Input Echo, Nozzle Item 1, Description:

Design Internal Pressure (Case 1)	P	125.00	psig
Temperature for Internal Pressure	TEMP	250.00	F
Include Hydrostatic Head Components		NO	
Shell or Head Material (Not Normalized or NA)		SA-516 70	
Material UNS Number		K02700	
Shell/Head Allowable Stress at Temperature	S	20000.00	psi
Shell/Head Allowable Stress At Ambient	SA	20000.00	psi
Shell/Head Yield Stress at Temperature	Sy	34200.00	psi
Inside Diameter of Cylindrical Shell	D	28.000	in.
Actual Thickness of Shell or Head	T	0.1880	in.
Corrosion Allowance for Shell or Head	CAS	0.0000	in.
Is this Nozzle a Radial Nozzle		YES	
Is this Nozzle a Lateral Nozzle (Y-angle)		NO	
Nozzle Material (Not Normalized or NA)		SA-53 E/B	
Material UNS Number		K03005	
Nozzle Allowable Stress at Temperature	SN	14600.00	psi
Nozzle Allowable Stress At Ambient	SNA	14600.00	psi
Diameter Basis for Nozzle	BASISN	OD	
Nominal Diameter of Nozzle	DIA	16.000	in.
Nozzle Size and Thickness Basis	DBN	Nominal	
Nominal Thickness of Nozzle	THKNOM	SCH 40	
Corrosion Allowance for Nozzle	CAN	0.0000	in.
Joint Efficiency of Shell Seam at Nozzle	ES	1.00	
Joint Efficiency of Nozzle Neck	EN	1.00	
Insert or Abutting Nozzle Type	NTYP	Insert	
Outward Projection of Nozzle	HO	6.000	in.
Weld leg size between Nozzle and Pad/Shell	WO	0.2500	in.
Groove weld depth between Nozzle and Vessel	WGNV	0.0000	in.
Inside Projection of Nozzle	H	2.0000	in.
Weld leg size, Inside Nozzle to Shell	WI	0.2500	in.
ASME Code Weld Type per UW-16.1		I	

Reinforcement CALCULATION, Description:

ASME Code, Section VIII, Division 1, 2007, A-09 UG-37 to UG-45

Actual Outside Diameter Used in Calculation		16.000	in.
Actual Thickness Used in Calculation		0.500	in.

Internal Pressure Results for SHELL/HEAD :

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Internal Press]
Thickness Due to Internal Pressure:
= (P*(D/2+CA)) / (S*E-0.6*P) per UG-27 (c)(1)
= (125.00*(28.0000/2+0.0000))/(20000.00*1.00-0.6*125.00)
= 0.0878 + 0.0000 = 0.0878 in.

Internal Pressure Results for NOZZLE :

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Internal Press]
Thickness Due to Internal Pressure:
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (125.00*(16.0000/2-0.000)/(14600.00*1.00+0.4*125.00)
= 0.0683 + 0.0000 = 0.0683 in.

UG-40, Thickness and Diameter Limit Results : Internal Pressure

```
Effective material diameter limit,              DL     30.000  in.
Effective material thickness limit, no pad   TLNP      0.470  in.
```

Results of Nozzle Reinforcement Area Calculations:

Area Available, A1 to A5		Design	External	Mapnc	
Area Required	Ar	1.341	NA	NA	in²
Area in Shell	A1	1.476	NA	NA	in²
Area in Nozzle Wall	A2	0.296	NA	NA	in²
Area in Inward Nozzle	A3	0.343	NA	NA	in²
Area in Welds	A4	0.091	NA	NA	in²
Area in Pad	A5	0.000	NA	NA	in²
Total Area Available	Atot	2.206	NA	NA	in²

Internal Pressure Case Governs the Analysis

```
Nozzle Tangent Angle Used in Area Calculations          90.00  Degs.
```

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle:

```
Ar = (DLR*TR+2*THK*TR*(1-FFR1)) UG-37(c) or UG-39
Ar = (15.0000*0.0878+2*(0.5000-0.0000)*0.0878*(1.0-0.73))
Ar =  1.341 in²
```

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Nozzle Opening size:
Area Available in Shell (A1):

```
A1 = (DL-DLR)*(ES*(T-CAS)-TR)-2*(THK-CAN)*(ES*(T-CAS)-TR)*(1-FFR1)
A1 = (30.000-15.000)*(1.00*(0.1880-0.000)-0.088)-2*(0.500-0.000)
     *(1.00*(0.1880-0.0000)-0.0878)*(1.0-0.73)
A1 =  1.476 in²
```

Area Available in Nozzle Wall, no Pad:

```
A2np = ( 2 * MIN(TLNP,HO) ) * ( THK - CAN - TRN ) * FFR2
A2np = ( 2 * 0.4700 ) * ( 0.5000 - 0.0000 - 0.0683 ) * 0.73 )
A2np = 0.296 in²
```

Area Available in Nozzle Penetration:

```
A3 = 2 * (TN-CAN-CAN) * MIN(H-CAN, TL, 2.5*(TN-CAN-CAN)) * FFR2
A3 = 2 * ( 0.5000 ) * ( 0.4700 ) * 0.73
A3 = 0.343 in²
```

Area Available in Welds, no Pad:

```
A4np = Wo^2*FFR2 + ( Wi-Can/0.707 )^2*FFR2
A4np = 0.2500 ^2 * 0.7300 + ( 0.2500 )^2 * 0.7300
A4np = 0.091 in²
```

UG-45 Minimum Nozzle Neck Thickness Requirement:

```
Wall Thickness per UG45(a),     tra = 0.0683 in.
Wall Thickness per UG16(b),   tr16b = 0.0625 in.
Wall Thickness per UG45(b)(1), trb1 = 0.0878 in.
Check UG16(b) Min. Thickness,  trb1 = Max(trb1, tr16b) = 0.0878 in.
Std. Wall Pipe per UG45(b)(4), trb4 = 0.3281 in.
Wall Thickness per UG45(b),     trb = Min(trb1, trb4) = 0.0878 in.

Final Required Thickness,      tr45 = Max(tra, trb) = 0.0878 in.
Available Nozzle Neck Thickness     = .875 * 0.5000 = 0.4375 in. --> OK
```

Large Opening Calculations per Appendix 1-10

Thickness of Nozzle [tn]:
```
= thickness - corrosion allowance
= 0.500 - 0.000
= 0.500 in.
```

Effective Pressure Radius [Reff]:
```
= Di/2 + corrosion allowance
= 28.000 /2 + 0.000
= 14.000 in.
```

Effective Length of Vessel Wall [LR]:
Note : Pad Thickness < 0.5*Shell Thk or Pad Width < 2*Shell Thk
```
= 8 * t
= 8 * 0.188
= 1.504 in.
```

Thickness Limit Candidate [LH1]:
```
= t + 0.78 * sqrt( Rn * tn )
= 0.188 + 0.78 * sqrt( 7.500 * 0.500 )
= 1.698 in.
```

Thickness Limit Candidate [LH2]:
```
= Lpr1 + t
= 6.000 + 0.188
= 6.188 in.
```

Thickness Limit Candidate [LH3]:
```
= 8 * ( t + te )
= 8 * ( 0.188 + 0.000 )
= 1.504 in.
```

Effective Nozzle Wall Length Outside the Vessel [LH]:
```
= min[ LH1, LH2, LH3 ]
= min[ 1.698 , 6.188 , 1.504 )
= 1.504 in.
```

Thickness Limit Candidate, Inside [LI1]:
```
= 0.78 * sqrt( Rn * tn )
= 0.78 * sqrt( 7.500 * 0.500 )
= 1.510 in.
```

Nozzle Projection from the Inside of the Vessel Wall [Lpr2, LI2]:
```
= LI - c
= 0.188 - 0.000
= 2.000 in.
= 2.000 in.
```
Thickness Limit Candidate, Inside [LI3]:
```
= 8 * ( t + te )
= 8 * ( 0.188 + 0.000 )
= 1.504 in.
```

Effective Nozzle Wall Length Inside the Vessel [LI]:
```
= min( LI1, LI2, LI3 )
= min( 1.510 , 2.000 , 1.504 )
= 1.504 in.
```

Effective Vessel Thickness [teff]:
```
= t
= 0.188 in.
```

Determine Parameter [Lamda]:
```
= min( 10, ( Dn + Tn )/( sqrt( ( Di + teff ) * teff )) )
= min( 10, (15.00 + 0.500 )/( sqrt((28.00 + 0.188 ) * 0.188 )) )
= 6.733
```

Compute Areas A1-A43 (No Pad) or A1-A5 (With Pad) :

Area Contributed by the Vessel Wall [A1]:
```
= t * LR * max( Lamda/4, 1 )
= 0.188 * 1.504 * max( 6.733 /4, 1 )
= 0.476 in²
```

Area Contributed by the Nozzle Outside the Vessel Wall [A2]:
```
= tn * LH
= 0.500 * 1.504
= 0.752 in²
```

Area Contributed by the Nozzle Inside the Vessel Wall [A3]:
```
= ( tn - c ) * L1
= ( 0.500 - 0.000 ) * 1.504
= 0.752 in²
```

Area Contributed by the Inside Fillet Weld [A43]:
```
= 0.5 * Leg43^2
= 0.5 * 0.250 ^2
= 0.031 in²
```

Area Contributed by the Outside Fillet Weld [A41]:
```
= 0.5 * Leg41^2
= 0.5 * 0.250 ^2
= 0.031 in²
```

The total area contributed by A1 through A43 [AT]:
```
= A1 + frn( A2 + A3 ) + A41 + A42 + A43
= 0.476+1.000(0.752+0.752)+0.031+0.000+0.000
= 2.042 in²
```

Allowable Local Primary Membrane Stress [Sallow]:
```
= 1.5 * S * E
= 1.5 * 20000.000 * 1.000
= 30000.0 psi
```

Determine Force acting on the Nozzle [fN]:
```
= P * Rn * ( LH - t )
= 125.000 * 7.500 * ( 1.504 - 0.188 )
= 1233.8 lb.
```

Determine Force acting on the Shell [fS]:
```
= P * Reff * ( LR + tn )
= 125.000 * 14.000 * ( 1.504 + 0.500 )
= 3507.0 lb.
```

Discontinuity Force from Internal Pressure [fY]:
```
= P * Reff * Rnc
= 125.000 * 14.000 * 7.500
= 13125.0 lb.
```

Area Resisting Internal Pressure [Ap]:
```
= Rn( LH - t ) + Reff( LR + tn + Rnc )
= 7.500 ( 1.504 - 0.188 ) + 14.000 ( 1.504 + 0.500 + 0.500
= 142.9 in²
```

Maximum Allowable Working Pressure Candidate [Pmax1]:
```
= Sallow /( 2 * Ap/AT - Rxs/teff )
= 30000.000 /( 2 * 142.926 /2.042 - 14.000 /0.188 )
= 458.1 psig
```

Maximum Allowable Working Pressure Candidate [Pmax2]:
```
= S[t/Reff]
= 20000.000 [0.188 /14.000 ]
= 268.6 psig
```

Maximum Allowable Working Pressure [Pmax]:
```
  = min( Pmax1, Pmax2 )
  = min( 458.106 , 268.571 )
  = 268.571 psig
```

Average Primary Membrane Stress [SigmaAvg]:
```
  = ( fN + fS + fY ) / AT
  = ( 1233.750 + 3507.000 + 13125.000 ) / 2.042
  = 8747.191 psi
```

General Primary Membrane Stress [SigmaCirc]:
```
  = P * Reff / teff
  = 125.000 * 14.000 / 0.188
  = 9308.5 psi
```

Maximum Local Primary Membrane Stress [PL]:
```
  = max( 2 * SigmaAvg - SigmaCirc, SigmaCirc )
  = max( 2 * 8747.191 - 9308.510 , 9308.510 )
  = 9308.5 psi
```

Summary of Nozzle Pressure/Stress Results:

Allowed Local Primary Membrane Stress	Sallow	30000.00	psi
Local Primary Membrane Stress	PL	9308.51	psi
Maximum Allowable Working Pressure	Pmax	268.57	psig