
M10 x 1,50	48,0	71,0	83,0
M12 x 1,75	84,0	123,0	144,0
M14 x 2,00	133,0	195,0	229,0
M16 x 2,00	206,0	302,0	354,4
M18 x 2,50	295,0	421,0	492,0
M20 x 2,50	415,0	592,0	692,0
M22 x 2,50	567,0	807,0	945,0

Correction Factor for estimating M_A with μ_{GES} ≠ 0,12

μ_{GES}	CF
0,08	0,77
0,10	0,89
0,12	1
0,14	1,10
0,16	1,18
0,20	1,33
0,25	1,47
0,30	1,57

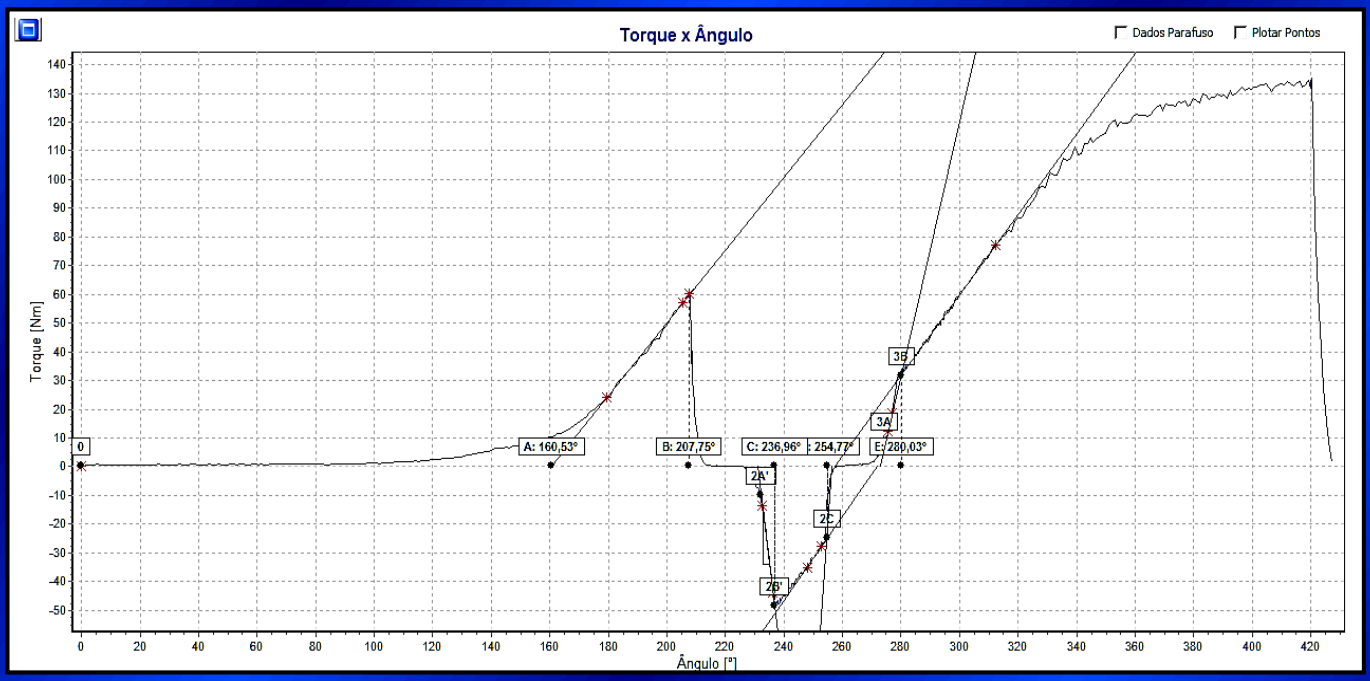
$$MA_{(\mu_{GES} \neq 0,12)} = M_{A(\mu_{GES} = 0,12)} \times CF$$

Mechanical Properties of screws according to ISO-898

Mechanical Properties		Property Class		
		8.8	10.9	12.9
Tensile Strength R_M (N/mm²)	Min.	800	1.040	1.200
	Max.	1.040	1.200	1.350
Hardness HV	Min.	250	320	380
	Max.	320	380	435
Hardness HRC	Min.	22	32	39
	Max.	32	39	44
Yield Point $R_{P0.2}$ (N/mm²)	Min.	640	940	1.100

Hardness Conversion

N/mm²	HV	BRINELL	HRC
610	190	181	---
640	200	190	---
675	210	199	---
705	220	209	---
740	230	219	---
770	240	228	---
800	250	238	---
820	255	242	23,1
850	265	252	24.8
880	275	261	26,4
900	280	266	27,1
930	290	276	28,5
950	295	280	29,2
995	310	295	31,0
1.040	320	304	32,2
1.060	330	314	33,3
1.095	340	323	34,4
1.125	350	333	35,5
1.155	360	342	36,6
1.190	370	352	37,7
1.200	380	361	38,8
1.255	390	371	39,8



Defining assembly properties through Torsion Angle Analysis extracted from Torque x Angle curve (Patent [EP1922179A1 / US20080209707A1](#) - Developed by BCT Consulting)

- μ_G - *Thread Friction coefficient*
- μ_K - *Bearing surface Friction coefficient*
- μ_{GES} - *Global Friction coefficient*
- *k - Torque coefficient*
- F_M - *Assembly Clamp Load*
- η - *Yield in combined tension state (Tension + Torsion)*
- R_M - *Tensile Strength*
- $\delta_S + \delta_P$ - *Joint Resilience*

CTF - Centro Tecnológico de Fixação

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