



Particle Physics Division

Mechanical Department Engineering Note

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Project:

G-2 MUON

Project Internal Reference:

Title:

FORCE & DEFLECTION ON OUTER COIL
PUSH ROD DIE SPRINGS AND RADIAL
BELLEVILLE WASHERS

Author(s):

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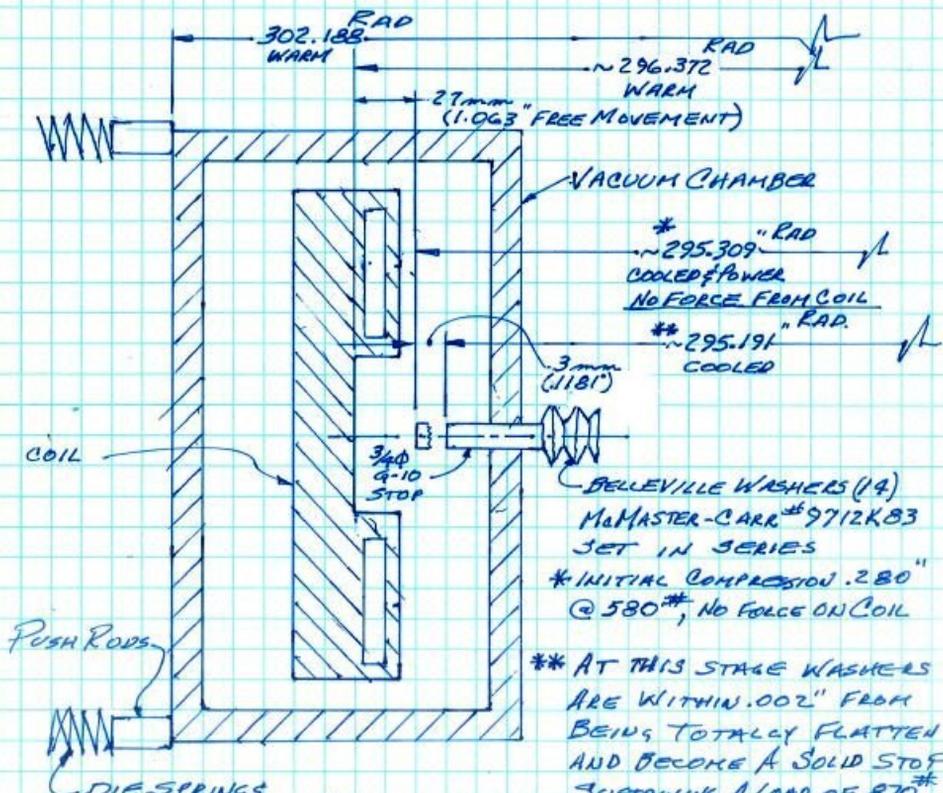
Reviewer(s):

Key Words:

SPRINGS, WASHERS

Abstract/Summary:

THIS NOTE DESCRIBES THE EXISTING
FORCES AND DEFLECTIONS IMPOSED ON
THE DIE SPRINGS AND BELLEVILLE
WASHERS AS SPECIFIED IN BNL NOTE #282



DIE SPRINGS
 McMASTER-CARR # 9588K92
 MAX DEFLECTION
 $30\% \times 3" = .900" @ 1800\# (2000\#/INCH)$
 THE DESIGN PRE-LOAD REQUIRED
 ACCORDING TO BNL NOTE #282, PAGE 26
 IS $1500\#$, THE AVERAGE WAS $1300\#$.
 THE COMPRESSION NEEDED
 IS: $\frac{900" \times 1500\#}{1800\#} = .750" / \text{PUSH ROD}$

* $\sim 295.309" \text{ RAD}$
 COOLED & POWER
 NO FORCE FROM COIL
 ** $\sim 295.191" \text{ RAD}$
 COOLED
 BELLEVILLE WASHERS (14)
 McMASTER-CARR #9712K83
 SET IN SERIES
 * INITIAL COMPRESSION .280"
 @ 580#, NO FORCE ON COIL

** AT THIS STAGE WASHERS
 ARE WITHIN .002" FROM
 BEING TOTALLY FLATTEN
 AND BECOME A SOLID STOP,
 SUSTAINING A LOAD OF 870#.
 BNL FOUND, BY USING STRAIN
 GAGES & RECORDED IN NOTE
 #282, PAGE #25, THAT THE
 LOAD RANGED FROM 30 TO 1420#
 FOR AN AVERAGE OF 520#

$\frac{3}{4} \phi \text{ G-10 COIL STOP}$
 $1420\# \text{ MAX FORCE}$
 $\sigma = \frac{1420\#}{(.75" \text{ OF } \phi)}$
 $= 3,214 \text{ psi}$
 G-10 COMPRESSIVE STRESS
 $35,000 \text{ psi}$
 $F.S. = \frac{35,000}{3,214} = 10.9$

BELLEVILLE SPRINGSUSED ON OUTER COIL FOR RADIAL STOPS

$$P = \frac{Ey}{(1-\mu^2)M(d_o/2)^2} [(h-y/2)(h-y)t + t^3] = 580 \# \text{ (SINGLE WASHER)}$$

@ $y = .020$

$$s = \frac{Ey}{(1-\mu^2)M(d_o/2)^2} [C_1(h-y/2) + C_2t] = 219K \text{ psi}$$

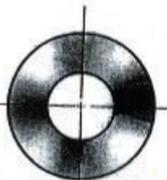
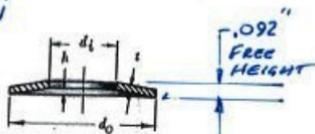
where

 P = axial load, lb y = deflection, in. = .020 t = thickness of washer, in. = .062 h = free height minus thickness, in. = .030 E = modulus of elasticity, psi = 29.3×10^6 s = stress at inside circumference, psi d_o = outside diameter of washer, in. = 1.250 d_i = inside diameter of washer, in. = .640 μ = Poisson's ratio (0.3 for steel) = .295

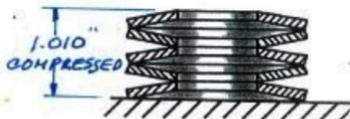
$$M = \frac{6}{\pi \log_e(d_o/d_i)} \left[\frac{d_o/d_i - 1}{d_o/d_i} \right]^2 = .679$$

$$C_1 = \frac{6}{\pi \log_e(d_o/d_i)} \left[\frac{d_o/d_i - 1}{\log_e(d_o/d_i)} - 1 \right] = 1.209$$

$$C_2 = \frac{6}{\pi \log_e(d_o/d_i)} \left[\frac{d_o/d_i - 1}{2} \right] = 1.3596$$



McMASTER # 9712K83



Series

14 WASHERS IN STACKCOMPRESSION ON EACH WASHER

$$y = (14 \times .092 - 1.010) / 14 = .020" \text{ (DESIGN)}$$

MAX. DEFLECTION POSSIBLE .420" (.030"/WASHER)

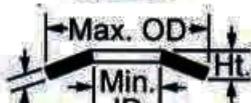
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High-Carbon Steel Belleville Disc Spring

.630" ID, 1.250" OD, .062" Thick

In stock
 \$9.89 per pack of 12
 9712K83

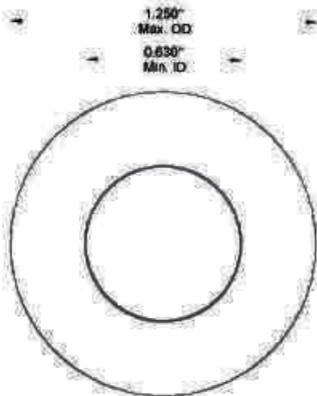


Thickness

Material	Steel
Minimum ID	0.630"
Maximum OD	1.250"
Thickness	0.062"
Height	0.082"
Deflection @ Working Load	0.015"
Working Load	475 lbs.
Flat Load	870 lbs.

} Max = .092 - .062 = .030"

Steel springs are high-carbon steel for strength, unless noted.



0.082" Height



0.062" Thickness

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 Steel Belleville Disc Spring

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McMASTER-CARR OVER 555,000 PRODUCTS(630) 633-0300
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Text 75420**Heavy Load Chrome-Silicon Steel Die Spring**

2" Hole, 1" Rod, 3" Length, .280" x .470" Wire

In stock
\$23.81 Each
9588K92

Fits Hole Size	2"
Fits Rod Size	1"
Overall Length	3"
Wire Height	0.280"
Wire Width	0.470"
Load	900 lbs.
Rate	2,000 lbs./inch
Additional Specifications	Bronze, Heavy Load—Load at 15% deflection. <u>Maximum deflection is 30%.</u>

Manufactured to handle repetitive punching and stamping jobs, these springs have high tensile strength for reliable, consistent operation over a long lifetime. Ends are closed and ground flat so springs stand straight and are easy to stack. They follow the Raymond die springs color code.



CRYOGENIC G10 SPECIFICATIONS

PROPERTY DATA	AREA OF TEST	RESULT
TENSILE	LENGTH-WISE	40,000 PSI
	CROSS-WISE	35,000 PSI
COMPRESSIVE STRENGTH	FLAT-WISE	60,000 PSI
	EDGE-WISE	35,000 PSI
FLEX STRENGTH	CROSS-WISE	46,000 PSI
	LENGTH-WISE	55,000 PSI
MODULUS OF ELASTICITY IN FLEX SHEAR STRENGTH	LENGTH-WISE	2,700,000
	CROSS-WISE	2,200,000
		19000 PSI
IZOD IMPACT	NOTCH	7
	NOTCH	5.5
ROCKWELL HARDNESS		(M) 110
SPECIFIC GRAVITY		1.82
WATER ABSORPTION	.062 " THICK	.25 % OVER 24 HOURS
	.125 " THICK	.15% OVER 24 HOURS
	.500 " THICK	.10 % OVER 24 HOURS
DIELECTRIC CONSTANT	.062 " THICK	500 VOLTS PER MIL
	.125 " THICK	400 VOLTS PER MIL
DISSIPATION FACTOR	CONDITION A	.025 MEGACYCLE
INSULATION RESISTANCE	96 HOURS AT 90% RELATIVE HUMIDITY	200000 MEGA OHMS
FLAME RATING	UNDERWATER LABC	UL94V-0
OPERATING TEMPERATURE	CONTINUOUS	289°F TO 177 °KELVIN
COEFFICIENT OF THERMAL EXPANSION	CM/CM/DEG C X -5	0.9
BOND STRENGTH	GREATER THAN 2,500 LBS	

3/4" PLUNGER COLL STOP

1420# MAX FORCE

$$\theta = \frac{1420\#}{(.75\pi/4)} = 3,214\text{psi} \Rightarrow \frac{35,000}{3,214} = 10.9 \text{ F.S.}$$

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