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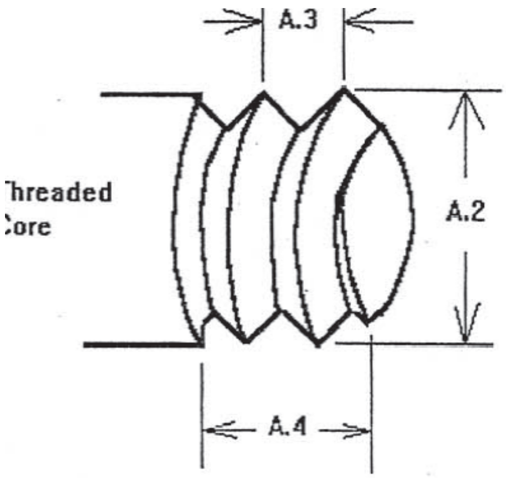
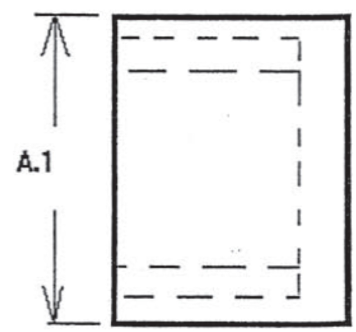
Example Problem for Hydraulic Unscrewing Device

This example will follow the DME Hydraulic Unscrewing Device "Engineering Design Guide".

DME Company Hydraulic Unscrewing Customer Cap information





A.1 = Plastic Cap Maximum Outside Diameter
A.2 = Threaded Core Maximum Outside Diameter of the Threads
A.3 = Threaded Core Thread Lead {= 1/Pitch where Pitch + # Threads/Unit Distance}
A.4 = Threaded Core Maximum Thread Length

Dimensions for the DME Mold Saver Cap Example (Customer application Information) is given as follows:

A. Enter in Application Information for the Caps

- ☐ 1.206" A.1) Enter the maximum outside diameter of Cap in Inches.
- ☐ 1.106" A.2) Enter the maximum outside Thread Diameter in Inches.
- ☐ 0.157" A.3) Enter the Thread Lead in Inches/Thread (Example: 8 threads per inch would be = 0.125 Inches/Thread.)
- ☐ 0.422" A.4) Enter threaded length of Cap in Inches.
- ☐ 15.000 A.5) Enter the maximum Injection Molding Cavity Pressure that will not be exceeded (Typical Injection Molding Machines generate up to 20,000 PSI Max. at the barrel).
- ☐ 2.000 A.6) Enter the maximum Hydraulic Pressure available (Maximum is 2,175 PSI).
- ☐ 8 A.7) Enter the desired number of cavitites in the mold.

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B. CALCULATE THE NUMBER OF THREADS/REVOLUTIONS TO REMOVE THE THREADED CORE

☐ 3.2 B.1) Enter the number of Threads or Revolutions to remove the Threaded Core.

Approach #1-Exact Calculation from Catalog

= [A.4] / [A.3] + (minimum .5 revolutions)
= [0.422] / [0.157] + .5
= 2.687898089 + .5
= 3.187898089

Round to 3.2 turns. This is the valued used for this example.
Note that the entire threaded core will be removed from the cap.

Approach #2- Use only the number of turns required to remove threads. Assume that the stripper plate will push the cap off the core.

Visually it takes 1.25 turns before the cap can be removed from the bottle
= 1.25 + .5
= 1.75 turns
Note that the threaded core will still be overlapping inside the cap. The stripper plate must push the cap completely off the remaining core.

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DME Company Hydraulic Unscrewing Customer Cap information

C. SELECTING THE MINIMUM SPACING BETWEEN CAP CAVITIES

☐ 2.125” C.1) Enter the minimum Cavity Spacing, Center to Center Distance in Inches.

Approach #1-Moldmaker knows the distance through years of experience and available bar stock diameters.

The maximum O.D. of the Cap in [A.1] was 1.206”
Assume the moldmaker would leave 1/2” material around Cap Cavity.
Assume moldmaker would pick inserts of 2-1/2” O.D. material.
When using cavity inserts, the moldmaker might leave 1/8” spacing between inserts
Standard DME Cavity Insert Rounds are 1”, 1-1/2”, 2”, 2-1/2”, 3”, 3-1/2” and 4” diameters
=2.500 + 0.125”
= 2.625”

Approach #2- DME DME Mold Components Catalog Procedure 3 Lookup Table

This table assumes a P-5 Cavity Insert Material with a Core Hardness of Rc = 15-25. The maximum cavity deflection that would be allowed is 0.001” total.

From the Table using [A.1] = 1.206, use 1.3 and [A.5] = 15,000
For a solid steel plate, minimum O.D. = 1.973” with 0.673” steel in between cavities. When using cavity inserts, you must add extra stock, for example 1/8” or 0.125”. Typically pick the next larger standard round size, so O.D. = 2”.
= 2.000 + 0.125”
= 2.125” (Note: This is the value we will use for this example problem.)

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Approach #3-DME Procedure 2-Step by Step Calculation Method

Assume using a H-13 hardened core at 800°F service.

Step 1: Calculate the minimum O.D. due to Cavity Deflection Criteria.
since [A.1] = 1.206”, use 1.3” and [A.5] = 15,000.
From the Table, minimum O.D. = 1.917” between 0.616”, and stress = 40,543 PSI

Step 2: Maximum Hoop Stress = 15,000 PSI x $((1.919^2 + 1.206^2) / (1.919^2 + 1.206^2))$
Maximum Hoop Stress = 15,000 x (5.136997 / 2.228125) = 15,000 x 2.3055246
Maximum Hoop Stress = 34, 582 PSI

Step 3: Check design stress levels for H-13 Rc 44 Design Stress < 68,400 PSI
Note: Maximum Hoop Stress 34, 582 PSI < Design Stress 68,400 PSI “True goto Step 4”
=SQRT { [15,000 x 1.206^2) / 68,400 + 1.206^2] / [1-15,000/68,400] }
=SQRT { [21,816.54) / 68,400 + 1.454436] / [0.780701755] }
=SQRT { [1.773391263] / [0.780701755] } = SQRT {2.271534874} = 1.508” Minimum Diameter

Step 4: Select Cavity Insert O.D. that will be used. Minimum O.D. = 1.917”
Step 5: between = 1.917 - 1.206 = 0.711”, if cavity inserts, use 2” diameter Bar = 2 - 1.206 = .794
Step 6: Minimum Cavity Spacing = 2”, Cavity Insert + 1/8” clearance = 2.125” spacing

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Example Problem for Hydraulic Unscrewing Device

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D. CALCULATING THE UNSCREWING TORQUE FOR ONE CAVITY

☐ 243.1 D.1) Enter the Torque in Inch-Pounds (in/lbs) required to unscrew the threaded core.
Note: These figures should only be used as a guideline as many other factors will affect the calculation.
(Material variation of dimensions, material shrinkage, core surface area, temperature, lubricant/friction, etc.)

Approach #1-DME Appendix BProcedure 1 Calculation Method

f) RP = [A.5] / 100 = 15,000 / 100 = 150 PSI residual pressure

g) SA = [A.2] x π x [A.4] x 2
= 1.106 x 3.14 x 0.422 x 2
= 2.931 Surface area of threads

h) UT = RP x SA [A.2] / 2 = 150 x 2.931 x 1.106 / 2
UT = Unscrewing Torque = 243.1 in-lbs (we will use this value)

Approach #2- DME Appendix D Procedure 2 Look Up Table Method

Using O.D. of Thread [A.2] = 1.106" use Table Value of 1-1/8"
Using Thread Length [A.4] = 0.422 use Table Value of 7/16
Using Table with [A.5] = 15,000 PSI Cavity Pressure

Unscrewing Torque = 260.9 in-lbs

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Example Problem for Hydraulic Unscrewing Device

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E. SELECTING A MINIMUM DIAMETER DRIVE SHAFT FOR THE THREADED CORE IN INCHES

☐ 0.501” E.1) Enter the minimum Shaft Diameter for the Threaded Core in Inches

Approach #1-Appendix C Procedure 2 Look Up Table Method

We will use an S-7 Shaft, Rc 39-40, with keyway
[D.1] from this example = 243.1 in-lbf
from the Table, use [D.1] = 300 in-lbf

Minimum Diameter = 0.501 Dia.

☐ 17.135 lbf E.2) Calculate the Static Thrust the shaft must support due to Maximum Cavity Pressure

Max. Thrust $= [A.1]^2 \times [A.5] \times 0.785398$
$= [1.206]^2 \times [15{,}000] \times 0.785398$
$= 1.454436 \times 15{,}000 \times 0.785398$
= 17, 135 lbf

☐ 0.750” E.3) Enter the Minimum Shaft diameter size where the gear will be slid over
lets assume that a step of 1/4” for the shaft diameter is needed to support the Static Thrust

= [E.1] + 1/4” = 0.501 + 0.250 ~/= 0.750” Diameter Shaft

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F. SELECTING THE PITCH DIAMETER OF THE DRIVE GEAR-USE 20° PRESSURE ANGLE GEARS ONLY

☐ 1.500" F.1) Enter the Pitch Diameter for the Drive Gear to be used in Inches

Using Appendix D-Table of Standard Gears, the following criteria must be met:

- gear revolutions for stroke length ≥ [B.1] (3.2) required revolutions
- maximum gear torque ≥ [D.1] (243.1) unscrewing torque for one cavity
- internal gear bore diameter ≥ [E.3] (0.750) minimum shaft diameter

We will select a Pitch Diameter of 1.500 Inches using a .40 C Alloy Heat-treated Steel gear, a cylinder stroke of 11.81" is not usable.

☐	12	F.2) Record the Gear's Diametral Pitch
		All DME SAE Racks at this time are 12 Diametral Pitch, 20° Pressure Angle Teeth
☐	0.750"	F.3) Record the Gear's Internal Bore Diameter
		Using the value from [F.1] use the Table in Appendix D to find this value.
☐	4.712"	F.4) Record the Gear's Pitch Circle Perimeter
		Using the value from [F.1] use the Table in Appendix D to find this value
☐	1.66"	F.5) Record the Gear's Outside Diameter
		Using the value from [F.1] use the Table in Appendix D to find this value

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Example Problem for Hydraulic Unscrewing Device

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DME Company Hydraulic Unscrewing Customer Cap information

G. MAKE FINAL CAVITY SPACING DECISION

☐ 3.000” G.1) Select Cavity Spacing in inches

The following criteria must be considered and met.

Cavity Spacing must be:

1. > [A.1] (1.206”) O.D. of the Cap
2. ≥ [C.1] (2.125”) Cavity Center to Center to Support pressure if Cavity/Stripper Inserts, use required clearance
3. ≥ [F.5] (1.66” + 1/8” = 1.785”) O.D. of Gear plus clearance.
4. ≥ O.D. of Thrust Bearing Plus Clearance - Designer’s Requirement, Let’s assume 1” added to diameter of shaft minimum = [E.3] + 1 or 0.750 + 1 = 1.750”
5. ≥ Required Plastic Flow Channel Requirements.
   Without cavity inserts minimum 1” spacing using DME Cool One this is not possible, actually Cap Diameter + 1/8” = 1.331”
   Without cavity inserts using DME Hot Ones, typical 1-1/2” to 2” water cooled inserts and GateMate 4, about 3” (we will use this)

Cavity Spacing ≥ 1.206, 2.125, 1.785, 1.750, or 3” whichever is greatest.
Cavity Spacing = 3”

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H. MAXIMUM NUMBER OF CAVITIES IN ONE STRAIGHT LINE FOR HYDRAULIC CYLINDERS BASED ON THE SELECTED GEAR

☐ 15.079" H.2) Calculate the minimum stroke needed to unscrew the cap in Inches.
= [F.4] x [B.1] = 4.712” x 3.2 = 15.0784”

H3. Calculate the Maximum Number of cavities per Cylinder Length in one straight line. Note: [G.1] = 3.000”

☐ 0 H3.1) Enter the maximum number of cavities for cylinder #ZG-25-300 = Int {13.85 / {G.1]} +1
= Int {4.616} +1 = 4+1 = 5. This value is 0 and unusable if [H.2] ≥ 11.81” stroke

☐ 6 H3.2) Enter the maximum number of cavities for cylinder #ZG-25-400 = Int {17.79 / {G.1]} +1
= Int {5.930} +1 = 5 +1 = 6. This value is 0 and unusable if [H.2] ≥ 15.74” stroke

☐ 8 H3.3) Enter the maximum number of cavities for cylinder #ZG-25-500 = Int {21.73 / {G.1]} +1
= Int {7.243} +1 = 7+1= 8. This value is 0 and unusable if [H.2] ≥ 19.68” stroke

☐ 0 H3.4) Enter the maximum number of cavities for cylinder #ZG-40-300 = Int {13.85/ {G.1]} +1
= Int {4.616} +1 = 4+1= 5. This value is 0 and unusable if [H.2] ≥ 11.81” stroke

☐ 6 H3.5) Enter the maximum number of cavities for cylinder #ZG-40-400 = Int {17.79 / {G.1]} +1
= Int {5.930} +1 = 5 +1= 6. This value is 0 and unusable if [H.2] ≥ 15.74” stroke

☐ 8 H3.6) Enter the maximum number of cavities for cylinder #ZG-40-500 = Int {21.73 / {G.1]} +1
= Int {7.243} +1 = 7+1= 8. This value is 0 and unusable if [H.2] ≥ 19.68” stroke

☐ 7 H3.7) Enter the maximum number of cavities for cylinder #ZG-63-400 = Int {18.46 / {G.1]} +1
= Int {6.153} +1 = 6+1= 7. This value is 0 and unusable if [H.2] ≥ 15.74” stroke

☐ 8 H3.8 Enter the maximum number of cavities for cylinder #ZG-63-500 = Int {22.40 / {G.1]} +1
= Int {7.466} +1 = 7+1= 8. This value is 0 and unusable if [H.2] ≥ 19.68” stroke

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Example Problem for Hydraulic Unscrewing Device

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DME Company Hydraulic Unscrewing Customer Cap information

I. MAXIMUM NUMBER OF CAVITIES FOR HYDRAULIC CYLINDERS BASED ON ITS PISTON DIAMETER

☐ 486.2 I.1) Calculate the hydraulic force required per cavity (lbf)

= {(Unscrewing Torque) / (GearPitch Radius)} x 1.5
= {(Unscrewing Torque) / (GearPitch Radius)} x 3.0
=[D.1] / {F.1] x 3.0 = (243.1 ÷ 1.500) x 3.0 = 486.2 lbf

☐ 3 I.2.1) Calculate maximum number of cavities for cylinders ZG-25-xxx
= Integer { 0.760466 x [A.6] / [I.1]}
= Integer { 0.760466 x 2000 / 486.2}
= Integer {3.128}
= 3

☐ 8 I.2.2) Calculate maximum number of cavities for cylinders ZG-40-xxx
= Integer { 1.9458051 x [A.6] / [I.1]}
= Integer { 1.9458051 x 2000 / 486.2}
= Integer {8.004}
= 8

☐ 19 I.2.3) Calculate maximum number of cavities for cylinders ZG-63-xxx
= Integer { 4.8305128 x [A.6] / [I.1]}
= Integer { 4.8305128 x 2000 / 486.2}
= Integer {19.870}
= 19

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J.MAKE A LIST OF CYLINDERS THAT CAN BE USED

J.1 For a single row of cavities and one-cylinder applications, check box if conditions are True.

Note: Max. = number of cavities due to force available from cylinder.
In-Between = number of cavities due to cavity spacing and if enough stroke available for unscrewing.
Min. = customer number of cavities required.

Cylinder	Max.		In-Between		Min.
ZG-25-300 conditions	[I2.1]	≥	[H3.1]	or less ≥	[A.7]
	3	≥	0	(0) ≥	8
ZG-25-400 conditions	[I2.1]	≥	[H3.2]	or less ≥	[A.7]
	3	≥	6	(3) ≥	8
ZG-25-500 conditions	[I2.1]	≥	[H3.3]	or less	[A.7]
	3	≥	8	(3) ≥	8
ZG-40-300 conditions	[I2.2]	≥	[H3.4]	or less ≥	[A.7]
	8	≥	0	(0) ≥	8
ZG-40-400 conditions	[I2.2]	≥	[H3.5]	or less ≥	[A.7]
	8	≥	6	(6) ≥	8
ZG-40-500 conditions	[I2.2]	≥	[H3.6]	or less ≥	[A.7]
	8	≥	8	(8) ≥	8
ZG-63-400 conditions	[I2.3]	≥	[H3.7]	or less ≥	[A.7]
	19	≥	7	(7) ≥	8
ZG-63-500 conditions	[I2.3]	≥	[H3.8]	or less ≥	[A.7]
	19	≥	8	(8) ≥	8

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DME Company Hydraulic Unscrewing Customer Cap information

J.MAKE A LIST OF CYLINDERS THAT CAN BE USED

J.1 For a two rows of cavities and one-cylinder applications, check box if conditions are True.

Note: Max. = number of cavities due to force available from cylinder.
In-Between = number of cavities due to cavity spacing and if enough stroke available for unscrewing.
Min. = customer number of cavities required.

Cylinder	Max.		In-Between		Min.
ZG-25-300 conditions	[I2.1]	≥ 2x	[H3.1]	or less ≥	[A.7]
	3	≥	0	(0) ≥	8
ZG-25-400 conditions	[I2.1]	≥ 2x	[H3.2]	or less ≥	[A.7]
	3	≥	12	(3) ≥	8
ZG-25-500 conditions	[I2.1]	≥ 2x	[H3.3]	or less	[A.7]
	3	≥	16	(3) ≥	8
ZG-40-300 conditions	[I2.2]	≥ 2x	[H3.4]	or less ≥	[A.7]
	8	≥	0	(0) ≥	8
ZG-40-400 conditions	[I2.2]	≥ 2x	[H3.5]	or less ≥	[A.7]
	8	≥	12	(8) ≥	8
ZG-40-500 conditions	[I2.2]	≥ 2x	[H3.6]	or less ≥	[A.7]
	8	≥	16	(8) ≥	8
ZG-63-400 conditions	[I2.3]	≥ 2x	[H3.7]	or less ≥	[A.7]
	19	≥	14	(14) ≥	8
ZG-63-500 conditions	[I2.3]	≥ 2x	[H3.8]	or less ≥	[A.7]
	19	≥	16	(16) ≥	8

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DME Company Hydraulic Unscrewing Customer Cap information

K. SELECT THE HYDRAULIC CYLINDER WHICH WILL BE USED

☐ ZG-40-500 K.1) Enter the DME Catalog Cylinder Number used
There are several options that can be chosen fron Section J.
We will choose a 2-row application using Cylinder ZG-40-500. This will allow for a balanced 8 Cavity Runner system instead of a straight line. It will use the smaller diameter, lighter and more managable cylinder. It will allow extra travel for use with the stripper plate. If we can avoid using full-cylinder travel, we will get better life from the cylinder seals.

☐ 8 K.2) Enter the total number of Cavities used

☐ 2 K.3) Enter the number of rows of cavities to be used (either 1 or 2)

☐ 3.745.6 K.4) Calculate the minimum Hydraulic unscrewing force needed (lbf)
= Hydraulic force required per cavity x number of cavities = [I.1] x [K.2]
= 486.2 x 8 = 3,745.6 lbf

☐ 1925 K.5) Calculate the minimum Hydraulic Pressure to supply the cylinder (max. 2175 PSI)
Max. available was [A.6]

For catalog number ZG-25-xxxx = [K.4] / (0.760466 in^2)
For catalog number ZG-40-xxx = [K.4] / (1.9458051in^2)
= 3,745.6 / 1.9458051 = 1924.96 ~/= 1925 PSI
Note that this is less than [A.6] of 2000 PSI
For catalog number ZG-63-xxx = [K.4] / (4.8305128 in^2)

☐ 15.079 K.6) Calculate the "Required Stroke" that the unscrewing action will use in Inches.
= Gears Pitch Circle Perimeter x number of revolutions = [F.4] x [B.1] = [H.2]
= 15.079

☐ 4.601" K.7) Calculate the available "Stripper Stroke" for moving the Stripper Plate (provides "bump")
For catalog number ZG-xx-300 = the total available stroke = 11.81"
For catalog number ZG-xx-400 = the total available stroke = 15.74"
For catalog number ZG-xx-500 = the total available stroke = 19.68"

= Total available stroke for catalog number [K.1]- Unscrewing Action Inches [K.6]
= 19.68 - 15.079 = 4.601

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Example Problem for Hydraulic Unscrewing Device

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L. CONTROL CAM CALCULATIONS-ANGLES THAT WILL BE PUT ON THE CAM RISER IN DEGREES

Place calculator in Degree Mode

☐ $1^o\ 54'\ 30.03''$ L.1) Calculate the Moving Cam Angle ($\propto$) Note: Moves Main Stripper Plate

$\alpha = \mathrm{Tan}^{-1}$ { [A.3] / [F.4] } in Degrees

= Tan^{-1} {[0.157] / [4.712] in Degrees

= Tan^{-1} {0.033319185} in Degrees

= 1.908342696 in Degrees

= $1^o\ 54'\ 30.03''$ (Degrees minus Seconds) Angle

☐ 0.2355 L.2) Enter the desired Stripper Height in Inches. Note: Provides "bump" or moves the anti-rotational stripper plate. Typically about 1-1/2 times the thread lead [A.3] minimum

= [A.3] x 1.5 = 0.157 x 1.5 = .2355

☐ $5^o\ 10'\ 24.86''$ L.3) Calculate Stripper Cam Angle ß (place calculator in Degree Mode)

Note: [K.7] = Available "Stripper Stroke". Try to leave at least 2" of unused stroke which will be stopped by a limit switch to increase internal hydraulic cylinder seals.

Stripper Stroke = [K.7] unused stroke (we will try not to use 2" of stroke to prevent excessive seal wear)

= [K.7] -2

= 4.601 -2

Stripper Stroke = 2.601

ß = Tan^{-1} {[L.2] / [Stripper Stroke]} in Degrees

= Tan^{-1} [[0.2355] / [2.601]}

= Tan^{-1} {0.09054099}

= 5.173573495

= $5^o\ 10'\ 24.86''$ (Degrees minus seconds)

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Example Problem for Hydraulic Unscrewing Device

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DME Company Hydraulic Unscrewing Customer Cap information

M. RECORD FINAL DESIGN PARAMETERS WHICH WILL BE USED

Values from this Engineering Guide

A.2	1.106″
A.3	0.157″
A.4	0.422″
E.1	0.501″
F.3	0.750″
G.1	3.000″
K.1	ZG-40-500
K.2	8
K.3	2
K.5	1925
K.6	15.079
K.7	4.601
L.1	1^{o} 54′ 30.03″
L.2	0.2355
L.3	5^{o} 10′ 24.86″

Values from DME Catalog Pages

Rack Length Q: 48″
Distance from center of hydraulic cylinder to the racks pitch line U: 1.750″