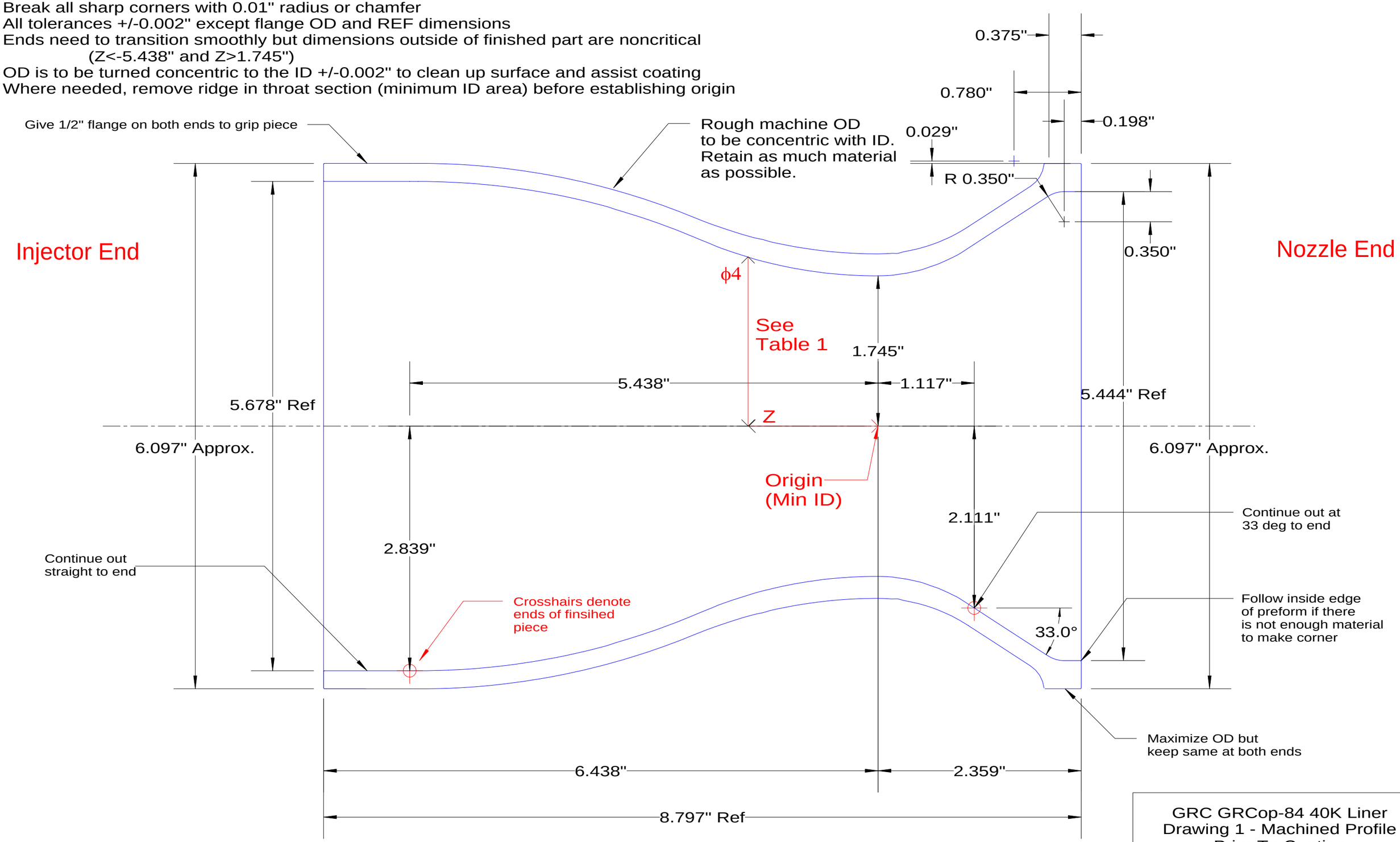
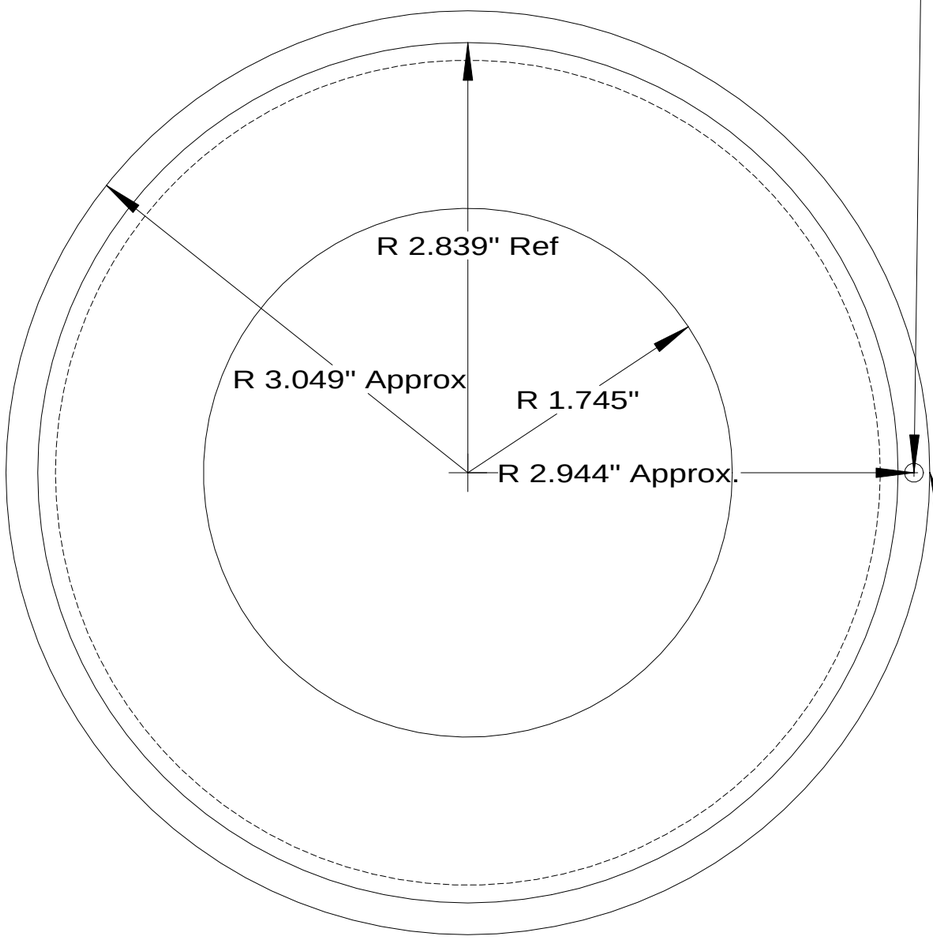
NOTES:
Break all sharp corners with 0.01" radius or chamfer
All tolerances +/-0.002" except flange OD and REF dimensions
Ends need to transition smoothly but dimensions outside of finished part are noncritical
(Z<-5.438" and Z>1.745")
OD is to be turned concentric to the ID +/-0.002" to clean up surface and assist coating
Where needed, remove ridge in throat section (minimum ID area) before establishing origin

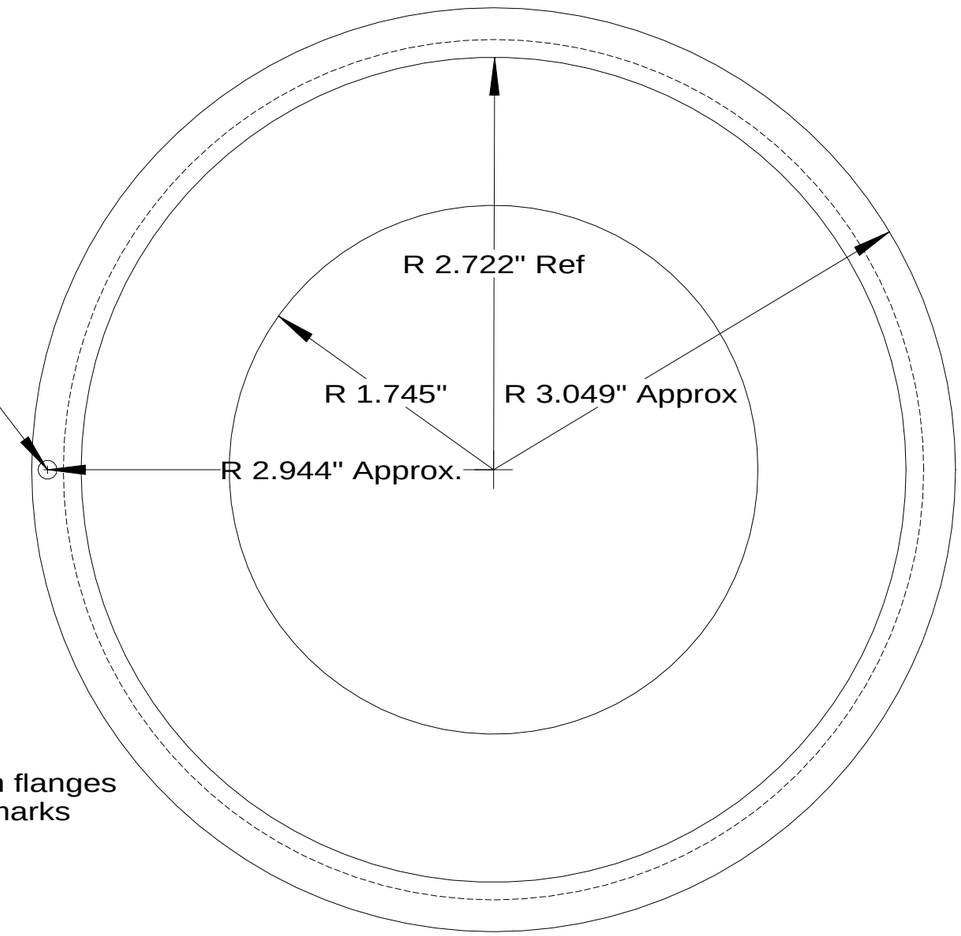



GRC GRCop-84 40K Liner
Drawing 1 - Machined Profile
Prior To Coating
David Ellis
216-433-8736 04/26/05

Provide two reference points, one on each end
1. Drill a 1/8" diameter x 1/8" deep hole or similar for automated measurement
2. Align reference holes on circumference and make concentric
3. Document location and concentricity of holes relative to each other




Vibroetch or otherwise scribe NASA supplied ID of each cylinder on flanges beside reference marks




Injector End

Nozzle End

GRC GRCop-84 40K Liner
Drawing 2 - Machined Profile
Prior To Coating End Views
David Ellis
216-433-8736 04/26/05

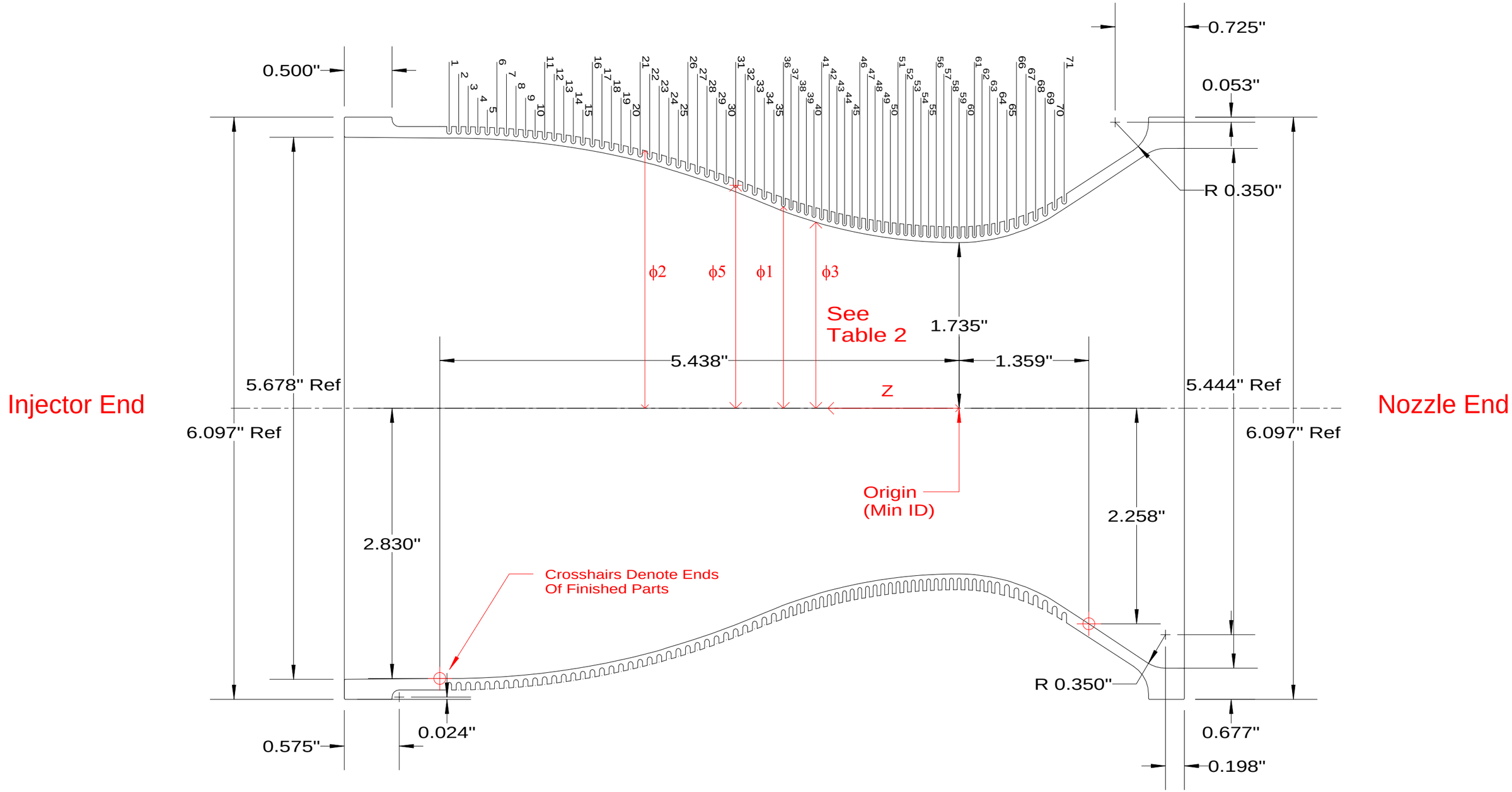
| Table 1<br>Drawing GRC Liner 1 Inner Radius | |
|---|---|
| **Z**<br>**Distance From Throat / Minimum Inside Diameter Location**<br>**(in)** | **$\Phi_4$**<br>**Radius to Machine Interior Surface Prior To Coating**<br>**(in)** |
| -5.340 | 2.839 |
| -5.240 | 2.839 |
| -5.140 | 2.837 |
| -5.040 | 2.834 |
| -4.940 | 2.830 |
| -4.840 | 2.825 |
| -4.740 | 2.819 |
| -4.640 | 2.811 |
| -4.540 | 2.802 |
| -4.440 | 2.792 |
| -4.340 | 2.781 |
| -4.240 | 2.768 |
| -4.140 | 2.754 |
| -4.040 | 2.739 |
| -3.940 | 2.723 |
| -3.840 | 2.705 |
| -3.740 | 2.687 |
| -3.640 | 2.667 |
| -3.540 | 2.645 |
| -3.440 | 2.623 |
| -3.340 | 2.599 |
| -3.240 | 2.573 |
| -3.140 | 2.547 |
| -3.040 | 2.514 |
| -2.940 | 2.484 |
| -2.840 | 2.453 |
| -2.740 | 2.421 |
| -2.640 | 2.388 |
| -2.540 | 2.353 |
| -2.440 | 2.316 |
| -2.340 | 2.279 |
| -2.240 | 2.239 |
| -2.140 | 2.198 |
| -2.040 | 2.156 |
| -1.940 | 2.116 |
| -1.840 | 2.074 |
| -1.760 | 2.045 |
| -1.680 | 2.018 |
| -1.600 | 1.992 |
| -1.520 | 1.967 |
| -1.440 | 1.941 |
| -1.360 | 1.919 |
| -1.280 | 1.899 |
| -1.200 | 1.880 |

| | |
|---|---|
| -1.120 | 1.862 |
| -1.040 | 1.845 |
| -0.960 | 1.830 |
| -0.880 | 1.816 |
| -0.800 | 1.803 |
| -0.720 | 1.792 |
| -0.640 | 1.781 |
| -0.560 | 1.772 |
| -0.480 | 1.765 |
| -0.400 | 1.758 |
| -0.320 | 1.753 |
| -0.240 | 1.749 |
| -0.160 | 1.746 |
| -0.080 | 1.745 |
| 0.000 | 1.745 |
| 0.080 | 1.746 |
| 0.160 | 1.751 |
| 0.240 | 1.763 |
| 0.320 | 1.774 |
| 0.400 | 1.791 |
| 0.500 | 1.815 |
| 0.600 | 1.850 |
| 0.700 | 1.885 |
| 0.800 | 1.927 |
| 0.900 | 1.979 |
| 1.000 | 2.041 |
| 1.100 | 2.106 |

**All tolerances ±0.002"**

Negative Z number indicates Injector End

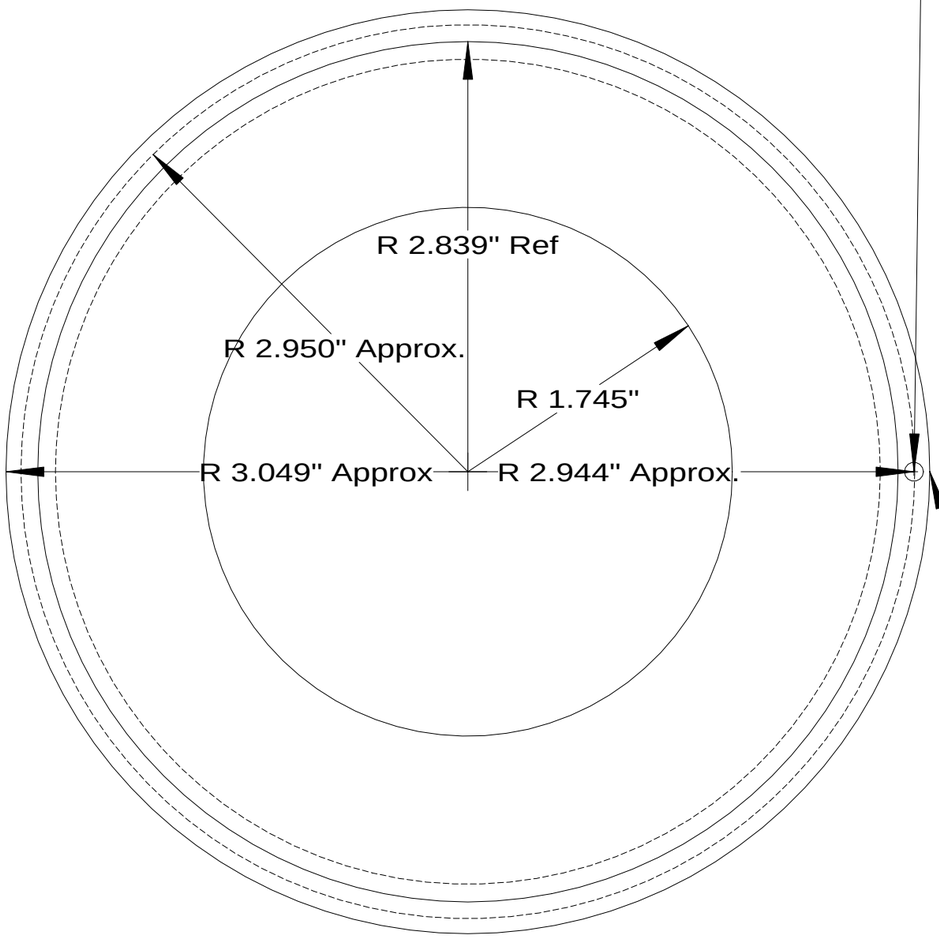
Positive Z number indicates Nozzle End



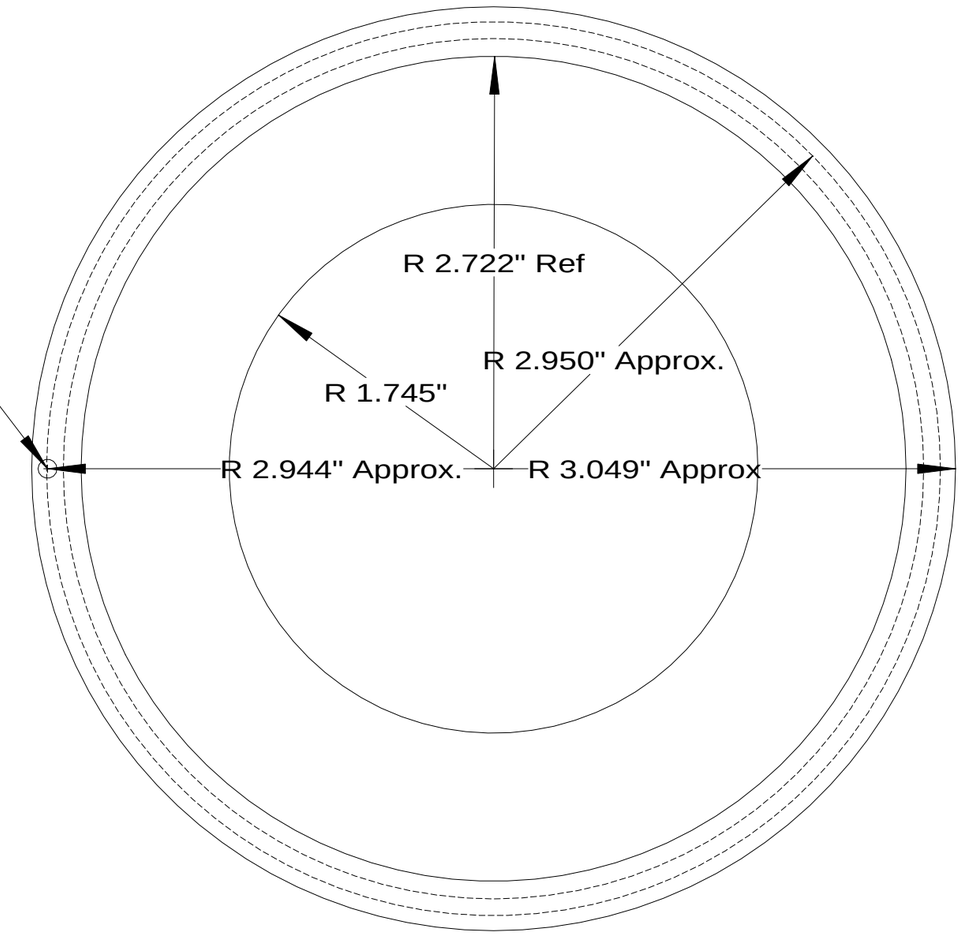

NOTES:
1. ID is coated with 0.003-0.007" NiCrAlY, balance of part is GRCop-84
2. All tolerances +/-0.001" except for REF
3. Machine OD per table prior to grooves
4. All groove edges on OD to be sharp, do not ease
5. Use reference points for determination of origin location
6. Transition the ID and OD smoothly to the end with up to 0.009" taper
7. Use machining techniques to minimize distortion from residual stresses

GRC GRCop-84 40K Liner
Drawing 3 - Machined Liner Profile
With 71 Circumferential Grooves
David Ellis
216-433-8736 04/26/05

Provide and maintain two reference points, one on each end
1. Drill a 1/8" diameter x 1/8" deep hole or similar for automated measurement
2. Align reference holes on circumference and make concentric
3. Document location and concentricity of holes relative to each other




Maintain
NASA supplied ID
for each cylinder




Injector End

Nozzle End

NOTE:
Grooves not shown for clarity.
Reference GRC GRCop-84 40K Liner Drawing 3 - Machined Liner Profile
With 71 Circumferential Grooves and Table 2 for groove information

GRC GRCop-84 40K Liner
Drawing 4 - Machined Profile
With Machined ID, OD and Grooves
David Ellis
216-433-8736 04/26/05

**Table 2**
**Drawing GRC Liner 2 Groove Width, Bottom Radius and Position**

| Groove # | Z Distance From Throat / Minimum Inside Diameter Location (in) | W Groove Width (in) | R Radius of Groove Bottom (in) | Φ1 Radius to Bottom of Groove From Centerline (in) | Φ3 Radius To Finished Inside Of Liner (in) | Φ5 Radius to Center of Groove Bottom (in) |
|---|---|---|---|---|---|---|
| 1 | -5.340 | 0.050 | 0.025 | 2.870 | 2.830 | 2.895 |
| 2 | -5.240 | 0.050 | 0.025 | 2.870 | 2.830 | 2.895 |
| 3 | -5.140 | 0.050 | 0.025 | 2.868 | 2.828 | 2.893 |
| 4 | -5.040 | 0.050 | 0.025 | 2.865 | 2.825 | 2.890 |
| 5 | -4.940 | 0.050 | 0.025 | 2.861 | 2.821 | 2.886 |
| 6 | -4.840 | 0.050 | 0.025 | 2.856 | 2.816 | 2.881 |
| 7 | -4.740 | 0.050 | 0.025 | 2.850 | 2.810 | 2.875 |
| 8 | -4.640 | 0.050 | 0.025 | 2.842 | 2.802 | 2.867 |
| 9 | -4.540 | 0.050 | 0.025 | 2.833 | 2.793 | 2.858 |
| 10 | -4.440 | 0.050 | 0.025 | 2.823 | 2.783 | 2.848 |
| 11 | -4.340 | 0.050 | 0.025 | 2.812 | 2.772 | 2.837 |
| 12 | -4.240 | 0.050 | 0.025 | 2.799 | 2.759 | 2.824 |
| 13 | -4.140 | 0.050 | 0.025 | 2.785 | 2.745 | 2.810 |
| 14 | -4.040 | 0.050 | 0.025 | 2.770 | 2.730 | 2.795 |
| 15 | -3.940 | 0.050 | 0.025 | 2.754 | 2.714 | 2.779 |
| 16 | -3.840 | 0.050 | 0.025 | 2.736 | 2.696 | 2.761 |
| 17 | -3.740 | 0.050 | 0.025 | 2.718 | 2.678 | 2.743 |
| 18 | -3.640 | 0.050 | 0.025 | 2.698 | 2.658 | 2.723 |
| 19 | -3.540 | 0.050 | 0.025 | 2.676 | 2.636 | 2.701 |
| 20 | -3.440 | 0.050 | 0.025 | 2.654 | 2.614 | 2.679 |
| 21 | -3.340 | 0.050 | 0.025 | 2.630 | 2.590 | 2.655 |
| 22 | -3.240 | 0.050 | 0.025 | 2.604 | 2.564 | 2.629 |
| 23 | -3.140 | 0.050 | 0.025 | 2.578 | 2.538 | 2.603 |
| 24 | -3.040 | 0.050 | 0.025 | 2.545 | 2.505 | 2.570 |
| 25 | -2.940 | 0.050 | 0.025 | 2.515 | 2.475 | 2.540 |
| 26 | -2.840 | 0.050 | 0.025 | 2.484 | 2.444 | 2.509 |
| 27 | -2.740 | 0.050 | 0.025 | 2.452 | 2.412 | 2.477 |
| 28 | -2.640 | 0.050 | 0.025 | 2.419 | 2.379 | 2.444 |
| 29 | -2.540 | 0.050 | 0.025 | 2.384 | 2.344 | 2.409 |
| 30 | -2.440 | 0.050 | 0.025 | 2.347 | 2.307 | 2.372 |
| 31 | -2.340 | 0.050 | 0.025 | 2.310 | 2.270 | 2.335 |
| 32 | -2.240 | 0.050 | 0.025 | 2.270 | 2.230 | 2.295 |
| 33 | -2.140 | 0.050 | 0.025 | 2.229 | 2.189 | 2.254 |
| 34 | -2.040 | 0.050 | 0.025 | 2.187 | 2.147 | 2.212 |
| 35 | -1.940 | 0.050 | 0.025 | 2.147 | 2.107 | 2.172 |
| 36 | -1.840 | 0.040 | 0.020 | 2.105 | 2.065 | 2.125 |
| 37 | -1.760 | 0.040 | 0.020 | 2.076 | 2.036 | 2.096 |
| 38 | -1.680 | 0.040 | 0.020 | 2.049 | 2.009 | 2.069 |
| 39 | -1.600 | 0.040 | 0.020 | 2.023 | 1.983 | 2.043 |
| 40 | -1.520 | 0.040 | 0.020 | 1.998 | 1.958 | 2.018 |
| 41 | -1.440 | 0.040 | 0.020 | 1.972 | 1.932 | 1.992 |
| 42 | -1.360 | 0.040 | 0.020 | 1.950 | 1.910 | 1.970 |
| 43 | -1.280 | 0.040 | 0.020 | 1.930 | 1.890 | 1.950 |
| 44 | -1.200 | 0.040 | 0.020 | 1.911 | 1.871 | 1.931 |
| 45 | -1.120 | 0.040 | 0.020 | 1.893 | 1.853 | 1.913 |
| 46 | -1.040 | 0.040 | 0.020 | 1.876 | 1.836 | 1.896 |
| 47 | -0.960 | 0.040 | 0.020 | 1.861 | 1.821 | 1.881 |
| 48 | -0.880 | 0.040 | 0.020 | 1.847 | 1.807 | 1.867 |
| 49 | -0.800 | 0.040 | 0.020 | 1.834 | 1.794 | 1.854 |
| 50 | -0.720 | 0.040 | 0.020 | 1.823 | 1.783 | 1.843 |
| 51 | -0.640 | 0.040 | 0.020 | 1.812 | 1.772 | 1.832 |
| 52 | -0.560 | 0.040 | 0.020 | 1.803 | 1.763 | 1.823 |
| 53 | -0.480 | 0.040 | 0.020 | 1.796 | 1.756 | 1.816 |
| 54 | -0.400 | 0.040 | 0.020 | 1.789 | 1.749 | 1.809 |
| 55 | -0.320 | 0.040 | 0.020 | 1.784 | 1.744 | 1.804 |
| 56 | -0.240 | 0.040 | 0.020 | 1.780 | 1.740 | 1.800 |
| 57 | -0.160 | 0.040 | 0.020 | 1.777 | 1.737 | 1.797 |
| 58 | -0.080 | 0.040 | 0.020 | 1.775 | 1.735 | 1.795 |
| 59 | 0.000 | 0.040 | 0.020 | 1.775 | 1.735 | 1.795 |
| 60 | 0.080 | 0.040 | 0.020 | 1.777 | 1.737 | 1.797 |
| 61 | 0.160 | 0.040 | 0.020 | 1.782 | 1.742 | 1.802 |
| 62 | 0.240 | 0.040 | 0.020 | 1.794 | 1.754 | 1.814 |
| 63 | 0.320 | 0.040 | 0.020 | 1.805 | 1.765 | 1.825 |
| 64 | 0.400 | 0.050 | 0.025 | 1.822 | 1.782 | 1.847 |
| 65 | 0.500 | 0.050 | 0.025 | 1.846 | 1.806 | 1.871 |
| 66 | 0.600 | 0.050 | 0.025 | 1.881 | 1.841 | 1.906 |
| 67 | 0.700 | 0.050 | 0.025 | 1.916 | 1.876 | 1.941 |
| 68 | 0.800 | 0.050 | 0.025 | 1.958 | 1.918 | 1.983 |
| 69 | 0.900 | 0.050 | 0.025 | 2.010 | 1.970 | 2.035 |
| 70 | 1.000 | 0.050 | 0.025 | 2.072 | 2.032 | 2.097 |
| 71 | 1.100 | 0.050 | 0.025 | 2.137 | 2.097 | 2.162 |

**All dimension tolerances - ±0.001"**
**Determine origin loaction from reference marks**