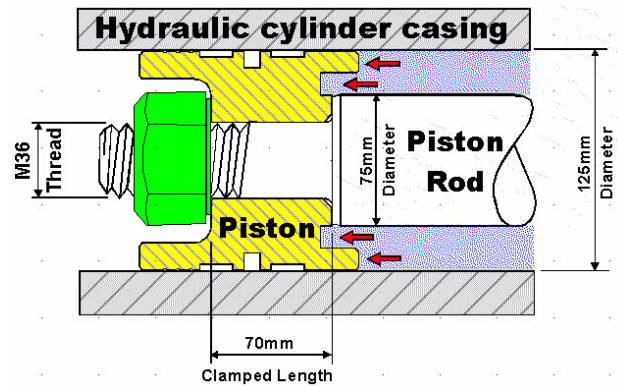


## BOLTCALC Program - Example Problem (Metric Units and thread)

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 mm <sup>2</sup>
Thread Root Area	= 759.280 mm <sup>2</sup>
Bearing Area under Nut/Bolt Head	= 1021.622 mm <sup>2</sup>
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/mm <sup>2</sup>
Fastener Modulus of Elasticity	= 208000.00 N/mm <sup>2</sup>
Fatigue Endurance Limit for the Fastener	= 33.75 N/mm <sup>2</sup>

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/mm <sup>2</sup>
Amount of Embedding within the Joint	= 0.00412 mm
Limiting Surface Pressure for the Material	= 400.00 N/mm <sup>2</sup>

### 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

Fastener Preload	= 310403.76 N
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/mm <sup>2</sup>
Induced Alternating Stress in the Fastener	= 31.45 N/mm <sup>2</sup>
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/mm <sup>2</sup>

## SUMMARY OF THE RESULTS

### 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/mm <sup>2</sup>
Induced Alternating Stress in the Fastener	= 31.45 N/mm <sup>2</sup>
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/mm <sup>2</sup>
Surface Pressure under the Nut Face	= 322.08 N/mm <sup>2</sup>
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

**Bolt Science – Expertise in Bolted Joint Technologies**

**Bolt Science Limited**

**15 Isleworth Drive, Chorley, Lancashire, U.K. PR7 2PU**

**Tel +44 (0) 1257 411503**

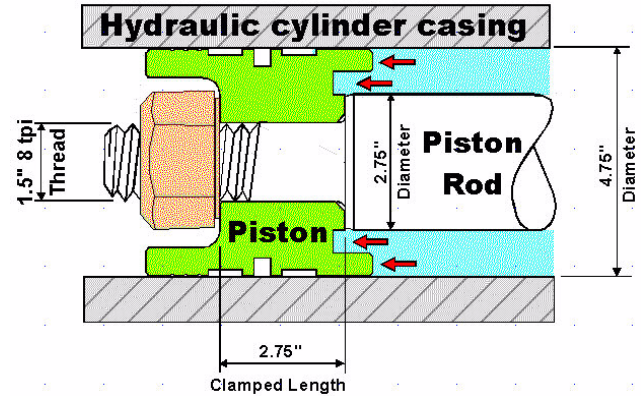
**Fax +44 (0) 1257 411650**

**Email [info@boltscience.com](mailto:info@boltscience.com)**

**URL: [www.boltscience.com](http://www.boltscience.com)**

## 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/in<sup>2</sup>, 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 in <sup>2</sup>
Thread Root Area	= 1.424 in <sup>2</sup>
Bearing Area under Nut/Bolt Head	= 1.900 in <sup>2</sup>
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/in <sup>2</sup>
Fastener Modulus of Elasticity	= 30000000 Lb/in <sup>2</sup>
Fatigue Endurance Limit for the Fastener	= 4871.519 Lb/in <sup>2</sup>

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/in <sup>2</sup>
Amount of Embedding within the Joint	= 1.592E-4 in
Limiting Surface Pressure for the Material	= 80000.00 Lb/in <sup>2</sup>

### 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 required 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/in <sup>2</sup>
Induced Alternating Stress in the Fastener	= 2861.22 Lb/in <sup>2</sup>
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/in <sup>2</sup>

### SUMMARY OF THE RESULTS

#### 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/in <sup>2</sup>
Induced Alternating Stress in the Fastener	= 2861.22 Lb/in <sup>2</sup>
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/in <sup>2</sup>
Surface Pressure under the Nut Face	= 32311.98 Lb/in <sup>2</sup>
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.

**Bolt Science – Expertise in Bolted Joint Technologies**  
 Bolt Science Limited  
 15 Isleworth Drive, Chorley, Lancashire, U.K. PR7 2PU  
 Tel +44 (0) 1257 411503  
 Fax +44 (0) 1257 411650  
 Email [info@boltscience.com](mailto:info@boltscience.com)  
 URL: [www.boltscience.com](http://www.boltscience.com)