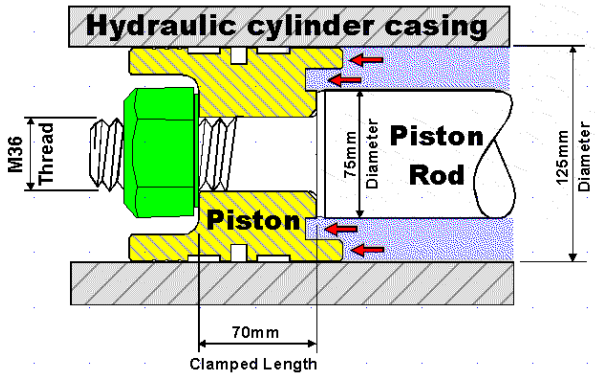
BOLTCALC Program - Example Problem (Metric Units and thread)

The attachment of the piston to the piston rod in a hydraulic cylinder is made by use of an M36 nut. The cylinder is subjected to a pressure of 150 bar, this results in a force of 117810N being applied on the rod side and -184080N on the head side of the cylinder. The piston is made from a high strength cast iron and the piston rod from an alloy steel. A 5000N residual clamp force is required to ensure that a seal is maintained between the piston and the piston rod. Details are presented of the analysis from the BOLTCALC program.



PROJECT TITLE
Calculation of a hydraulic piston to piston rod attachment.

COMMENTS
Example calculation using metric units of a piston to piston rod joint in an hydraulic cylinder.

FASTENER DETAILS

Fastener Diameter	= 36.00 mm
Thread Pitch	= 4.00 mm
Thread Pitch Diameter	= 33.402 mm
Thread Root Diameter	= 31.093 mm
Diameter related to the Thread Stress Area	= 32.247 mm
Thread Stress Area	= 816.722 mm²
Thread Root Area	= 759.280 mm²
Bearing Area under Nut/Bolt Head	= 1021.622 mm²
Fastener Outer Bearing Diameter	= 51.10 mm
Fastener Inner Bearing Diameter	= 36.20 mm
Fastener Clearance Hole Diameter	= 36.20 mm
Fastener Yield Strength	= 500.00 N/mm²
Fastener Modulus of Elasticity	= 208000.00 N/mm²
Fatigue Endurance Limit for the Fastener	= 33.75 N/mm²

Note: The Fatigue Endurance Limit of the fastener is based upon the thread being machine cut.

JOINT DETAILS

Clamped Length for the Joint	= 70.00 mm
Clamped Length to Diameter ratio	= 1.94
Load Introduction Level Factor	= 0.90
Joint Material Modulus of Elasticity	= 170000.00 N/mm²
Amount of Embedding within the Joint	= 0.00412 mm
Limiting Surface Pressure for the Material	= 400.00 N/mm²

DETAILS OF APPLIED FORCES

Axial force	= 117810.00 N
Direct shear force	= 0.00 N
Force required to prevent shear movement	= 0.00 N
Force required for functional reasons	= 5000.00 N
Lower value of the applied dynamic force	= -184080.00 N

BOLT AND JOINT RESILIENCES

Fastener Resilience	= 5.806E-7 mm/N
Joint Resilience	= 1.238E-7 mm/N
Load Factor	= 0.176
Load Factor adjusted for Load Introduction	= 0.158

JOINT ASSEMBLY DETAILS

Tightening Details: Torque controlled tightening using dynamic torque measurement and precision tools. Torque value theoretical.

Tightening Factor	= 1.60

Thread Frictional Conditions:
Phosphated steel external thread, black oxide finish on steel internal thread, oiled.

Thread Friction Value	= 0.120

Underhead Frictional Conditions:
Black oxide steel nut or bolt, oiled, machined cast iron bearing surface.

Nut/Bolt Head Friction Value	= 0.140

BOLT TIGHTENING ANALYSIS

Yield Point Tightening Factor specified	= 0.90
Total Tightening Torque	= 1873.58 Nm
Torque needed to extend the fastener	= 197.61 Nm
Torque needed to overcome thread friction	= 718.32 Nm
Torque needed to overcome nutface friction	= 957.65 Nm

ANALYSIS RESULTS

Direct Force that would Yield the Fastener	= 408361.18 N
Preload Loss due to Embedding	= 5855.04 N
Maximum Clamping Force required	= 176044.04 N
Minimum Clamping Force required	= 110027.53 N
Surface Pressure under the Nut Face	= 322.08 N/mm²
Induced Alternating Stress in the Fastener	= 31.45 N/mm²
Maximum Fastener Force	= 329041.27 N
Minimum Residual Force on the Joint	= 134359.72 N
Force reducing Clamp Force on the Joint	= 99172.49 N
Force increasing the Fasteners Tension	= 18637.51 N
Tensile Stress due to Preload	= 380.06 N/mm²

S U M M A R Y O F T H E R E S U L T S

FASTENER CLAMP FORCE ANALYSIS

Fastener Preload	= 310403.76 N
Maximum Clamping Force required	= 176044.04 N
Factor of Safety	= 1.76

CONCLUSION
The residual clamp force present when the applied forces have been taken into account will provide the fastener with a degree of resistance to loosening based on the data entered.

FASTENER OVERLOADING ANALYSIS

Direct Force that would Yield the Fastener	= 408361.18 N
Maximum Fastener Force	= 329041.27 N
Factor of Safety	= 1.24

CONCLUSION
The force in the fastener will not exceed its yield strength based on the data entered.

FASTENER FATIGUE FAILURE ANALYSIS

Fatigue Endurance Limit for the Fastener	= 33.75 N/mm²
Induced Alternating Stress in the Fastener	= 31.45 N/mm²
Factor of Safety	= 1.07

CONCLUSION
The fastener should not sustain fatigue failure based upon the data entered.

SURFACE PRESSURE ANALYSIS

Limiting Surface Pressure for the Material	= 400.00 N/mm²
Surface Pressure under the Nut Face	= 322.08 N/mm²
Factor of Safety	= 1.24

CONCLUSION
The surface pressure calculated is within the quoted maximum value.

OVERALL CONCLUSIONS
All safety factors are greater than unity, the defined fastener is capable of sustaining the applied forces entered by the user

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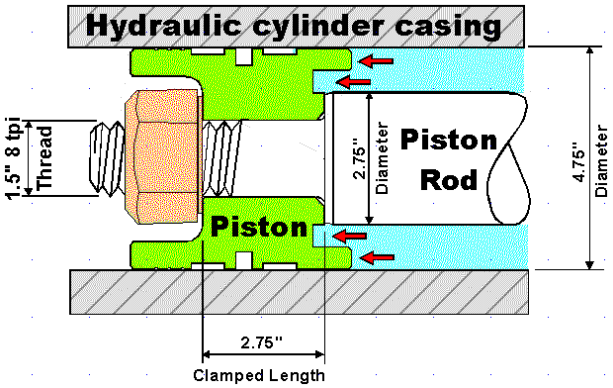
BOLTCALC Program - Example Problem (Imperial Units and thread)

The attachment of the piston to the piston rod in a hydraulic cylinder is made by use of a 1.5 inch American National (UN) thread 8 threads per inch. The cylinder is subjected to a pressure of 3000 Lb/in², this results in a force of 35343 lbs being applied on the rod side and -53162 lbs on the head side of the cylinder. The piston is made from a high strength cast iron (nodular cast iron) and the piston rod from an alloy steel. A 1000lb residual clamp force is required to ensure that a seal is maintained between the piston and the piston rod. Details are presented of the analysis from the BOLTCALC program.



PROJECT TITLE
Calculation of a hydraulic cylinder to piston rod attachment

COMMENTS
Example calculation using inch sized components for a piston to piston rod joint.

FASTENER DETAILS

Fastener Diameter	= 1.500 in
Thread Pitch	= 0.125 in
Thread Pitch Diameter	= 1.419 in
Thread Root Diameter	= 1.347 in
Diameter related to the Thread Stress Area	= 1.383 in
Thread Stress Area	= 1.502 in²
Thread Root Area	= 1.424 in²
Bearing Area under Nut/Bolt Head	= 1.900 in²
Fastener Outer Bearing Diameter	= 2.172 in
Fastener Inner Bearing Diameter	= 1.516 in
Fastener Clearance Hole Diameter	= 1.516 in
Fastener Yield Strength	= 75000 Lb/in²
Fastener Modulus of Elasticity	= 30000000 Lb/in²
Fatigue Endurance Limit for the Fastener	= 4871.519 Lb/in²

Note: The Fatigue Endurance Limit of the fastener is based upon the thread being machine cut.

JOINT DETAILS

Clamped Length for the Joint	= 2.750 in
Clamped Length to Diameter ratio	= 1.83
Load Introduction Level Factor	= 0.50
Joint Material Modulus of Elasticity	= 23500000 Lb/in²
Amount of Embedding within the Joint	= 1.592E-4 in
Limiting Surface Pressure for the Material	= 80000.00 Lb/in²

DETAILS OF APPLIED FORCES

Axial force	= 35343.00 Lb
Direct shear force	= 0.00 Lb
Force required to prevent shear movement	= 0.00 Lb
Force r equired for functional reasons	= 1000.00 Lb
Lower value of the applied dynamic force	= -53162.00 Lb

BOLT AND JOINT RESILIENCES

Fastener Resilience	= 9.206E-8 in/Lb
Joint Resilience	= 2.078E-8 in/Lb
Load Factor	= 0.184
Load Factor adjusted for Load Introduction	= 0.092

JOINT ASSEMBLY DETAILS

Tightening Details:
Torque controlled tightening using dynamic torque measurement and precision tools. Torque value theoretical.

Tightening Factor	= 1.60

Thread Frictional Conditions:
Phosphated steel external thread, black oxide finish on steel internal thread, oiled.

Thread Friction Value	= 0.120

Underhead Frictional Conditions:
Black oxide steel nut or bolt, oiled, machined cast iron bearing surface.

Nut/Bolt Head Friction Value	= 0.140

BOLT TIGHTENING ANALYSIS

Yield Point Tightening Factor specified	= 0.60
Total Tightening Torque	= 1204.68 Lb-ft
Torque needed to extend the fastener	= 96.39 Lb-ft
Torque needed to overcome thread friction	= 476.27 Lb-ft
Torque needed to overcome nutface friction	= 632.01 Lb-ft

ANALYSIS RESULTS

Fastener Preload	= 58142.45 Lb
Direct Force that would Yield the Fastener	= 112621.98 Lb
Preload Loss due to Embedding	= 1410.54 Lb
Maximum Clamping Force required	= 55198.15 Lb
Minimum Clamping Force required	= 34498.84 Lb
Surface Pressure under the Nut Face	= 32311.98 Lb/in²
Induced Alternating Stress in the Fastener	= 2861.22 Lb/in²
Maximum Fastener Force	= 61397.15 Lb
Minimum Residual Force on the Joint	= 2944.30 Lb
Force reducing Clamp Force on the Joint	= 32088.31 Lb
Force increasing the Fasteners Tension	= 3254.69 Lb
Tensile Stress due to Preload	= 38719.65 Lb/in²

S U M M A R Y O F T H E R E S U L T S

FASTENER CLAMP FORCE ANALYSIS

Fastener Preload	= 58142.45 Lb
Maximum Clamping Force required	= 55198.15 Lb
Factor of Safety	= 1.05

CONCLUSION
Due to the relatively small residual clamp force, the fastener will have an inherently low resistance to loosening.

FASTENER OVERLOADING ANALYSIS

Direct Force that would Yield the Fastener	= 112621.98 Lb
Maximum Fastener Force	= 61397.15 Lb
Factor of Safety	= 1.83

CONCLUSION
The force in the fastener will not exceed its yield strength based on the data entered.

FASTENER FATIGUE FAILURE ANALYSIS

Fatigue Endurance Limit for the Fastener	= 4871.52 Lb/in²
Induced Alternating Stress in the Fastener	= 2861.22 Lb/in²
Factor of Safety	= 1.70

CONCLUSION
The fastener should not sustain fatigue failure based upon the data entered.

SURFACE PRESSURE ANALYSIS

Limiting Surface Pressure for the Material	= 80000.00 Lb/in²
Surface Pressure under the Nut Face	= 32311.98 Lb/in²
Factor of Safety	= 2.48

CONCLUSION
The surface pressure calculated is within the quoted maximum value.

OVERALL CONCLUSIONS
All safety factors are greater than unity, the defined fastener is capable of sustaining the applied forces entered by the user.

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