MECH 200

Design Project #2

Hydraulic Cylinder

Group 16

[redacted]

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Ben Roberts - V00974976

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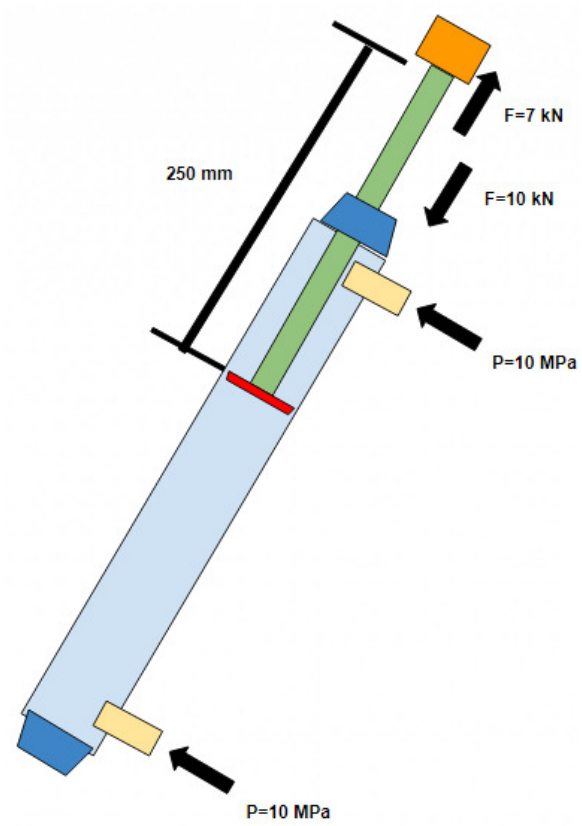
Design Calculations



Area of the Piston:

Pushing:

$P = F/A \rightarrow A1 = F/P = 10kN/10MPa = 1000\,mm^2$

Pulling:

$P = F/A \rightarrow A2 = F/P = 7kN/10MPa = 700\,mm^2$

Area the rod Encompasses:

$A = A1 - A2 = 1000\,mm^2 - 700\,mm^2 = 300\,mm^2$

Diameter of Piston:

$d = 2 \times \sqrt{A1/\pi} = 35.68\,mm = 1.405"$

Diameter of Rod:

$d = 2 \times \sqrt{A/\pi} = 19.54\,mm = 0.769"$

Cylinder wall thickness:

$I.D_{Cylinder} = O.D_{O-ring} = 1.475"$

$t = PD/2\sigma \rightarrow t = (1450.377psi)(1.475")/2\sigma \rightarrow t = 1069.653/\sigma$

$O.D = I.D + 2t$

Outside Diameter of Iron Gland:
OD gland = OD cylinder = ID cylinder + 2t (for low carbon steel, see page 4) = 1.475” +2(0.0238") = 1.523”

ID Iron Gland:
ID gland =OD Rod + clearance = .769”+ ~3 thou = ~ .772”

O-Ring Parameters:

- Material: Buna-N
- Hardness: 70
- Size
    - Similar to McMaster-Carr #: 9452K114
    - OD: 1.475”
    - ID: 1.335”
    - Width: 0.07”
- Backup Rings x 2
    - Similar to McMaster-Carr #: 9560K108
    - OD: 1.441”
    - ID: 1.335”
    - Width: 0.049”

Low Carbon Steel Gland O-Ring Parameters:

- Quantity: 4 (2 inner, 2 outer)
- Material: Buna-N
- Hardness: 70
- Size (Outer O-Ring):
  - OD: 1.58”
  - ID: 1.38”
  -Thickness: 0.1”
- Size (Inner O-Ring):
  -OD: 0.81”
  -ID: 0.71”
  -Thickness: .05”

Cylinder Material Options:

- 6061 Aluminum - $t > 0.0306$
- 2024 Aluminum - $t > 0.0255$
- 5086 Aluminum - $t > 0.0383$
- Low-Carbon Steel - $t > 0.0238$
- 4140 Alloy Steel - $t > 0.0179$
- 4130 Alloy Steel - $t > 0.0153$
- 304 Stainless Steel - $t > 0.0357$

Material Cost Analysis:

Material Choice	Wall Thickness	I.D	O.D	Yield Strength (psi)	Cost (for 1ft)	Notes	OD Required (I.D. + 2*t)
Alum. 6061	0.035	1.402	1.5	35000	17.19	Viable	1.472
Alum. 2024	0.035	1.43	1.5	42000	18.83	Viable	1.5
Alum. 5086	0.113	0.842	1.05	28000	64.55	NA	1.068
Low-Carbon Steel	0.049	1.402	1.5	45000	5.56	Viable	1.5
4140 Alloy Steel	0.083	1.459	1.625	70000	26.58	Viable	1.625
304 Stainless steel	0.035	1.43	1.5	24000	23.89	Viable	1.5

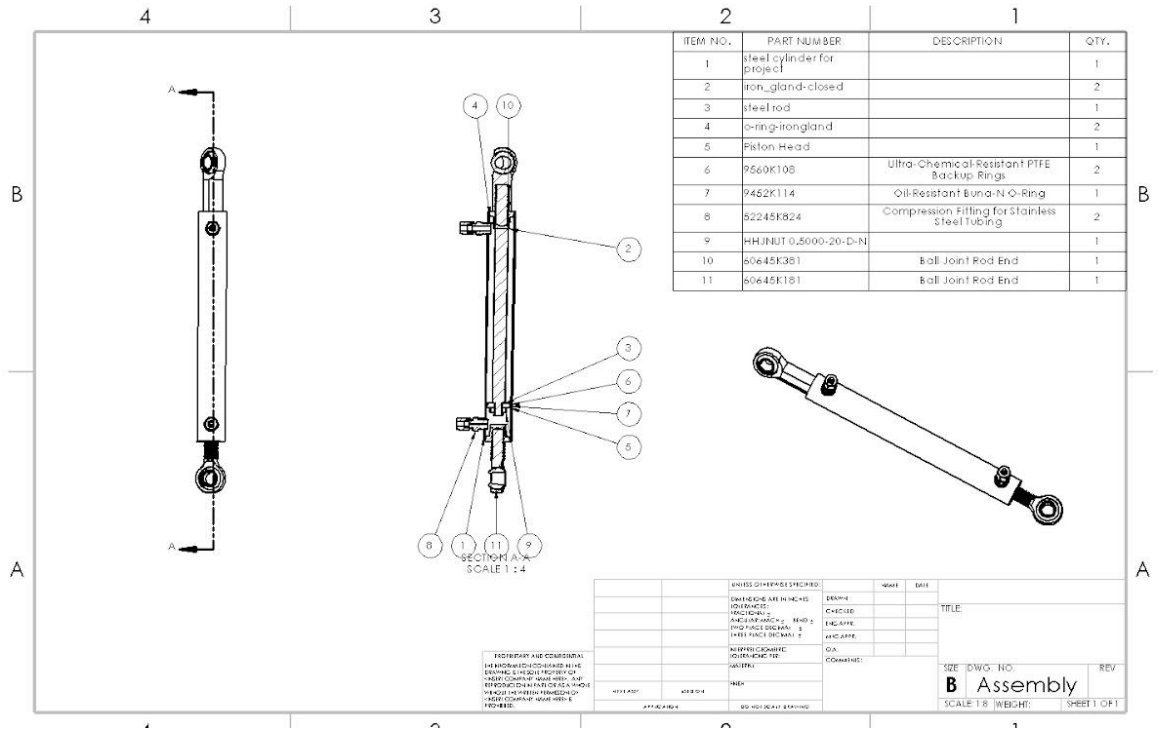
Based on this table we can decide that the best material to go with according to mcmaster carr and our calculations is Low-Carbon Steel as it is very strong and also is the most affordable when compared to the others analyzed.

Engineering Bill of Materials:

Part No.	Description	Quantity	Unit Cost ($)	Cost ($)	McMaster Carr Part ID
1	1.472” Iron Gland (Open)	1	139.00	139.00	2019N113
2	1.472” Iron Gland (Closed)	1	139.00	139.00	2019N113
3	1.523” Low-Carbon Steel Cylinder	1	5.56	5.56	Custom
4	3/8” NPT Hose Connection	2	97.88	195.76	52245K824
5	Steel Rod	1	34.26	34.26	Custom
6	1.405” diameter Piston	1	30.24	30.24	Custom
7	Rod End (Female)	1	10.20	10.20	60645K381
8	Rod End (Male)	1	89.90	89.90	60645K181
9	Piston O-Ring	1	10.55	10.55	Custom
10	Piston Backup Ring	2	16.11	32.22	Custom

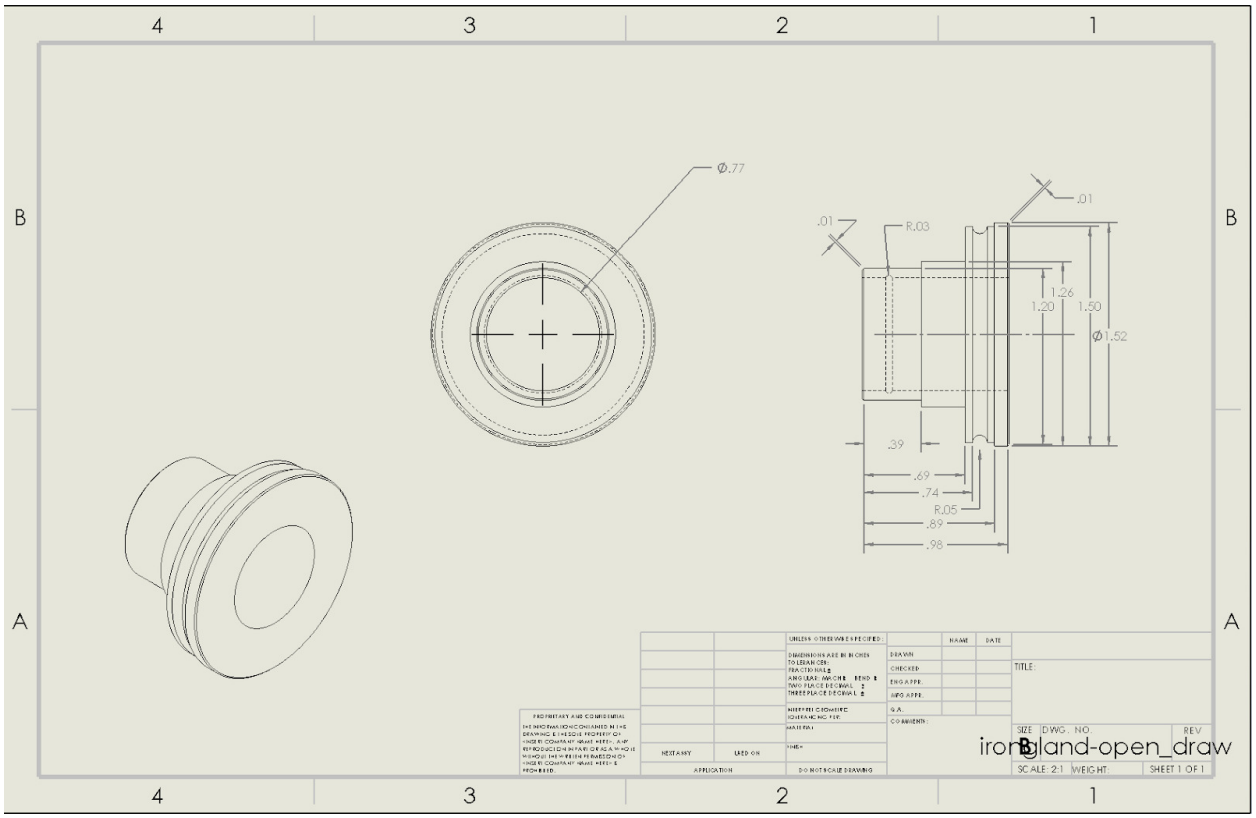
11	Nut for piston	1	12.40	12.40	91879A032
12	028 Buna-N O-Ring for Glands (Outer)	2, Minimum order 100	10.82	10.82	9452K115
13	017 Buna-N O-Ring for Glands (Inner)	2, Minimum order 100	5.85	5.85	9452K71
TOTAL			585.66	**699.65**	

Assembly Drawing:

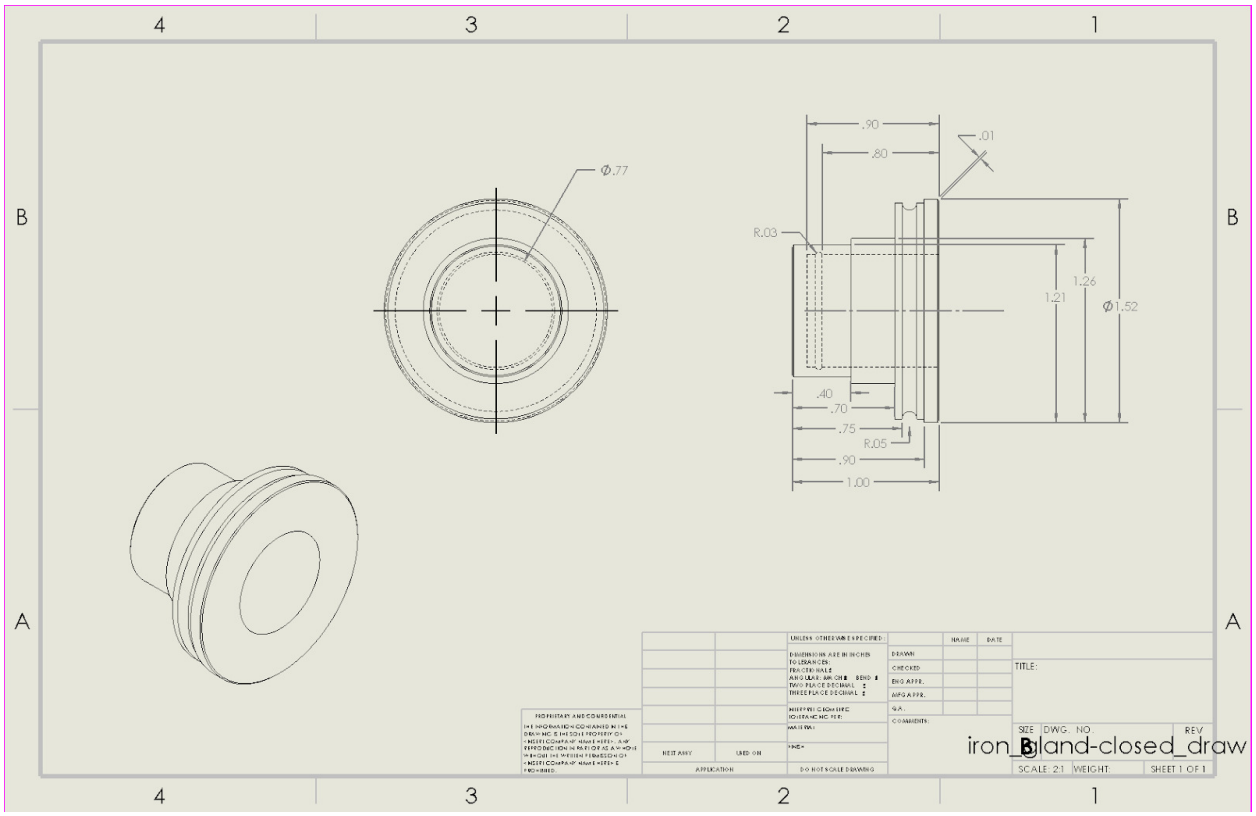


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	steel cylinder for project		1
2	iron_gland-closed		2
3	steel rod		1
4	o-ring-irongland		2
5	Piston Head		1
6	9560K108	Ultra-Chemical-Resistant PTFE Backup Rings	2
7	9452K114	Oil-Resistant Buna-N O-Ring	1
8	52245K824	Compression Fitting for Stainless Steel Tubing	2
9	HHJNUT 0.5000-20-D-N		1
10	60645K381	Ball Joint Rod End	1
11	60645K181	Ball Joint Rod End	1

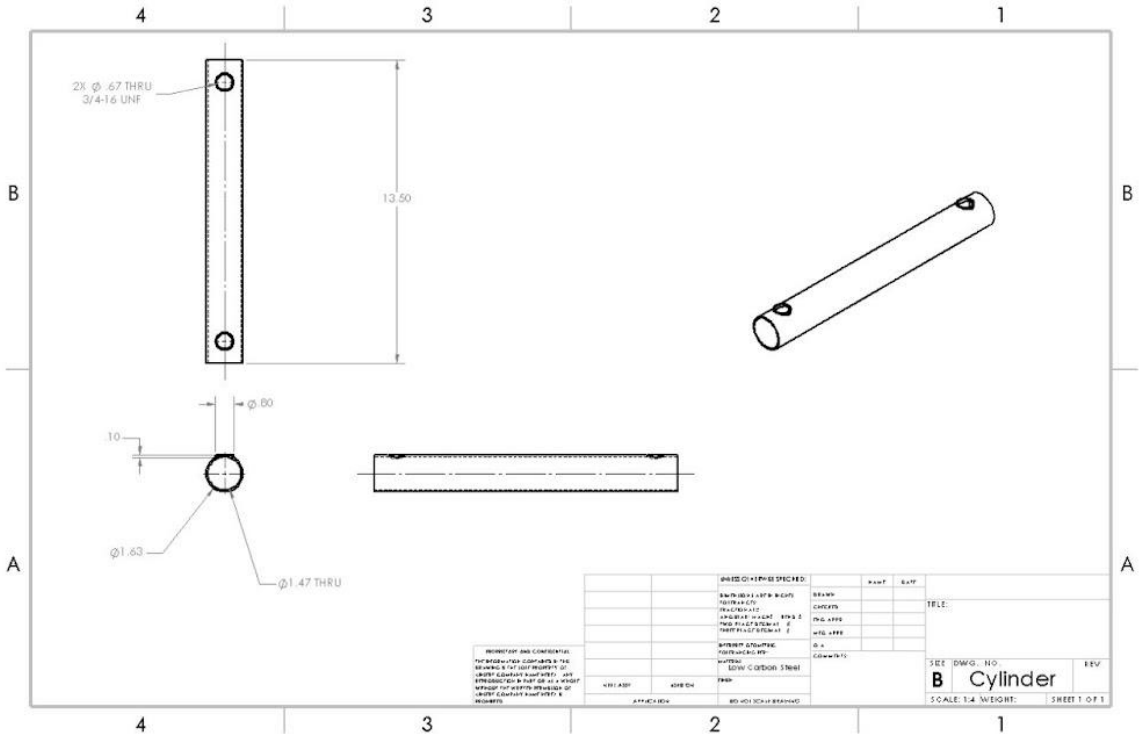
Part No. 1:


4
3
2
1
B
A
Ø.77
.01
.01
R.03
1.26
1.20
1.50
Ø1.52
.39
.69
.74
R.05
.89
.98
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
SIZE
DWG. NO.
REV
SCALE: 2:1
WEIGHT:
SHEET 1 OF 1
ironEngland-open_draw

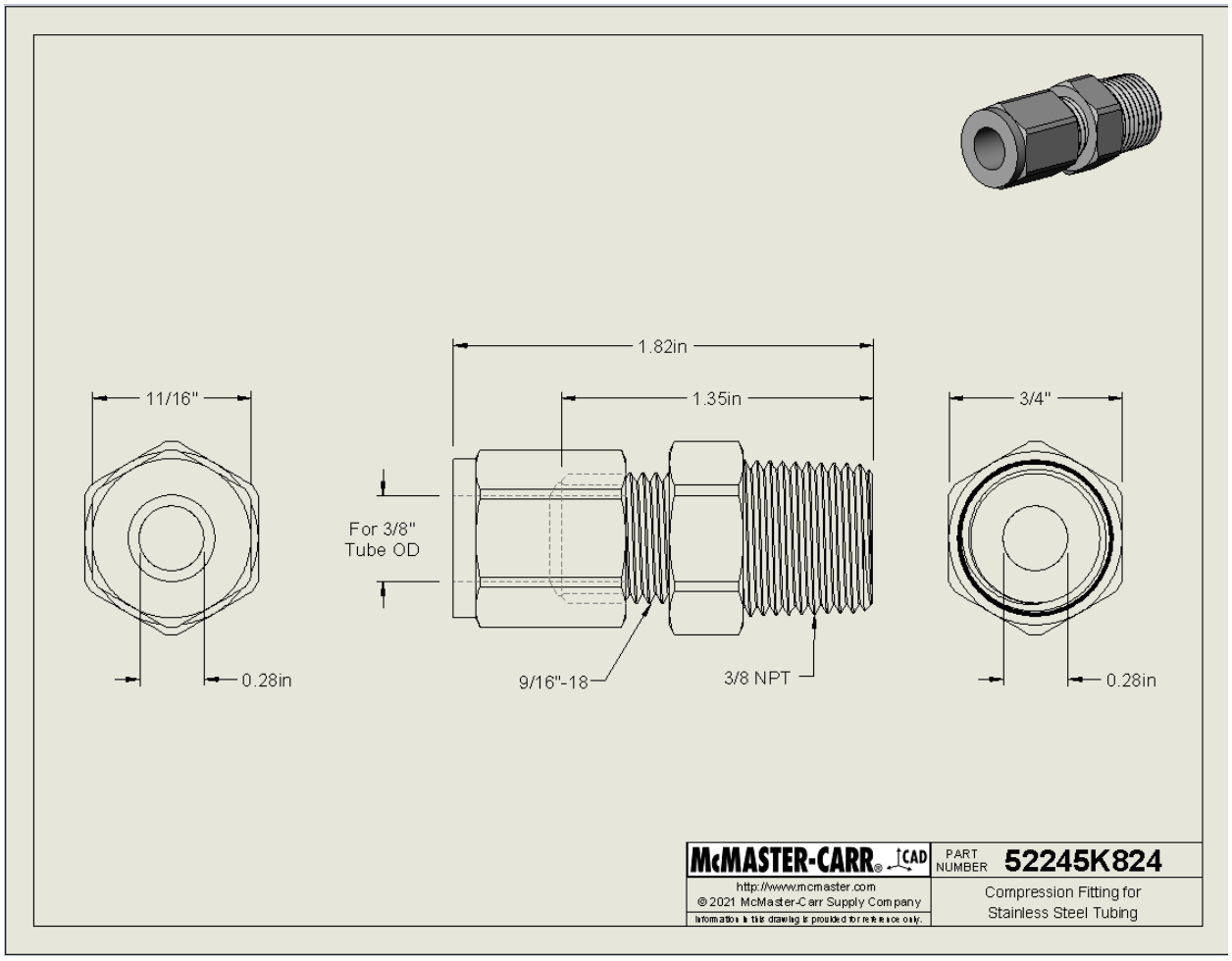
Part No. 2:


4
3
2
1
B
A
Φ.77
.90
.80
.01
R.03
1.26
1.21
Φ1.52
.40
.70
.75
R.05
.90
1.00
iron_gland-closed_draw
SIZE
DWG. NO.
REV
SCALE: 2:1
WEIGHT:
SHEET 1 OF 1

Part No. 3:

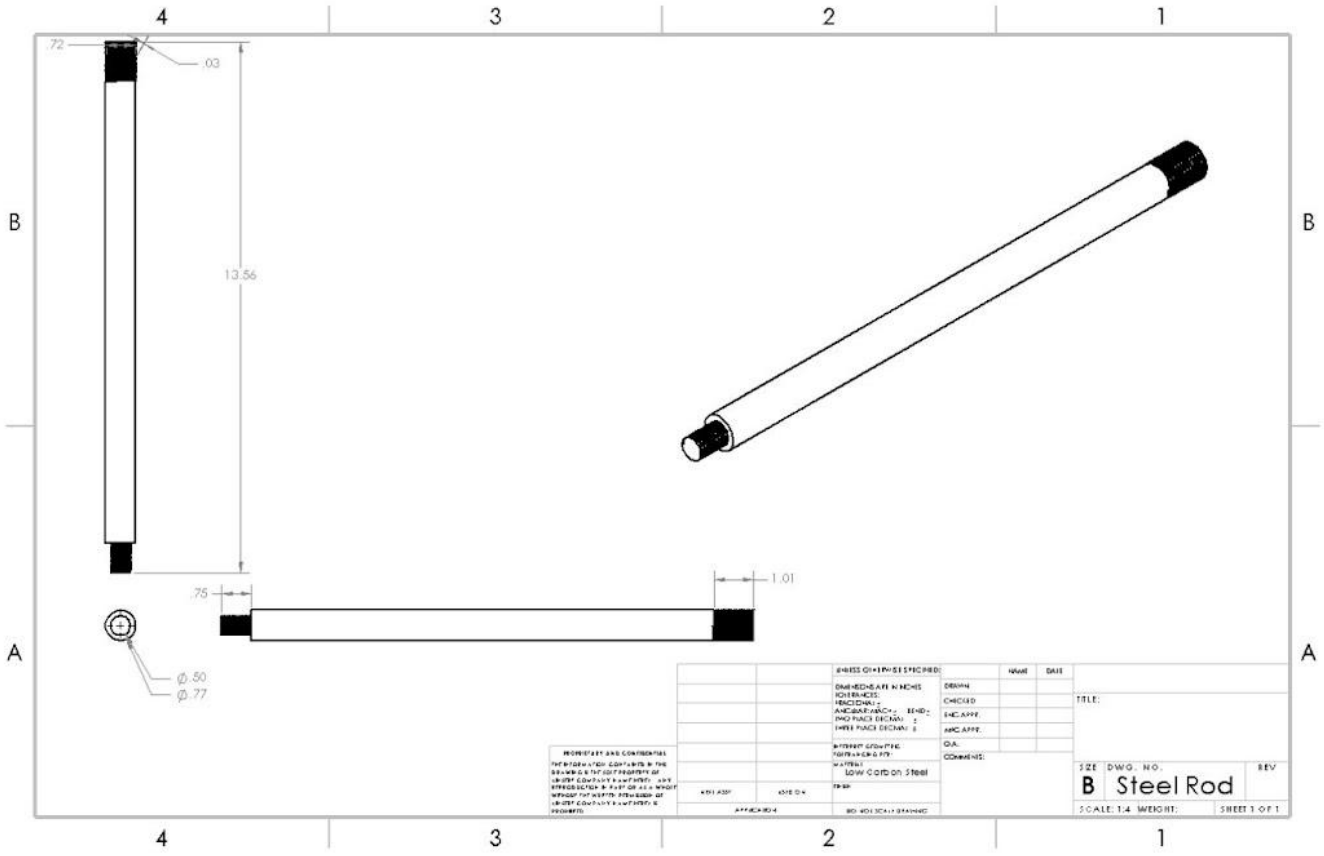

2X Ø .67 THRU
3/4-16 UNF
13.50
Ø.80
10
Ø1.63
Ø1.47 THRU
Low Carbon Steel
B
Cylinder
SCALE: 1:4 WEIGHT:
SHEET 1 OF 1

Part No. 4:

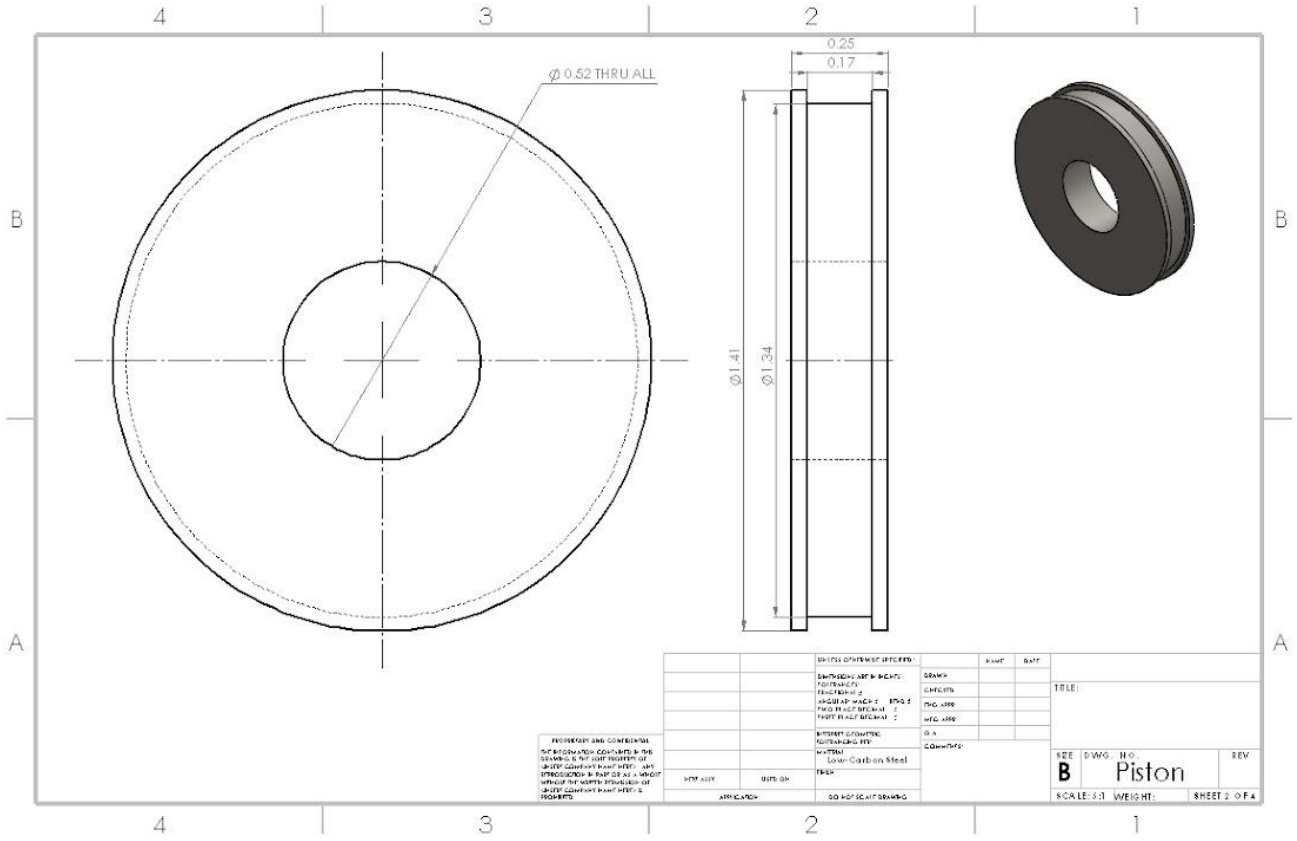

1.82in
1.35in
11/16"
3/4"
For 3/8"
Tube OD
0.28in
9/16"-18
3/8 NPT
0.28in
McMASTER-CARR
CAD
PART NUMBER 52245K824
http://www.mcmaster.com
© 2021 McMaster-Carr Supply Company
Information in this drawing is provided for reference only.
Compression Fitting for
Stainless Steel Tubing

\

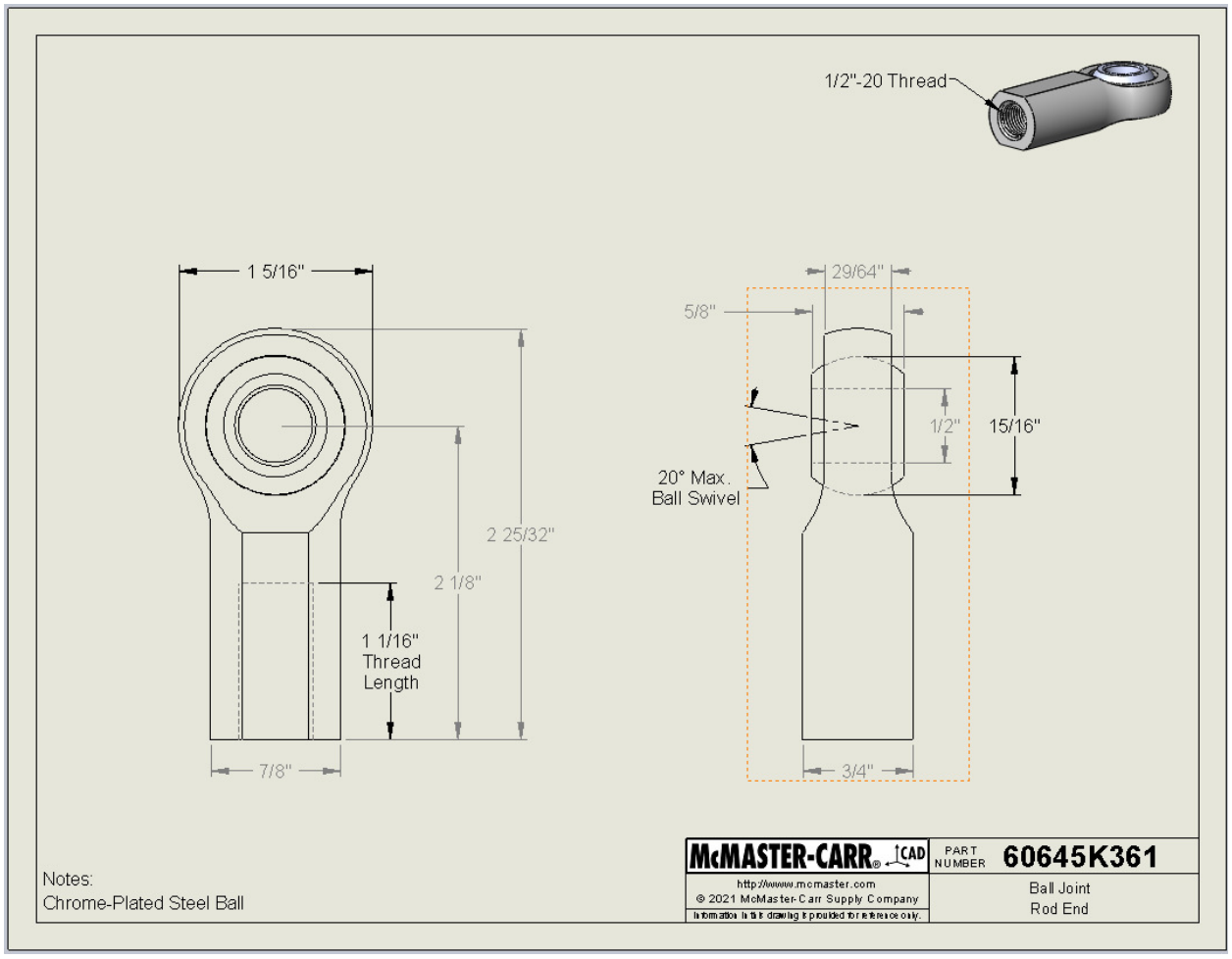
Part No. 5:



Part No. 6:


Ø 0.52 THRU ALL
0.25
0.17
Ø1.41
Ø1.34
Low Carbon Steel
Piston
B
SCALE: 5:1
SHEET 2 OF 4

Part No. 7:


1/2"-20 Thread
1 5/16"
2 25/32"
2 1/8"
1 1/16"
Thread
Length
7/8"
29/64"
5/8"
1/2"
15/16"
20° Max.
Ball Swivel
3/4"
Notes:
Chrome-Plated Steel Ball
McMASTER-CARR
CAD
http://www.mcmaster.com
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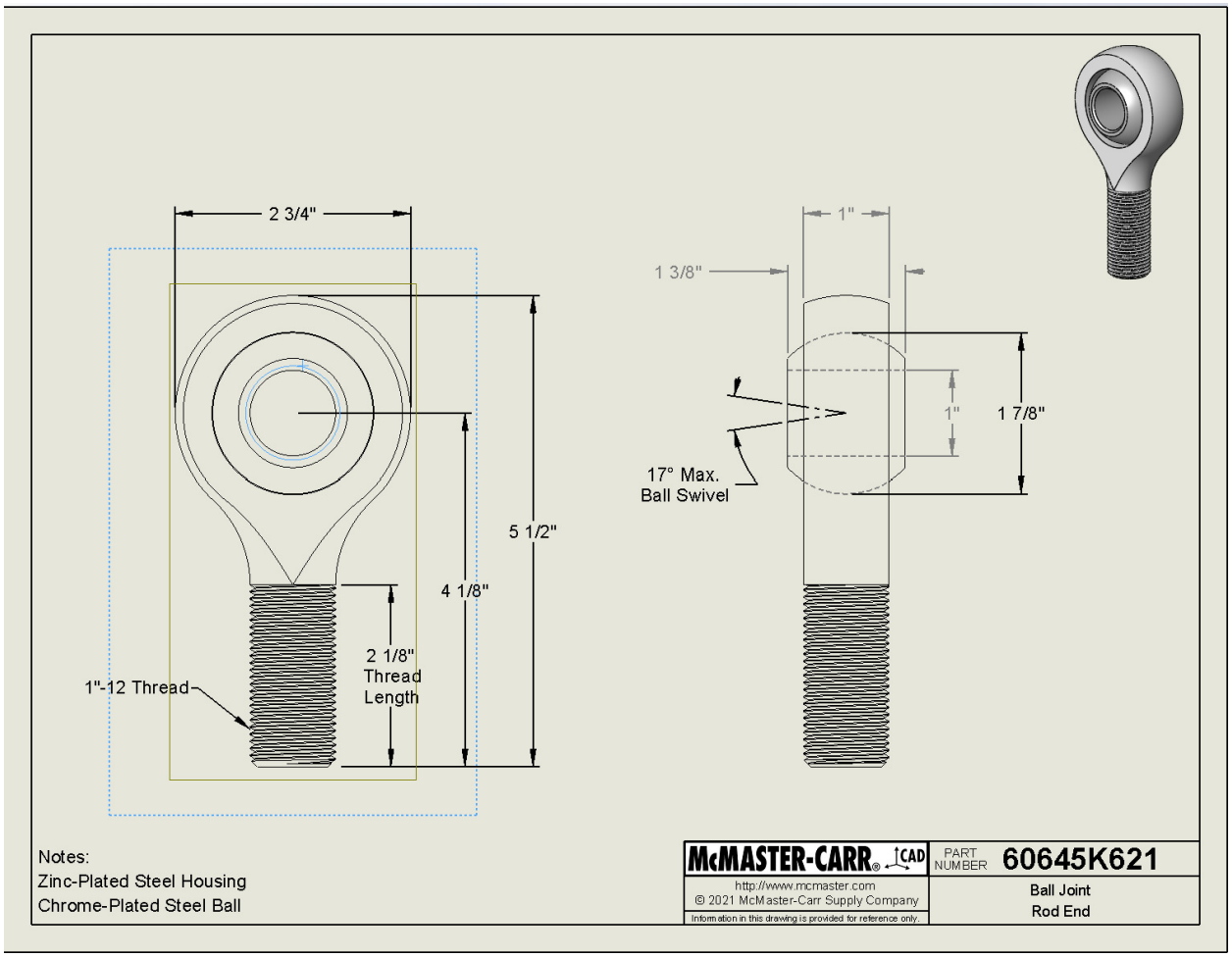
Information in this drawing is provided for reference only.
PART NUMBER
60645K361
Ball Joint
Rod End

Part No. 8


2 3/4"
1"
1 3/8"
1"
1 7/8"
17° Max.
Ball Swivel
5 1/2"
4 1/8"
2 1/8"
Thread
Length
1"-12 Thread
Notes:
Zinc-Plated Steel Housing
Chrome-Plated Steel Ball
McMASTER-CARR
CAD
http://www.mcmaster.com
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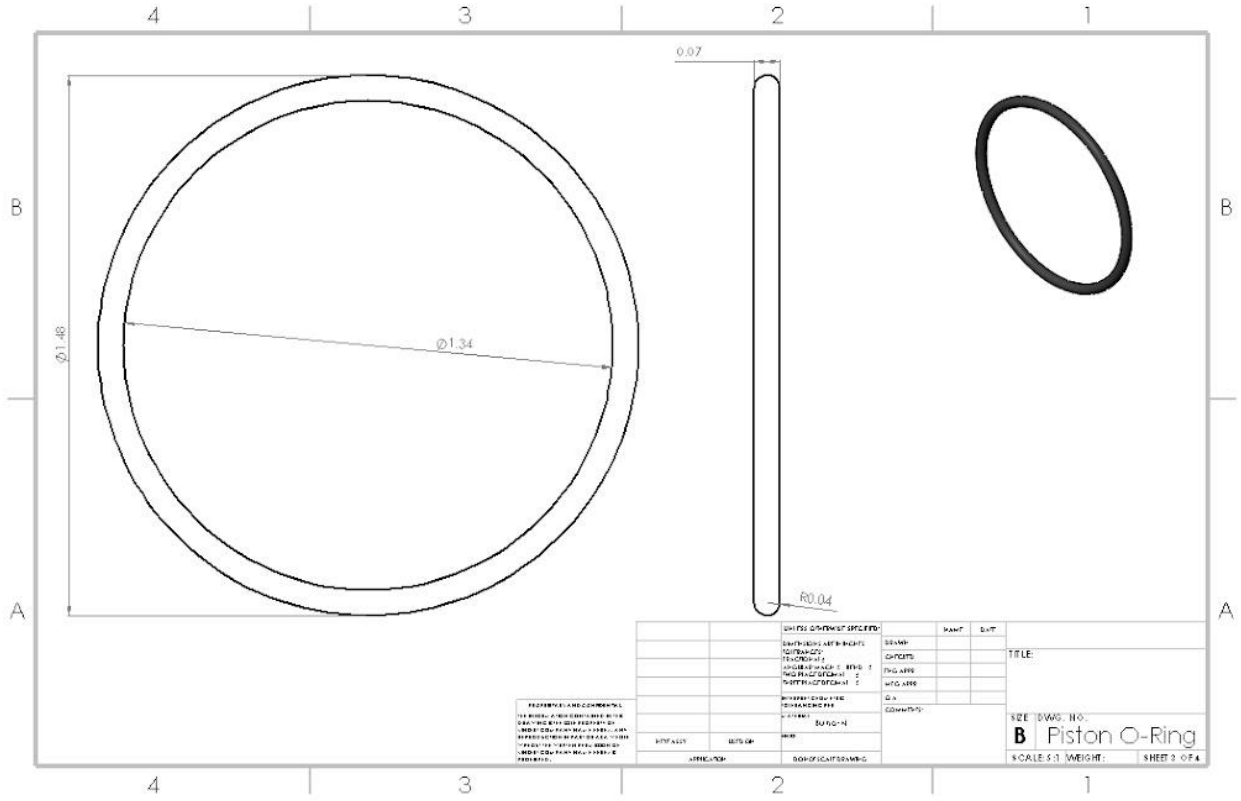
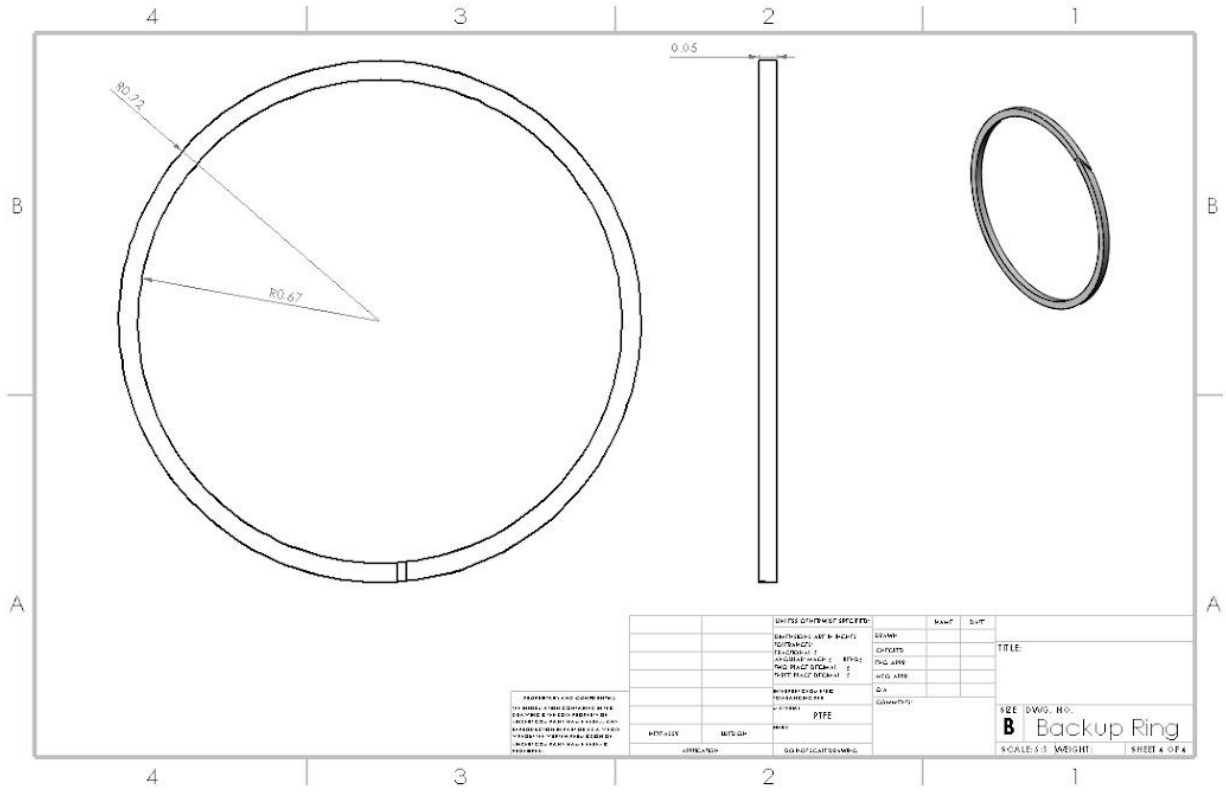
Information in this drawing is provided for reference only.
PART NUMBER 60645K621
Ball Joint
Rod End

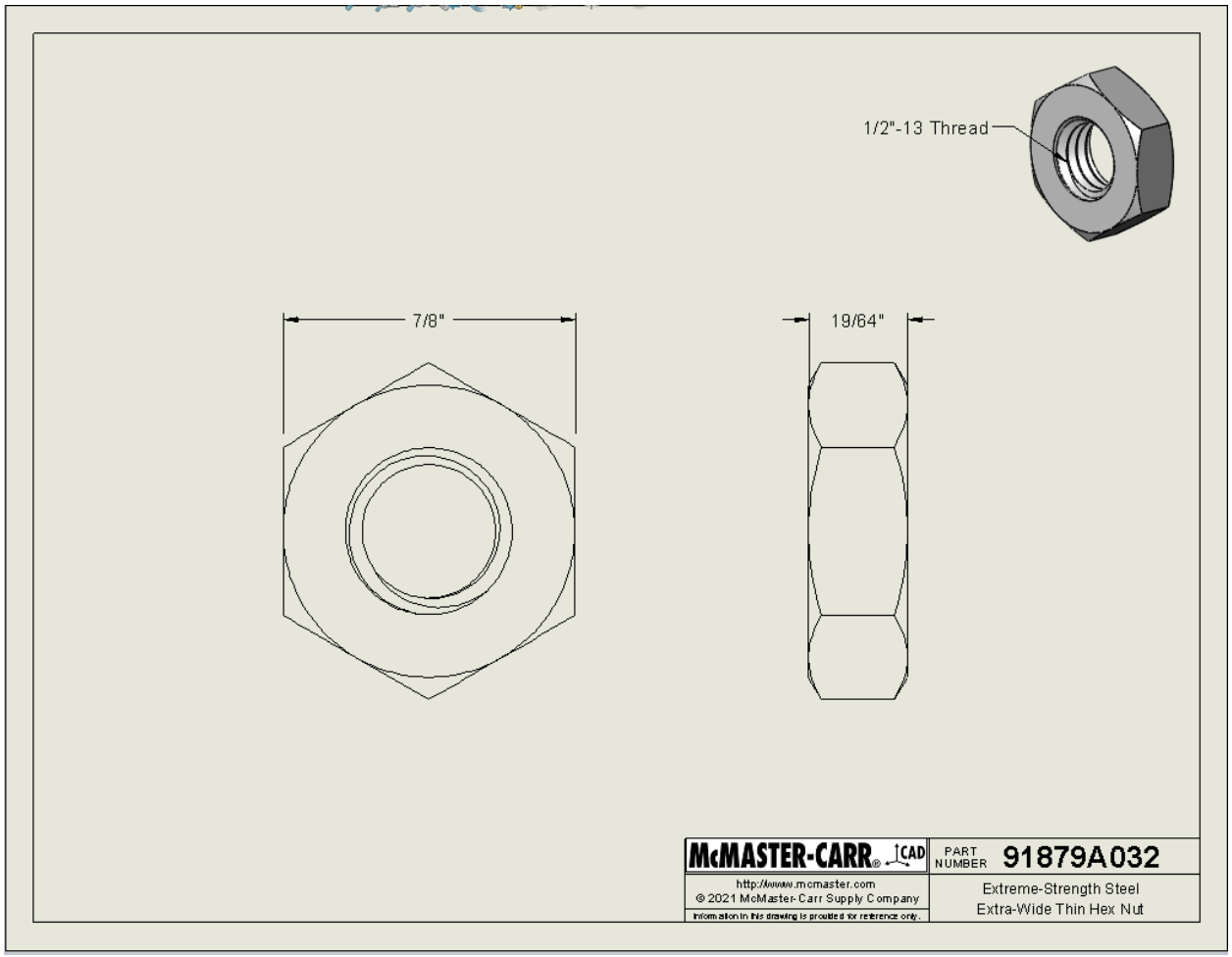
Part No. 9:



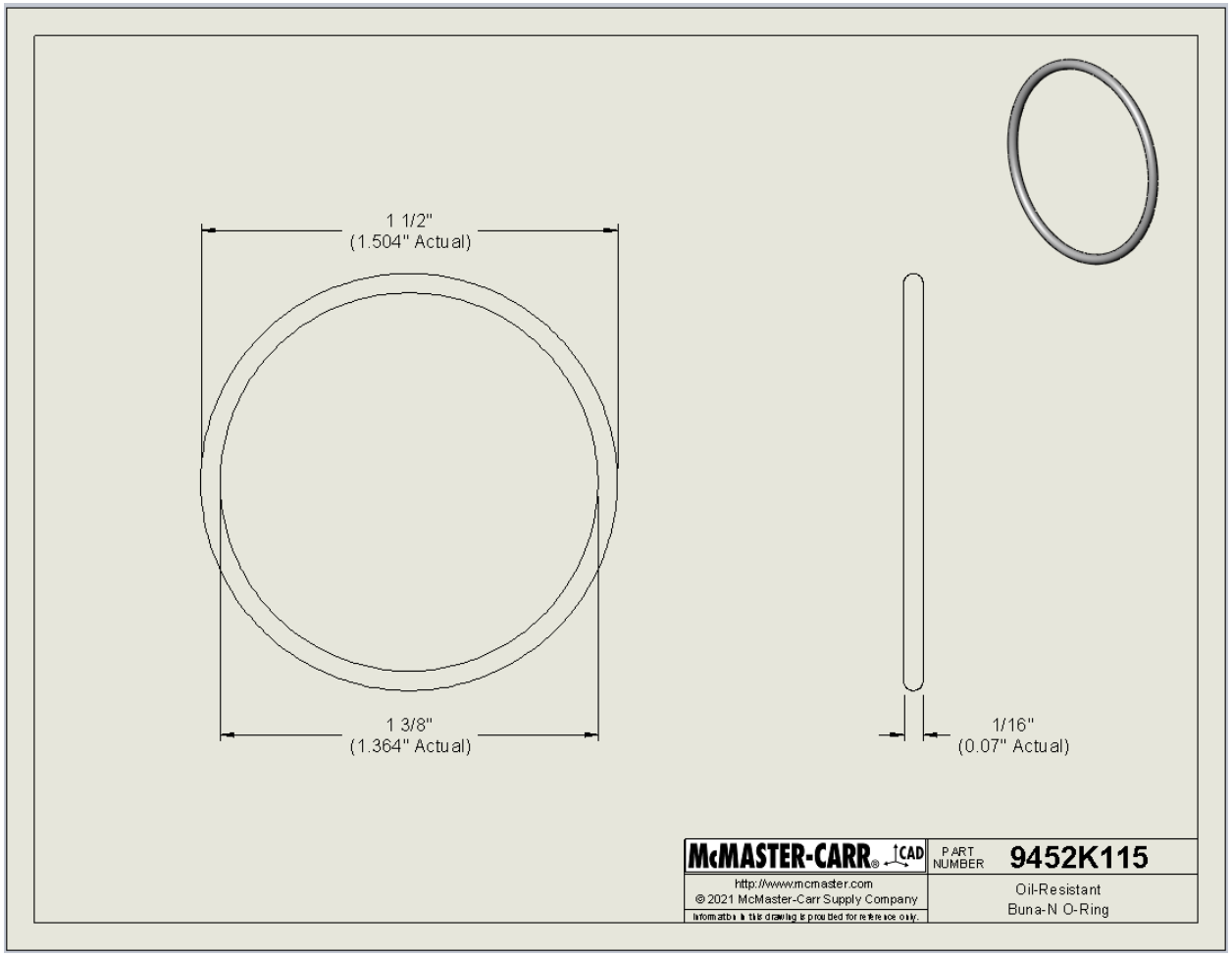
Part No. 10:



Part No. 11:


1/2"-13 Thread
7/8"
19/64"
McMASTER-CARR
CAD
PART NUMBER 91879A032
http://www.mcmaster.com
© 2021 McMaster-Carr Supply Company
Information in this drawing is provided for reference only.
Extreme-Strength Steel
Extra-Wide Thin Hex Nut

Part No. 12:


1 1/2"
(1.504" Actual)
1 3/8"
(1.364" Actual)
1/16"
(0.07" Actual)
McMASTER-CARR
CAD
PART NUMBER
9452K115
http://www.mcmaster.com
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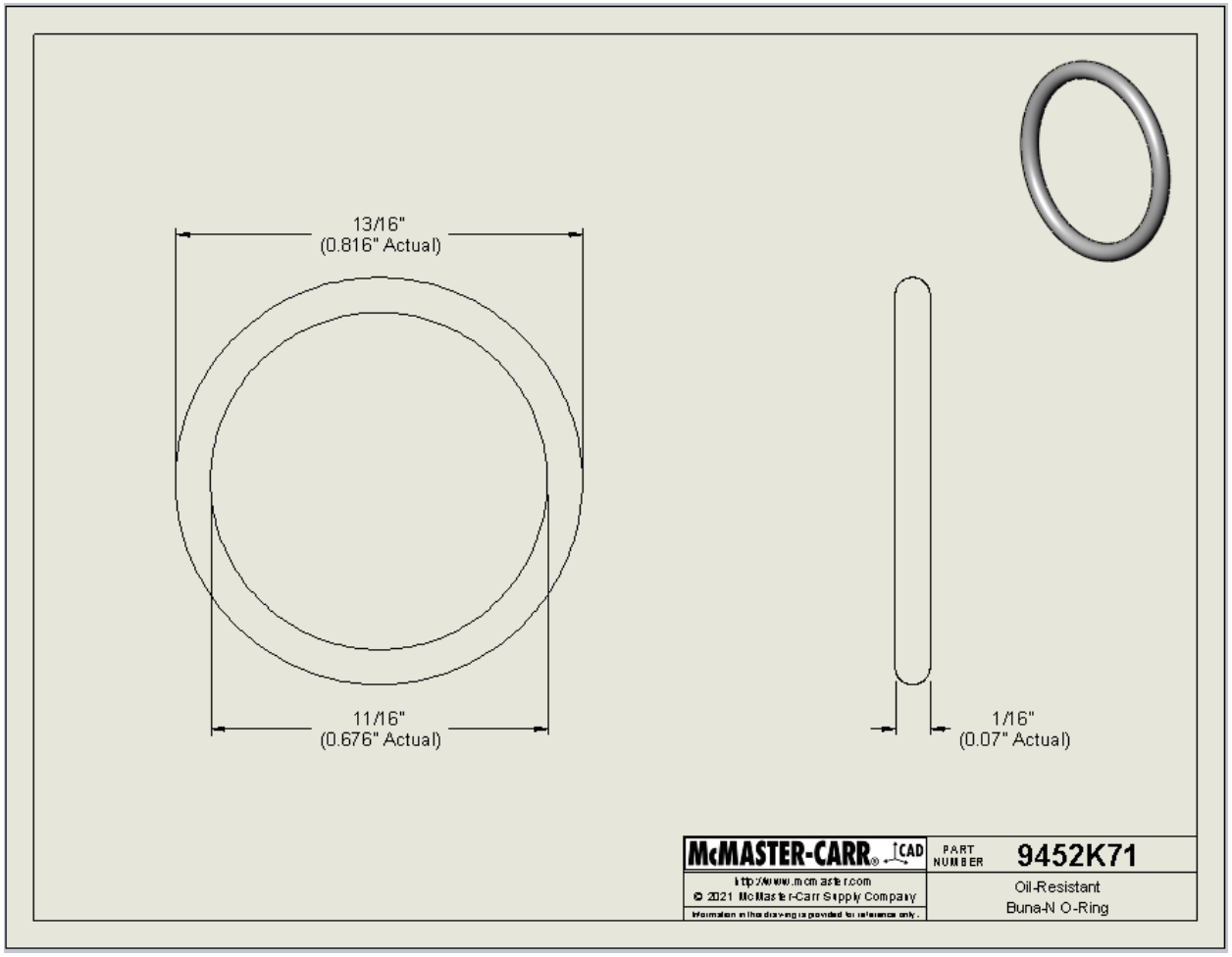
Information in this drawing is provided for reference only.
Oil-Resistant
Buna-N O-Ring

Part No. 13:


13/16"
(0.816" Actual)
11/16"
(0.676" Actual)
1/16"
(0.07" Actual)
McMASTER-CARR
CAD
http://www.mcmaster.com
© 2021 McMaster-Carr Supply Company
Information in this drawing is provided for reference only.
PART NUMBER
9452K71
Oil-Resistant
Buna-N O-Ring