

## Drill Troubleshooting

| Solutions                       |                               | Tool Failure |             |          |         |              |                  |                 |                |                       |                   |                       | Chip Formation |                      | Tool Life    | Workpiece        |                  |           |                 |                |                | Process             |                     |               |               |                   |            |                  |         |           |                |              |                      |
|---------------------------------|-------------------------------|--------------|-------------|----------|---------|--------------|------------------|-----------------|----------------|-----------------------|-------------------|-----------------------|----------------|----------------------|--------------|------------------|------------------|-----------|-----------------|----------------|----------------|---------------------|---------------------|---------------|---------------|-------------------|------------|------------------|---------|-----------|----------------|--------------|----------------------|
|                                 |                               | Flank Wear   | Margin Wear | Breakage | Flaking | Greater Wear | Chisel Edge Wear | Corner Chipping | Flute Chipping | Cutting Edge Chipping | Cutting Edge Wear | Point Center Chipping | Rake Face      | Scoring on Tool Body | Long Stringy | Varied Chip Form | Blue/Brown Chips | Tool Life | Undersized Hole | Oversized Hole | Poor Alignment | Poor Surface Finish | Heavy Burr Breakout | Retract Marks | Hole Location | Hole Straightness | Deflection | Point Deflection | Galling | Vibration | Abnormal Noise | Chip Packing | No Drill Penetration |
| Speed & Feed                    | Reduce Feed or Reduce at Exit | x            |             | x        |         |              | x                | x               | x              | x                     |                   | x                     | x              | x                    |              |                  |                  | x         | x               | x              |                | x                   |                     |               |               |                   |            |                  |         |           |                | x            |                      |
|                                 | Reduce Feed at Entrance       |              |             | x        |         |              |                  |                 |                |                       |                   |                       |                |                      |              |                  |                  |           | x               |                | x              |                     |                     | x             |               | x                 |            |                  |         |           |                | x            |                      |
|                                 | Consistent Feed Rate          |              |             | x        |         |              |                  |                 |                |                       |                   |                       |                | x                    | x            |                  |                  |           |                 |                |                |                     |                     |               |               |                   |            |                  | x       |           |                | x            |                      |
|                                 | Increase Feed                 | x            |             |          |         |              | x                |                 |                |                       | x                 |                       |                | x                    |              |                  |                  |           | x               | x              |                |                     |                     |               |               |                   |            |                  |         |           |                |              |                      |
|                                 | Reduce Speed                  | x            | x           |          |         | x            |                  | x               |                |                       | x                 |                       |                |                      |              |                  |                  |           | x               | x              |                |                     |                     |               |               |                   |            | x                |         | x         | x              |              |                      |
|                                 | Increase Speed                |              |             |          |         |              |                  |                 |                |                       |                   |                       |                |                      |              |                  |                  |           |                 |                |                | x                   |                     |               |               |                   |            |                  |         |           |                |              |                      |
| Coolant                         | Coolant Mix                   |              | x           | x        | x       |              |                  |                 |                | x                     |                   |                       |                | x                    |              |                  |                  | x         | x               |                | x              | x                   |                     |               |               |                   |            |                  |         |           |                | x            |                      |
|                                 | Coolant Increase Flow         | x            |             | x        |         |              |                  | x               | x              | x                     |                   |                       |                |                      |              | x                |                  |           | x               | x              |                |                     |                     |               |               |                   |            |                  |         |           |                | x            |                      |
|                                 | Coolant Filter                | x            |             | x        | x       |              |                  |                 |                | x                     |                   |                       |                |                      |              |                  |                  |           | x               | x              |                | x                   | x                   |               |               |                   |            |                  |         |           |                | x            |                      |
| Setup                           | Workpiece Clamp Rigid         |              | x           | x        |         |              |                  | x               | x              | x                     |                   |                       |                |                      |              |                  |                  | x         |                 | x              | x              | x                   | x                   | x             | x             |                   |            |                  |         |           |                | x            |                      |
|                                 | Collet Accuracy               |              |             | x        |         |              |                  |                 | x              |                       |                   |                       |                |                      |              |                  |                  |           |                 | x              |                |                     |                     |               | x             | x                 |            |                  |         | x         |                |              |                      |
|                                 | Toolholder Fit .0008          |              |             | x        |         |              |                  |                 |                | x                     |                   |                       |                |                      |              |                  |                  |           |                 | x              |                |                     |                     | x             | x             |                   |            |                  |         | x         |                |              |                      |
|                                 | Alignment                     |              |             | x        |         |              |                  |                 |                | x                     |                   |                       |                |                      |              |                  |                  |           |                 | x              |                |                     |                     |               |               |                   |            |                  |         |           |                |              | x                    |
|                                 | Peck Drill                    |              |             | x        |         |              |                  |                 |                |                       |                   |                       |                |                      |              |                  |                  |           |                 |                |                |                     |                     |               |               |                   |            |                  |         |           |                |              |                      |
|                                 | Concentricity                 |              | x           | x        | x       |              |                  |                 | x              | x                     |                   |                       |                |                      | x            |                  |                  |           |                 |                | x              | x                   |                     | x             | x             | x                 |            | x                |         | x         |                |              |                      |
| Do Not Extract Tool During Peck |                               |              |             |          |         |              |                  |                 |                |                       |                   |                       |                |                      |              |                  |                  |           |                 |                |                |                     |                     |               |               |                   |            |                  |         |           |                |              |                      |

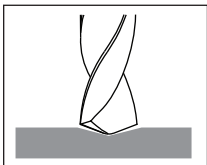
## Carbide Micro Spotting Speeds & Feeds

| Material                    | Grades   | SFM      |         | Tool Diameter (IPR) |         |         |         |         |         |         |         |
|-----------------------------|--|----------|---------|---------------------|---------|---------|---------|---------|---------|---------|---------|
|                             |  | Uncoated | AlTiN   | (.0050)             | (.0100) | (.0150) | (.0200) | (.0312) | (.0625) | (.0938) | (.1250) |
| <b>P - Steels</b>           |  |          |         |                     |         |         |         |         |         |         |         |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01  | 295-390  | 360-460 | .00015              | .0003   | .0006   | .0008   | .0010   | .0019   | .0025   | .0030   |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 260-325  | 325-390 | .00015              | .0003   | .0006   | .0008   | .0010   | .0019   | .0025   | .0030   |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 195-300  | 260-360 | .00015              | .0003   | .0006   | .0008   | .0010   | .0019   | .0025   | .0030   |
| <b>M - Stainless Steels</b> |  |          |         |                     |         |         |         |         |         |         |         |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 80-165   | 95-195  | .0001               | .0005   | .0008   | .0011   | .0017   | .0020   | .0027   | .0033   |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 80-165   | 95-195  | .0001               | .0005   | .0008   | .0011   | .0017   | .0020   | .0027   | .0033   |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355 /363, PH13-8MO, PH14-8/MO   | 80-165   | 95-195  | .0001               | .0005   | .0008   | .0011   | .0017   | .0020   | .0027   | .0033   |
| <b>K - Cast Irons</b>       |  |          |         |                     |         |         |         |         |         |         |         |
| Ductile                     | A536, J434, 60-40-18   | 195-295  | 230-295 | .0001               | .0004   | .0008   | .0011   | .0019   | .0028   | .0032   | .0040   |
| Gray                        | A48, A436, A319, Class 20, G4000   | 165-250  | 260-295 | .0001               | .0004   | .0008   | .0011   | .0019   | .0028   | .0032   | .0040   |
| Malleable                   | A220, A602, J158   | 290-350  | 330-390 | .0001               | .0004   | .0008   | .0011   | .0019   | .0028   | .0032   | .0040   |
| <b>N - Non-Ferrous</b>      |  |          |         |                     |         |         |         |         |         |         |         |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | 325-590  | 490-655 | .0003               | .0010   | .0015   | .0025   | .0025   | .0040   | .0050   | .0060   |
| Aluminum High Silicon       | A380, A390   | 325-590  | 490-655 | .0003               | .0010   | .0015   | .0025   | .0025   | .0040   | .0050   | .0060   |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | 190-300  | 225-375 | .0003               | .0010   | .0015   | .0025   | .0025   | .0040   | .0050   | .0060   |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | 325-590  | 490-655 | .0003               | .0010   | .0015   | .0025   | .0025   | .0040   | .0050   | .0060   |
| Copper                      |  | 190-300  | 225-375 | .0003               | .0010   | .0015   | .0025   | .0025   | .0040   | .0050   | .0060   |
| Magnesium                   |  | 260-325  | 260-295 | .0003               | .0010   | .0015   | .0025   | .0025   | .0040   | .0050   | .0060   |
| <b>S - High Temp Alloys</b> |  |          |         |                     |         |         |         |         |         |         |         |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 80-115   | 95-130  | .0001               | .0003   | .0009   | .0011   | .0017   | .0020   | .0025   | .0030   |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | 60-80    | 80-100  | .0001               | .0003   | .0009   | .0011   | .0017   | .0020   | .0025   | .0030   |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoloy, Udimet 500 & 700         | 60-80    | 80-100  | .0001               | .0003   | .0009   | .0011   | .0017   | .0020   | .0025   | .0030   |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si,v Ti-8Al-1Mo, Ti-8Al-4Mo   | 80-115   | 95-130  | .0001               | .0003   | .0009   | .0011   | .0017   | .0020   | .0025   | .0025   |

**NOTE:** Speeds and Feeds listed are estimated and will vary by application. These tools can be found on pages 222-223.

### Selecting the Correct Spotting Drill

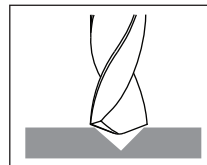
#### Spotting for Carbide Drills



Select a spotting drill with a point angle = to or > Greater than the final drill point angle.

The spot drill diameter should be 30% less than your drill diameter.

#### Spotting for HSS/Cobalt Drills



Select a spotting drill with a point angle < Less than the final drill point angle.

The spot drill diameter should be 30% less than your drill diameter.

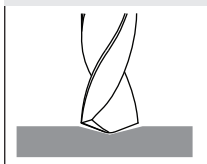
### N/C Spotting Drills Speeds & Feeds

| Material                    | Grades  | SFM     | Tool Diameter (IPR) |             |             |             |             |             |             |
|-----------------------------|---|---------|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                             |   |         | 1/8                 | 3/16        | 1/4         | 3/8         | 1/2         | 5/8         | 3/4         |
|                             |   |         | (.1250)             | (.1875)     | (.2500)     | (.3750)     | (.5000)     | (.6250)     | (.7500)     |
| <b>P - Steels</b>           |   |         |                     |             |             |             |             |             |             |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, O1   | 80-175  | .0008-.0.0030       | .0020-.0040 | .0020-.0050 | .0030-.0060 | .0030-.0060 | .0040-.0080 | .0050-.0100 |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310  | 100-175 | .0010-.0030         | .0020-.0040 | .0025-.0050 | .0030-.0080 | .0040-.0100 | .0050-.0120 | .0060-.0130 |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 100-175 | .0010-.0030         | .0020-.0040 | .0025-.0050 | .0030-.0080 | .0040-.0100 | .0050-.0120 | .0060-.0130 |
| <b>M - Stainless Steels</b> |   |         |                     |             |             |             |             |             |             |
| Austenitic                  | 301-304L, 310, 316L, 321, 347   | 80-175  | .0008-.0030         | .0020-.0040 | .0020-.0070 | .0030-.0070 | .0040-.0080 | .0040-.0100 | .0050-.0110 |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440   | 80-150  | .0008-.0030         | .0016-.0040 | .0020-.0040 | .0020-.0070 | .0030-.0080 | .0040-.0100 | .0050-.0110 |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO   | 80-175  | .0008-.0030         | .0016-.0040 | .0020-.0040 | .0020-.0070 | .0030-.0080 | .0040-.0100 | .0050-.0110 |
| <b>K - Cast Irons</b>       |   |         |                     |             |             |             |             |             |             |
| Ductile                     | A536, J434, 60-40-18  | 125-200 | .0020-.0040         | .0020-.0050 | .0030-.0060 | .0040-.0060 | .0050-.0080 | .0060-.0100 | .0070-.0120 |
| Gray                        | A48, A436, A319, Class 20, G4000  | 100-200 | .0020-.0040         | .0020-.0050 | .0030-.0060 | .0040-.0060 | .0050-.0080 | .0060-.0100 | .0070-.0120 |
| Malleable                   | A220, A602, J158  | 125-175 | .0016-.0030         | .0020-.0040 | .0020-.0040 | .0030-.0060 | .0040-.0080 | .0050-.0100 | .0060-.0120 |
| <b>N - Non-Ferrous</b>      |   |         |                     |             |             |             |             |             |             |
| Aluminum Alloys             | 2014, 2024, 6061, 7075  | 250-500 | .0020-.0040         | .0030-.0060 | .0035-.0080 | .0040-.0100 | .0060-.0120 | .0070-.0140 | .0080-.0150 |
| Aluminum High Silicon       | A380, A390  | 175-300 | .0015-.0030         | .0020-.0050 | .0030-.0070 | .0030-.0080 | .0050-.0100 | .0060-.0120 | .0070-.0130 |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze   | 125-300 | .0016-.0040         | .0020-.0050 | .0025-.0060 | .0030-.0070 | .0040-.0080 | .0050-.0100 | .0060-.0110 |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics  | 150-300 | .0020-.0040         | .0020-.0050 | .0020-.0060 | .0030-.0070 | .0050-.0080 | .0060-.0100 | .0070-.0120 |
| Copper                      |   | 150-300 | .0020-.0040         | .0020-.0050 | .0020-.0060 | .0030-.0070 | .0050-.0080 | .0060-.0100 | .0070-.0120 |
| Magnesium                   |   | 200-500 | .0020-.0040         | .0020-.0050 | .0020-.0060 | .0030-.0070 | .0050-.0080 | .0060-.0100 | .0070-.0120 |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo   | 150-200 | .0016-.0030         | .0018-.0032 | .0020-.0040 | .0030-.0060 | .0040-.0080 | .0050-.0100 | .0060-.0110 |
| <b>S - High Temp Alloys</b> |   |         |                     |             |             |             |             |             |             |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605   | 80-150  | .0008-.0020         | .0009-.0025 | .0010-.0040 | .0020-.0050 | .0030-.0080 | .0040-.0100 | .0050-.0120 |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3   | 150-200 | .0010-.0030         | .0020-.0040 | .0025-.0050 | .0030-.0080 | .0040-.0100 | .0050-.0120 | .0060-.0130 |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Wasp-oloy, Udimet 500 & 700       | 100-150 | .0016-.0030         | .0018-.0035 | .0020-.0040 | .0030-.0070 | .0040-.0100 | .0050-.0120 | .0060-.0130 |

**NOTE:** Speeds and Feeds listed are estimated and will vary by application. These tools can be found on pages 224-225.

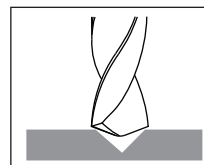
### Selecting the Correct Spotting Drill

#### Spotting for Carbide Drills



Select a spotting drill with a point angle = to or > Greater than the final drill point angle.  
The spot drill diameter should be 30% less than your drill diameter.

#### Spotting for HSS/Cobalt Drills



Select a spotting drill with a point angle < Less than the final drill point angle.  
The spot drill diameter should be 30% less than your drill diameter.



# Micro-Drills 130° Point, 35° Helix

## Technical Information

- RedLine Hole Shot High Performance Drills are designed to give optimal performance in a wide range of materials. Our 130° point is designed to reduce thrust and our flute design stabilizes our drills for better positioning and for a more accurate hole.
- High Performance Micro-Drills found on pages 226-229.

### Micro-Drills, Solid Carbide, 130° Point Speeds & Feeds

| Material                    | Grades   | Tool Diameter in Decimal |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |
|-----------------------------|--|--------------------------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|
|                             |  | (.0080)                  |       | (.0100) |       | (.0200) |       | (.0310) |       | (.0390) |       | (.0490) |       | (.0590) |       | (.0690) |       | (.0790) |       | (.0890) |       | (.0980) |       | (.1080) |       | (.1180) |       |
|                             |  | RPM                      | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   | RPM     | IPR   |
| <b>P - Steels</b>           |  |                          |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, O1  | 80000                    | .0002 | 69970   | .0004 | 34990   | .0004 | 21870   | .0008 | 17490   | .0010 | 13990   | .0014 | 11660   | .0015 | 10000   | .0015 | 8750    | .0015 | 7770    | .0015 | 7000    | .0015 | 6360    | .0015 | 5830    | .0015 |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 80000                    | .0002 | 80000   | .0004 | 57520   | .0004 | 35780   | .0008 | 28630   | .0010 | 22900   | .0014 | 19080   | .0015 | 16360   | .0015 | 14310   | .0015 | 12720   | .0015 | 11450   | .0015 | 10410   | .0015 | 9540    | .0015 |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 80000                    | .0002 | 80000   | .0004 | 44530   | .0004 | 27830   | .0008 | 22260   | .0010 | 17810   | .0014 | 14840   | .0015 | 12720   | .0015 | 11130   | .0015 | 9900    | .0015 | 8910    | .0015 | 8100    | .0015 | 7420    | .0015 |
| <b>M - Stainless Steels</b> |  |                          |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 80000                    | .0002 | 76330   | .0003 | 38170   | .0003 | 23850   | .0006 | 19080   | .0008 | 15270   | .0010 | 12720   | .0015 | 10900   | .0015 | 9540    | .0015 | 8480    | .0015 | 7630    | .0015 | 6940    | .0015 | 6360    | .0015 |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 47710                    | .0002 | 38170   | .0004 | 19080   | .0004 | 11930   | .0008 | 9540    | .0010 | 7630    | .0014 | 6360    | .0015 | 5450    | .0015 | 4770    | .0015 | 4240    | .0015 | 3820    | .0015 | 3470    | .0015 | 3180    | .0015 |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363 PH13-8MO, PH14-8/MO   | 39760                    | .0002 | 31810   | .0004 | 15900   | .0004 | 9940    | .0008 | 7950    | .0010 | 6360    | .0014 | 5300    | .0015 | 4540    | .0015 | 3980    | .0015 | 3530    | .0015 | 3180    | .0015 | 2890    | .0015 | 2650    | .0015 |
| <b>K - Cast Irons</b>       |  |                          |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |
| Ductile                     | A536, J434, 60-40-18   | 80000                    | .0002 | 79800   | .0004 | 69270   | .0004 | 44832   | .0008 | 35401   | .0010 | 29635   | .0013 | 23169   | .0015 | 19710   | .0015 | 17551   | .0015 | 15484   | .0015 | 14057   | .0015 | 12598   | .0015 | 11638   | .0015 |
| Gray                        | A48, A436, A319, Class 20, G4000   | 80000                    | .0002 | 80000   | .0004 | 76330   | .0004 | 47710   | .0008 | 38170   | .0010 | 30530   | .0014 | 25440   | .0015 | 21810   | .0015 | 19080   | .0015 | 16960   | .0015 | 15270   | .0015 | 13880   | .0015 | 12720   | .0015 |
| Malleable                   | A220, A602, J158   | 80000                    | .0002 | 80000   | .0004 | 69970   | .0004 | 43730   | .0008 | 34990   | .0010 | 27990   | .0014 | 23320   | .0015 | 19990   | .0015 | 17490   | .0015 | 15550   | .0015 | 13990   | .0015 | 12720   | .0015 | 11660   | .0015 |
| <b>N - Non-Ferrous</b>      |  |                          |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | 80000                    | .0002 | 80,000  | .0004 | 80,000  | .0004 | 55660   | .0008 | 44530   | .0010 | 35620   | .0014 | 29690   | .0015 | 25440   | .0015 | 22260   | .0015 | 19790   | .0015 | 17810   | .0015 | 16190   | .0015 | 14840   | .0015 |
| Aluminum High Silicon       | A380, A390   | 80000                    | .0002 | 80,000  | .0004 | 63,610  | .0004 | 39760   | .0008 | 31810   | .0010 | 25440   | .0014 | 21200   | .0015 | 18170   | .0015 | 15900   | .0015 | 14140   | .0015 | 12720   | .0015 | 11570   | .0015 | 10600   | .0015 |
| Brass/Bronze                | Aluminum Bronze  | 80000                    | .0002 | 80,000  | .0004 | 80,000  | .0004 | 55660   | .0008 | 44530   | .0010 | 35620   | .0014 | 29690   | .0015 | 25440   | .0015 | 22260   | .0015 | 19790   | .0015 | 17810   | .0015 | 16190   | .0015 | 14840   | .0015 |
|                             | Low Silicon Bronze   | 80000                    | .0002 | 80,000  | .0004 | 63,610  | .0004 | 39760   | .0008 | 31810   | .0010 | 25440   | .0014 | 21200   | .0015 | 18170   | .0015 | 15900   | .0015 | 14140   | .0015 | 12720   | .0015 | 11570   | .0015 | 10600   | .0015 |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | 80000                    | .0005 | 80000   | .0010 | 80000   | .0010 | 79520   | .0020 | 63610   | .0030 | 50890   | .0040 | 42410   | .0050 | 36350   | .0050 | 31810   | .0050 | 28270   | .0050 | 25440   | .0050 | 23130   | .0050 | 21200   | .0050 |
| Copper                      |  | 80000                    | .0002 | 80,000  | .0004 | 80,000  | .0004 | 55660   | .0008 | 44530   | .0010 | 35620   | .0014 | 29690   | .0015 | 25440   | .0015 | 22260   | .0015 | 19790   | .0015 | 17810   | .0015 | 16190   | .0015 | 14840   | .0015 |
| Magnesium                   |  | 80000                    | .0002 | 80,000  | .0004 | 80,000  | .0004 | 55660   | .0008 | 44530   | .0010 | 35620   | .0014 | 29690   | .0015 | 25440   | .0015 | 22260   | .0015 | 19790   | .0015 | 17810   | .0015 | 16190   | .0015 | 14840   | .0015 |
| <b>S - High Temp Alloys</b> |  |                          |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |         |       |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 23850                    | .0002 | 19080   | .0003 | 9540    | .0003 | 5960    | .0006 | 4770    | .0008 | 3820    | .0010 | 3180    | .0012 | 2730    | .0012 | 2390    | .0012 | 2120    | .0012 | 1910    | .0012 | 1730    | .0012 | 1590    | .0012 |
| Iron Base                   | Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3   | 23850                    | .0002 | 19080   | .0003 | 9540    | .0003 | 5960    | .0006 | 4770    | .0008 | 3820    | .0010 | 3180    | .0012 | 2730    | .0012 | 2390    | .0012 | 2120    | .0012 | 1910    | .0012 | 1730    | .0012 | 1590    | .0012 |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700          | 23850                    | .0002 | 19080   | .0003 | 9540    | .0003 | 5960    | .0006 | 4770    | .0008 | 3820    | .0010 | 3180    | .0012 | 2730    | .0012 | 2390    | .0012 | 2120    | .0012 | 1910    | .0012 | 1730    | .0012 | 1590    | .0012 |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 23850                    | .0002 | 19080   | .0003 | 9540    | .0003 | 5960    | .0006 | 4770    | .0008 | 3820    | .0010 | 3180    | .0012 | 2730    | .0012 | 2390    | .0012 | 2120    | .0012 | 1910    | .0012 | 1730    | .0012 | 1590    | .0012 |

NOTE: Speeds and Feeds listed are estimated and will vary by application.



## Micro-Drills 135° Point, 12° Helix Technical Information

- RedLine Hole Shot High Performance Drills are designed to give optimal performance in a wide range of materials. Our 135° point is designed to reduce thrust and our flute design stabilizes our drills for better positioning and for a more accurate hole.
- High Performance Micro-Drills found on pages 230-233.

### Micro-Drills, Solid Carbide, 135° Point Speeds & Feeds

| Material                    | Grades   | SFM     | Tool Diameter (IPR) |         |              |              |              |              |             |  |
|-----------------------------|--|---------|---------------------|---------|--------------|--------------|--------------|--------------|-------------|--|
|                             |  |         | (.0040)             | (.0100) | 1/64 (.0156) | 1/32 (.0312) | 1/16 (.0625) | 3/32 (.0937) | 1/8 (.1250) |  |
| <b>P - Steels</b>           |  |         |                     |         |              |              |              |              |             |  |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01  | 85-120  | .00010              | .00026  | .0004        | .0008        | .0015        | .0023        | .0030       |  |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 110-150 | .00010              | .00026  | .0004        | .0008        | .0015        | .0023        | .0030       |  |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 90-130  | .00010              | .00026  | .0004        | .0008        | .0015        | .0023        | .0030       |  |
| <b>M - Stainless Steels</b> |  |         |                     |         |              |              |              |              |             |  |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 90-125  | .00010              | .00026  | .0004        | .0008        | .0015        | .0023        | .0030       |  |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 80-110  | .00010              | .00026  | .0004        | .0008        | .0015        | .0023        | .0030       |  |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 45-60   | .00010              | .00013  | .0002        | .0004        | .0007        | .0011        | .0014       |  |
| <b>K - Cast Irons</b>       |  |         |                     |         |              |              |              |              |             |  |
| Ductile                     | A536, J434, 60-40-18   | 110-150 | .00010              | .00026  | .0004        | .0008        | .0015        | .0023        | .0030       |  |
| Gray                        | A48, A436, A319, Class 20, G4000   | 110-150 | .00010              | .00026  | .0004        | .0008        | .0015        | .0023        | .0030       |  |
| Malleable                   | A220, A602, J158   | 110-150 | .00010              | .00026  | .0004        | .0008        | .0015        | .0023        | .0030       |  |
| <b>N - Non-Ferrous</b>      |  |         |                     |         |              |              |              |              |             |  |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | 175     | .00010              | .00030  | .0005        | .0010        | .0020        | .0030        | .0040       |  |
| Aluminum High Silicon       | A380, A390   | 175     | .00010              | .00030  | .0005        | .0010        | .0020        | .0030        | .0040       |  |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | 100     | .00010              | .00030  | .0005        | .0010        | .0020        | .0030        | .0040       |  |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | 175     | .00010              | .00030  | .0005        | .0010        | .0020        | .0030        | .0040       |  |
| Copper                      |  | 175     | .00010              | .00030  | .0005        | .0010        | .0020        | .0030        | .0040       |  |
| Magnesium                   |  | 175     | .00010              | .00030  | .0005        | .0010        | .0020        | .0030        | .0040       |  |
| <b>S - High Temp Alloys</b> |  |         |                     |         |              |              |              |              |             |  |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 45-60   | .00010              | .00015  | .0002        | .0004        | .0007        | .0011        | .0014       |  |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | 45-60   | .00010              | .00015  | .0002        | .0004        | .0007        | .0011        | .0014       |  |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700          | 45-60   | .00010              | .00015  | .0002        | .0004        | .0007        | .0011        | .0014       |  |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 50-70   | .00020              | .00030  | .0004        | .0008        | .0015        | .0023        | .0030       |  |

**NOTE:** Speeds and Feeds listed are estimated and will vary by application.

| Recommended Peck Depths by Diameter* (Inch) |                |
|---|----------------|
| Diameter                                    | Peck Depth     |
| 1/64  | .5 x Diameter  |
| 1/32  | 1 x Diameter   |
| 1/16  | 1.5 x Diameter |
| 3/32  | 2 x Diameter   |
| 1/8   | 3 x Diameter   |

| Recommended Peck Depths by Diameter* (mm) |                |
|---|----------------|
| Diameter                                  | Peck Depth     |
| 0.5 mm                                    | .5 x Diameter  |
| 1.0 mm                                    | 1 x Diameter   |
| 1.5 mm                                    | 1.5 x Diameter |
| 2.0 mm                                    | 2 x Diameter   |
| 3.0 mm                                    | 3 x Diameter   |

| High Performance Drills Tolerances |              |              |             |              |              |
|------------------------------------|--------------|--------------|-------------|--------------|--------------|
| Inches                             |              |              | Millimeters |              |              |
| Size                               | Drill ø (m7) | Shank ø (h6) | Size        | Drill ø (m7) | Shank ø (h6) |
| .0000-.1250                        | +0/-0.0003   | +0/-0.0002   | 0-3.00      | +0/-0.008    | +0/-0.005    |

\* Peck depths can vary by material type.



## Multi-Material (Non-Coolant Fed) Stub & Regular Length Drills Technical Information



- RedLine Hole Shot High Performance Drills are designed to give optimal performance in a wide range of materials. Our 142° point is designed to reduce thrust and our flute design stabilizes our drills for better positioning and for a more accurate hole.
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Multi-Material, Non-Coolant Fed, High Performance Drills found on pages 234-238 & 252-256.

### Multi-Material, Solid Carbide, Speeds & Feeds

| Materials                   | Grades   | SFM     | Tool Diameter (IPR) |             |             |             |             |             |
|-----------------------------|--|---------|---------------------|-------------|-------------|-------------|-------------|-------------|
|                             |  |         | 1/8                 | 1/4         | 3/8         | 1/2         | 5/8         | 3/4         |
|                             |  |         | (.1250)             | (.2500)     | (.3750)     | (.5000)     | (.6250)     | (.7500)     |
| <b>P - Steels</b>           |  |         |                     |             |             |             |             |             |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01  | 170-200 | .0014-.0030         | .0035-.0060 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 265-390 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 260-330 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| <b>M - Stainless Steels</b> |  |         |                     |             |             |             |             |             |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 100-130 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 200-300 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 100-130 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| <b>K - Cast Irons</b>       |  |         |                     |             |             |             |             |             |
| Ductile                     | A536, J434, 60-40-18   | 190-280 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Gray                        | A48, A436, A319, Class 20, G4000   | 350-480 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Malleable                   | A220, A602, J158   | 190-280 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Magnesium                   |  | N/A     |                     |             |             |             |             |             |
| <b>N - Non-Ferrous</b>      |  |         |                     |             |             |             |             |             |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Aluminum High Silicon       | A380, A390   | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Copper                      |  | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| <b>S - High Temp Alloys</b> |  |         |                     |             |             |             |             |             |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 40      | .0014               | .0023       | .0040       | .0050       | .0060       | .0090       |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | 70      | .0014               | .0023       | .0040       | .0050       | .0060       | .0090       |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoloy, Udimet 500 & 700         | 45-80   | .0014               | .0043       | .0060       | .0070       | .0080       | .0100       |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 90-130  | .0040               | .0080       | .0100       | .0110       | .0140       | .0150       |

NOTE: Speeds and Feeds listed are estimated and will vary by application.

| High Performance Drills Tolerances (Inch) |              |              |
|---|--------------|--------------|
| Size                                      | Drill ø (m7) | Shank ø (h6) |
| .0000-.1181                               | +0/-.00008   | +0/-.00044   |
| .1182-.2362                               | +0/-.00015   | +0/-.00063   |
| .2363-.3937                               | +0/-.00023   | +0/-.00083   |
| .3938-.7087                               | +0/-.00027   | +0/-.00098   |
| .7088-1.181                               | +0/-.00031   | +0/-.00114   |

| High Performance Drills Tolerances (mm) |              |              |
|---|--------------|--------------|
| Size                                    | Drill ø (m7) | Shank ø (h6) |
| .0000-3mm                               | +0/-.002mm   | +0/-.012mm   |
| 3.01-6mm                                | +0/-.004mm   | +0/-.016mm   |
| 6.01-10mm                               | +0/-.006mm   | +0/-.021mm   |
| 10.01-18mm                              | +0/-.007mm   | +0/-.025mm   |
| 18.01-20mm                              | +0/-.008mm   | +0/-.029mm   |



## Multi-Material, Coolant Fed, Stub & Regular Length Drills Technical Information



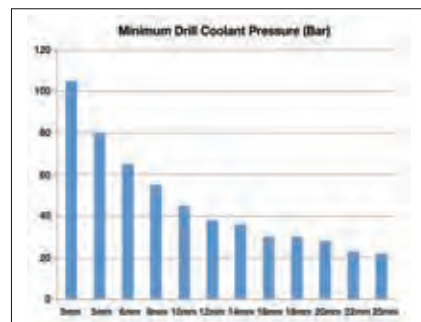
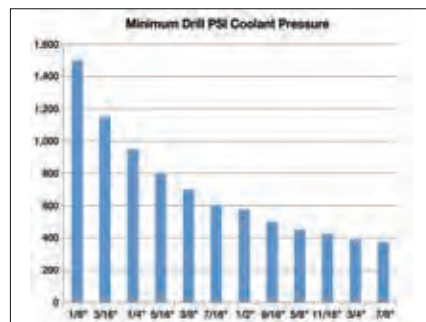
- RedLine Hole Shot High Performance Drills are designed to give optimal performance in a wide range of materials. Our 142° point is designed to reduce thrust and our flute design stabilizes our drills for better positioning and for a more accurate hole.
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Multi-Material, Coolant-Fed, High Performance Drills found on pages 239-242 & 257-261.

### Multi-Material, Solid Carbide, Coolant Fed, Stub & Regular Length Speeds & Feeds

| Material                    | Grades   | SFM     | Tool Diameter (IPR) |             |             |             |             |             |
|-----------------------------|--|---------|---------------------|-------------|-------------|-------------|-------------|-------------|
|                             |  |         | 1/8                 | 1/4         | 3/8         | 1/2         | 5/8         | 3/4         |
|                             |  |         | (.1250)             | (.2500)     | (.3750)     | (.5000)     | (.6250)     | (.7500)     |
| <b>P - Steels</b>           |  |         |                     |             |             |             |             |             |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01  | 190-250 | .0014-.0030         | .0035-.0060 | .0070-.0100 | .0090-.0110 | .0100-.0140 | .0100-.0150 |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 500-660 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0090-.0110 | .0100-.0140 | .0100-.0150 |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 315-575 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0090-.0110 | .0100-.0140 | .0100-.0150 |
| <b>M - Stainless Steels</b> |  |         |                     |             |             |             |             |             |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 230-300 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0060-.0110 | .0100-.0140 | .0100-.0150 |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 330-550 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0060-.0110 | .0100-.0140 | .0100-.0150 |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 230-300 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0060-.0110 | .0100-.0140 | .0100-.0150 |
| <b>K - Cast Irons</b>       |  |         |                     |             |             |             |             |             |
| Ductile                     | A536, J434, 60-40-18   | 200-320 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0100-.0150 |
| Gray                        | A48, A436, A319, Class 20, G4000   | 500-660 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0100-.0150 |
| Malleable                   | A220, A602, J158   | 200-280 | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0100-.0150 |
| <b>N - Non-Ferrous</b>      |  |         |                     |             |             |             |             |             |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Aluminum High Silicon       | A380, A390   | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Copper                      |  | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| Magnesium                   |  | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         |
| <b>S - High Temp Alloys</b> |  |         |                     |             |             |             |             |             |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 50      | .0014               | .0023       | .0040       | .0050       | .0060       | .0090       |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | 85      | .0014               | .0023       | .0040       | .0050       | .0060       | .0090       |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoloy, Udimet 500 & 700         | 75-115  | .0014               | .0023       | .0040       | .0050       | .0060       | .0090       |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 150-230 | .0030-.0040         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0100-.0150 |

NOTE: Speeds and Feeds listed are estimated and will vary by application.

### Coolant Pressure Requirements





## Double Margin (Non-Coolant Fed) Stub & Regular Length Drills Technical Information

- RedLine Pro Line Extra High Performance drills reduce cutting forces and provides additional stability for Heavier Feed Rates in most materials and gives increased performance when drilling Stainless Steel, Titanium, Carbon Steels and Cast Iron. Our Double Margin design provides improved hole finishes, quicker hole engagement and better location accuracy when drilling through cross holes.
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Multi-Material, Non-Coolant Fed, High Performance Drills found on pages 243-247 & 262-265.

### Double Margin, Solid Carbide, Speeds & Feeds

| Materials                             | Grades   | SFM      | Starting SFM | Tool Diameter (IPR) |             |             |             |             |             |
|---------------------------------------|--|----------|--------------|---------------------|-------------|-------------|-------------|-------------|-------------|
|                                       |  |          |              | 1/8                 | 1/4         | 3/8         | 1/2         | 5/8         | 3/4         |
|                                       |  |          |              | (.1250)             | (.2500)     | (.3750)     | (.5000)     | (.6250)     | (.7500)     |
| <b>P - Steels</b>                     |  |          |              |                     |             |             |             |             |             |
| High Strength Tool Steel              | A2, D2, P20, H11, H13, S2, O1  |          | 170-200      | .0014-.0030         | .0035-.0060 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Low Carbon                            | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   |          | 265-390      | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Medium Carbon                         | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 |          | 260-330      | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| <b>M - Stainless Steels</b>           |  |          |              |                     |             |             |             |             |             |
| Austenitic                            | 301-304L, 310, 316L, 321, 347  |          | 100-130      | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Martensitic                           | 403, 410, 416, 420, 430, 431, 440  |          | 200-300      | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Precipitation Hardening               | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  |          | 100-130      | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| <b>K - Cast Irons</b>                 |  |          |              |                     |             |             |             |             |             |
| Ductile                               | A536, J434, 60-40-18   |          | 190-280      | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Gray                                  | A48, A436, A319, Class 20, G4000   |          | 350-480      | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Malleable                             | A220, A602, J158   |          | 190-280      | .0030-.0050         | .0055-.0080 | .0070-.0100 | .0080-.0110 | .0100-.0140 | .0110-.0150 |
| Magnesium                             |  |          | N/A          |                     |             |             |             |             |             |
| <b>N - Non-Ferrous</b>                |  |          |              |                     |             |             |             |             |             |
| Aluminum & Wrought Aluminum Alloys    | 600-100 Brinell HB   | 390-1480 | 750          | .005-.010           | .007-.014   | .011-.020   | .013-.022   | .014-.023   | .015-.025   |
| Cast Aluminum Alloys                  | 75-90 Brinell HB   | 390-1150 | 720          | .006-.009           | .007-.013   | .011-.018   | .013-.021   | .015-.023   | .017-.025   |
| Aluminum Alloys Cast                  | 13-22 SI   | 330-1310 | 590          | .005-.007           | .006-.010   | .011-.015   | .013-.017   | .015-.019   | .017-.021   |
| Copper & Copper Alloys, Brass, Bronze | 90-110 Brinell HB  | 330-980  | 430          | .004-.006           | .006-.009   | .007-.013   | .008-.014   | .009-.015   | .010-.016   |
| <b>S - High Temp Alloys</b>           |  |          |              |                     |             |             |             |             |             |
| Cobalt Base                           | Stellite, HS-21, Haynes 25/188, X40, L605  |          | 40           | .0014               | .0023       | .0040       | .0050       | .0060       | .0090       |
| Iron Base                             | Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3   |          | 70           | .0014               | .0023       | .0040       | .0050       | .0060       | .0090       |
| Nickel Base                           | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoloy, Udimet 500 & 700         |          | 45-80        | .0014               | .0043       | .0060       | .0070       | .0080       | .0100       |
| Titanium                              | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  |          | 90-130       | .0040               | .0080       | .0100       | .0110       | .0140       | .0150       |

NOTE: Speeds and Feeds listed are estimated and will vary by application.

### High Performance Drills Tolerances (Inch)

| Drill Size  | Tolerance by Drill ø (m7) | Shank ø (h6) |
|-------------|---------------------------|--------------|
| .0000-.1181 | +0/--.00008               | +0/--.00044  |
| .1182-.2362 | +0/--.00015               | +0/--.00063  |
| .2363-.3937 | +0/--.00023               | +0/--.00083  |
| .3938-.7087 | +0/--.00027               | +0/--.00098  |
| .7088-1.181 | +0/--.00031               | +0/--.00114  |

### High Performance Drills Tolerances (mm)

| Drill Size | Tolerance by Drill ø (m7) | Shank ø (h6) |
|------------|---------------------------|--------------|
| .0000-3mm  | +0/--.002mm               | +0/--.012mm  |
| 3.01-6mm   | +0/--.004mm               | +0/--.016mm  |
| 6.01-10mm  | +0/--.006mm               | +0/--.021mm  |
| 10.01-18mm | +0/--.007mm               | +0/--.025mm  |
| 18.01-20mm | +0/--.008mm               | +0/--.029mm  |





## Double Margin, Coolant Fed, Stub & Regular Length Drills Technical Information

- RedLine Pro Line Extra High Performance drills reduce cutting forces and provides additional stability for Heavier Feed Rates in most materials and gives increased performance when drilling Stainless Steel, Titanium, Carbon Steels and Cast Iron. Our Double Margin design provides improved hole finishes, quicker hole engagement and better location accuracy when drilling through cross holes.
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Multi-Material, Coolant-Fed, High Performance Drills found on pages 248-251 & 266-270.

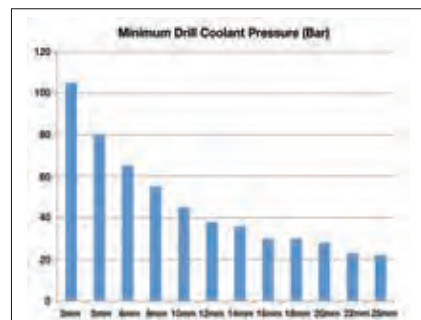
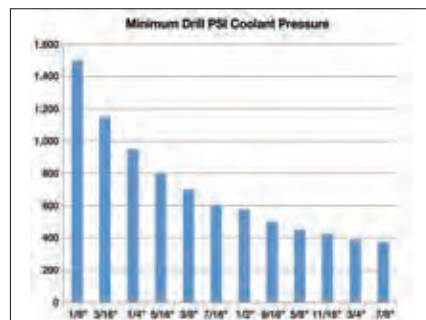


### Double Margin, Solid Carbide, Coolant Fed, Stub & Regular Length Speeds & Feeds

| Material                              | Grades   | SFM      | Starting SFM | Tool Diameter (IPR) |                |                |                |                |                |
|---------------------------------------|--|----------|--------------|---------------------|----------------|----------------|----------------|----------------|----------------|
|                                       |  |          |              | 1/8<br>(.1250)      | 1/4<br>(.2500) | 3/8<br>(.3750) | 1/2<br>(.5000) | 5/8<br>(.6250) | 3/4<br>(.7500) |
| <b>P - Steels</b>                     |  |          |              |                     |                |                |                |                |                |
| High Strength Tool Steel              | A2, D2, P20, H11, H13, S2, O1  |          | 190-250      | .0014-.0030         | .0035-.0060    | .0070-.0100    | .0090-.0110    | .0100-.0140    | .0100-.0150    |
| Low Carbon                            | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   |          | 500-660      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0090-.0110    | .0100-.0140    | .0100-.0150    |
| Medium Carbon                         | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 |          | 315-575      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0090-.0110    | .0100-.0140    | .0100-.0150    |
| <b>M - Stainless Steels</b>           |  |          |              |                     |                |                |                |                |                |
| Austenitic                            | 301-304L, 310, 316L, 321, 347  |          | 230-300      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0060-.0110    | .0100-.0140    | .0100-.0150    |
| Martensitic                           | 403, 410, 416, 420, 430, 431, 440  |          | 330-550      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0060-.0110    | .0100-.0140    | .0100-.0150    |
| Precipitation Hardening               | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  |          | 230-300      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0060-.0110    | .0100-.0140    | .0100-.0150    |
| <b>K - Cast Irons</b>                 |  |          |              |                     |                |                |                |                |                |
| Ductile                               | A536, J434, 60-40-18   |          | 200-320      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0080-.0110    | .0100-.0140    | .0100-.0150    |
| Gray                                  | A48, A436, A319, Class 20, G4000   |          | 500-660      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0080-.0110    | .0100-.0140    | .0100-.0150    |
| Malleable                             | A220, A602, J158   |          | 200-280      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0080-.0110    | .0100-.0140    | .0100-.0150    |
| <b>N - Non-Ferrous</b>                |  |          |              |                     |                |                |                |                |                |
| Aluminum & Wrought Aluminum Alloys    | 600-100 Brinell HB   | 390-1480 | 750          | .005-.010           | .007-.014      | .011-.020      | .013-.022      | .014-.023      | .015-.025      |
| Cast Aluminum Alloys                  | 75-90 Brinell HB   | 390-1150 | 720          | .006-.009           | .007-.013      | .011-.018      | .013-.021      | .015-.023      | .017-.025      |
| Aluminum Alloys Cast                  | 13-22 SI   | 330-1310 | 590          | .005-.007           | .006-.010      | .011-.015      | .013-.017      | .015-.019      | .017-.021      |
| Copper & Copper Alloys, Brass, Bronze | 90-110 Brinell HB  | 330-980  | 430          | .004-.006           | .006-.009      | .007-.013      | .008-.014      | .009-.015      | .010-.016      |
| <b>S - High Temp Alloys</b>           |  |          |              |                     |                |                |                |                |                |
| Cobalt Base                           | Stellite, HS-21, Haynes 25/188, X40, L605  |          | 50           | .0014               | .0023          | .0040          | .0050          | .0060          | .0090          |
| Iron Base                             | Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3   |          | 85           | .0014               | .0023          | .0040          | .0050          | .0060          | .0090          |
| Nickel Base                           | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700          |          | 75-115       | .0014               | .0023          | .0040          | .0050          | .0060          | .0090          |
| Titanium                              | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  |          | 150-230      | .0030-.0040         | .0055-.0080    | .0070-.0100    | .0080-.0110    | .0100-.0140    | .0100-.0150    |

**NOTE:** Speeds and Feeds listed are estimated and will vary by application.

### Coolant Pressure Requirements





## Multi-Material, Coolant Fed, Long Length Drills Technical Information

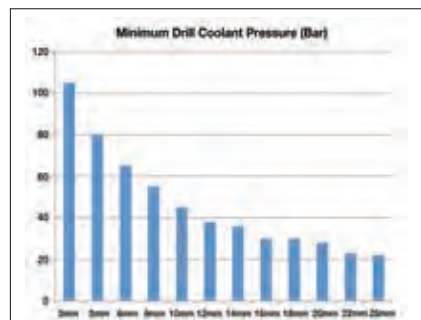
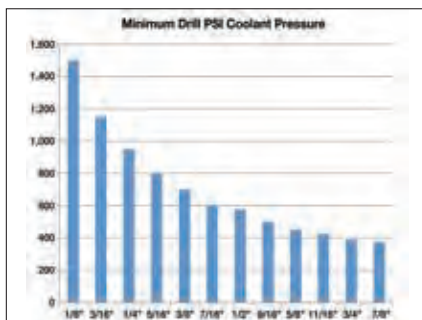
- RedLine Hole Shot High Performance Drills are designed to give optimal performance in a wide range of materials. Our 142° point is designed to reduce thrust and our flute design stabilizes our drills for better positioning and for a more accurate hole.
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Multi-Material, Coolant-Fed, High Performance Drills found on pages 271-274.

### Multi-Material, Solid Carbide, Coolant Fed, Long Length Speeds & Feeds

| Material                    | Grades  | SFM     | Tool Diameter (IPR) |                |                |                |                |                |
|-----------------------------|---|---------|---------------------|----------------|----------------|----------------|----------------|----------------|
|                             |   |         | 1/8<br>(.1250)      | 1/4<br>(.2500) | 3/8<br>(.3750) | 1/2<br>(.5000) | 5/8<br>(.6250) | 3/4<br>(.7500) |
| <b>P - Steels</b>           |   |         |                     |                |                |                |                |                |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01   | 170-225 | .0019-.0031         | .0038-.0063    | .0050-.0088    | .0063-.0100    | .0088-.0120    | .0100-.0140    |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310  | 530-595 | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345 1520-1572, 4023-4063, 4120-4161. 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 280-375 | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| <b>M - Stainless Steels</b> |   |         |                     |                |                |                |                |                |
| Austenitic                  | 301-304L, 310, 316L, 321, 347   | 185-280 | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440   | 280-350 | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0080-.0110    | .0100-.0140    | .0110-.0150    |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO   | 125-190 | .0019-.0031         | .0038-.0063    | .0050-.0088    | .0063-.010     | .0088-.0120    | .0100-.0140    |
| <b>K - Cast Irons</b>       |   |         |                     |                |                |                |                |                |
| Ductile                     | A536, J434, 60-40-18  | 475-590 | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| Gray                        | A48, A436, A319, Class 20, G4000  | 530-590 | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| Malleable                   | A220, A602, J158  | 250-320 | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| <b>N - Non-Ferrous</b>      |   |         |                     |                |                |                |                |                |
| Aluminum Alloys             | 2014, 2024, 6061, 7075  | N/A     | N/A                 | N/A            | N/A            | N/A            | N/A            | N/A            |
| Aluminum High Silicon       | A380, A390  | N/A     | N/A                 | N/A            | N/A            | N/A            | N/A            | N/A            |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze   | N/A     | N/A                 | N/A            | N/A            | N/A            | N/A            | N/A            |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics  | N/A     | N/A                 | N/A            | N/A            | N/A            | N/A            | N/A            |
| Copper                      |   | N/A     | N/A                 | N/A            | N/A            | N/A            | N/A            | N/A            |
| Magnesium                   |   | N/A     | N/A                 | N/A            | N/A            | N/A            | N/A            | N/A            |
| <b>S - High Temp Alloys</b> |   |         |                     |                |                |                |                |                |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605   | 50      | .0010               | .0025          | .0040          | .0050          | .0060          | .0075          |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3   | 95      | .0010               | .0025          | .0040          | .0050          | .0060          | .0075          |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700         | 120     | .0010               | .0025          | .0040          | .0050          | .0060          | .0075          |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo   | 180     | .0010               | .0025          | .0040          | .0050          | .0060          | .0075          |

NOTE: Speeds and Feeds listed are estimated and will vary by application.

### Coolant Pressure Requirements





## Double Margin, Coolant Fed, Long Length Drills Technical Information

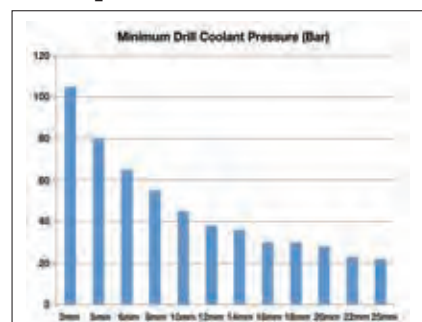
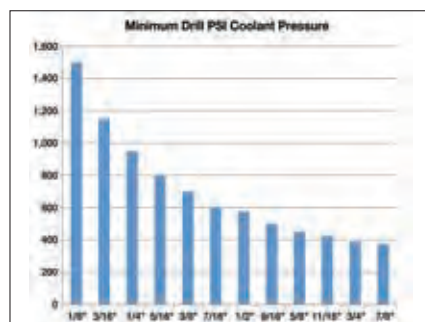
- RedLine Pro Line Extra High Performance drills reduce cutting forces and provides additional stability for Heavier Feed Rates in most materials and gives increased performance when drilling Stainless Steel, Titanium, Carbon Steels and Cast Iron. Our Double Margin design provides improved hole finishes, quicker hole engagement and better location accuracy when drilling through cross holes.
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Multi-Material, Coolant-Fed, High Performance Drills found on pages 275-278.

### Double Margin, Solid Carbide, Coolant Fed, Long Length Speeds & Feeds

| Material                              | Grades  | SFM      | Starting SFM | Tool Diameter (IPR) |                |                |                |                |                |
|---------------------------------------|---|----------|--------------|---------------------|----------------|----------------|----------------|----------------|----------------|
|                                       |   |          |              | 1/8<br>(.1250)      | 1/4<br>(.2500) | 3/8<br>(.3750) | 1/2<br>(.5000) | 5/8<br>(.6250) | 3/4<br>(.7500) |
| <b>P - Steels</b>                     |   |          |              |                     |                |                |                |                |                |
| High Strength Tool Steel              | A2, D2, P20, H11, H13, S2, O1   |          | 170-225      | .0019-.0031         | .0038-.0063    | .0050-.0088    | .0063-.0100    | .0088-.0120    | .0100-.0140    |
| Low Carbon                            | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310  |          | 530-595      | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| Medium Carbon                         | 1040-1095, 1140-1151, 1330-1345 1520-1572, 4023-4063, 4120-4161. 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 |          | 280-375      | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| <b>M - Stainless Steels</b>           |   |          |              |                     |                |                |                |                |                |
| Austenitic                            | 301-304L, 310, 316L, 321, 347   |          | 185-280      | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| Martensitic                           | 403, 410, 416, 420, 430, 431, 440   |          | 280-350      | .0030-.0050         | .0055-.0080    | .0070-.0100    | .0080-.0110    | .0100-.0140    | .0110-.0150    |
| Precipitation Hardening               | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO   |          | 125-190      | .0019-.0031         | .0038-.0063    | .0050-.0088    | .0063-.010     | .0088-.0120    | .0100-.0140    |
| <b>K - Cast Irons</b>                 |   |          |              |                     |                |                |                |                |                |
| Ductile                               | A536, J434, 60-40-18  |          | 475-590      | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| Gray                                  | A48, A436, A319, Class 20, G4000  |          | 530-590      | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| Malleable                             | A220, A602, J158  |          | 250-320      | .0038-.0063         | .0063-.0088    | .0088-.0110    | .0100-.0125    | .0110-.0150    | .0120-.0170    |
| <b>N - Non-Ferrous</b>                |   |          |              |                     |                |                |                |                |                |
| Aluminum & Wrought Aluminum Alloys    | 600-100 Brinell HB  | 390-1480 | 750          | .005-.010           | .007-.014      | .011-.020      | .013-.022      | .014-.023      | .015-.025      |
| Cast Aluminum Alloys                  | 75-90 Brinell HB  | 390-1150 | 720          | .006-.009           | .007-.013      | .011-.018      | .013-.021      | .015-.023      | .017-.025      |
| Aluminum Alloys Cast                  | 13-22 SI  | 330-1310 | 590          | .005-.007           | .006-.010      | .011-.015      | .013-.017      | .015-.019      | .017-.021      |
| Copper & Copper Alloys, Brass, Bronze | 90-110 Brinell HB   | 330-980  | 430          | .004-.006           | .006-.009      | .007-.013      | .008-.014      | .009-.015      | .010-.016      |
| <b>S - High Temp Alloys</b>           |   |          |              |                     |                |                |                |                |                |
| Cobalt Base                           | Stellite, HS-21, Haynes 25/188, X40, L605   |          | 50           | .0010               | .0025          | .0040          | .0050          | .0060          | .0075          |
| Iron Base                             | Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3  |          | 95           | .0010               | .0025          | .0040          | .0050          | .0060          | .0075          |
| Nickel Base                           | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700         |          | 120          | .0010               | .0025          | .0040          | .0050          | .0060          | .0075          |
| Titanium                              | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo   |          | 180          | .0010               | .0025          | .0040          | .0050          | .0060          | .0075          |

**NOTE:** Speeds and Feeds listed are estimated and will vary by application.

### Coolant Pressure Requirements





## Multi-Material, Coolant Fed, X-Long Length Drills Technical Information

- RedLine Hole Shot High Performance Drills are designed to give optimal performance in a wide range of materials. Our 142° point is designed to reduce thrust and our flute design stabilizes our drills for better positioning and for a more accurate hole.
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Multi-Material, Coolant-Fed, High Performance Drills found on pages 271-274 & 279.

### Multi-Material, Solid Carbide, Coolant Fed, X-Long Length Speeds & Feeds

| Material                    | Grades   | SFM | Tool Diameter (IPR) |                |                |                |                |                |  |
|-----------------------------|--|-----|---------------------|----------------|----------------|----------------|----------------|----------------|--|
|                             |  |     | 5MM<br>(.1968)      | 1/4<br>(.2500) | 5/16<br>(.312) | 3/8<br>(.3750) | 7/16<br>(.437) | 1/2<br>(.5000) |  |
| <b>P - Steels</b>           |  |     |                     |                |                |                |                |                |  |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, O1  | 260 | .0010-.0035         | .0010-.0045    | .0020-.0076    | .0023-.009     | .0025-.0096    | .0026-.0100    |  |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 350 | .0035               | .0042          | .0076          | .0090          | .0096          | .0100          |  |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 260 | .0035               | .0045          | .0076          | .0090          | .0096          | .0100          |  |
| <b>M - Stainless Steels</b> |  |     |                     |                |                |                |                |                |  |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 180 | .0035               | .0046          | .0076          | .0090          | .0096          | .0100          |  |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 125 | .0035               | .0046          | .0076          | .0090          | .0096          | .0100          |  |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 125 | .0035               | .0046          | .0076          | .0090          | .0096          | .0100          |  |
| <b>K - Cast Irons</b>       |  |     |                     |                |                |                |                |                |  |
| Ductile                     | A536, J434, 60-40-18   | 260 | .0039               | .0047          | .0076          | .0094          | .0100          | .0110          |  |
| Gray                        | A48, A436, A319, Class 20, G4000   | 400 | .0039               | .0047          | .0076          | .0094          | .0100          | .0110          |  |
| Malleable                   | A220, A602, J158   | 260 | .0039               | .0047          | .0076          | .0094          | .0100          | .0110          |  |
| <b>N - Non-Ferrous</b>      |  |     |                     |                |                |                |                |                |  |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | 500 | .0030               | .0066          | .0110          | .0120          | .0130          | .0140          |  |
| Aluminum High Silicon       | A380, A390   | 350 | .0030               | .0066          | .0110          | .0120          | .0130          | .0140          |  |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | 400 | .0035               | .0042          | .0110          | .0130          | .0150          | .0160          |  |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | N/A | N/A                 | N/A            | N/A            | N/A            | N/A            | N/A            |  |
| Copper                      |  | 300 | .0035               | .0046          | .0110          | .0130          | .0140          | .0150          |  |
| Magnesium                   |  | 300 | .0035               | .0046          | .0110          | .0130          | .0140          | .0150          |  |
| <b>S - High Temp Alloys</b> |  |     |                     |                |                |                |                |                |  |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 80  | .0007               | .0014          | .0025          | .0028          | .0034          | .0040          |  |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | 60  | .0007               | .0014          | .0025          | .0028          | .0034          | .0040          |  |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700          | 80  | .0007               | .0014          | .0025          | .0028          | .0034          | .0040          |  |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 160 | .0020               | .0024          | .0040          | .0050          | .0060          | .0070          |  |

NOTE: Speeds and Feeds listed are estimated and will vary by application.



## Multi-Material, Coolant Fed, X-Long Length Drills Deep Hole Drilling Techniques



### Step 1

Using a coolant or non-coolant pilot drill, start by producing a hole 1.5 x to 3 x diameter deep. Make sure the pilot drill has a point angle the same as or greater than the deep hole drill. You should run this drill at 100% of the final drill speed and 1/2 the normal feed.

### Step 2

Retract, then tool change to the final deep hole drill.

### Step 3

Ensuring not to exceed 400 to 500 RPM, rapid to clearance plane and enter the pilot hole at 25% of the final speed and 1 to 2 IPM—this helps with true position by eliminating drill whip. Once into the hole, turn on the coolant and advance to the material start. It is here that you can add a dwell to clear any chips that have been left from the previous drill and let the spindle get to full speed. Increase the speed and feed to final drilling parameters.

### Step 4

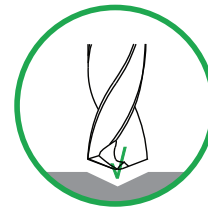
Drill one shot to the final hole depth or through.

### Step 5

If you experience any squeaking, this could mean that chip packing is occurring. As a result, you may need to retract the drill and increase your feed.

### Step 6

Once through the material, reducing the RPM may be required to eliminate breakage of the drill due to drill whip. Now retract to the clearance plane.



**CORRECT**  
Make contact  
here with drill



**INCORRECT**  
Do not make  
contact here  
with drill

**Machine Requirements:**  
High Pressure Pump System (1,000 PSI)  
Tool runout of .0003" (.008 mm) Max.



## Multi-Material, Coolant Fed, X-Long Length Drills Technical Information

- RedLine Hole Shot High Performance Drills are designed to give optimal performance in a wide range of materials. Our 142° point is designed to reduce thrust and our flute design stabilizes our drills for better positioning and for a more accurate hole.
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Multi-Material, Coolant-Fed, High Performance Drills found on pages 271-274 & 279.

### Multi-Material, Solid Carbide, Coolant Fed, X-Long Length Speeds & Feeds

| Material                    | Grades   | SFM | Tool Diameter (IPR) |                |                |                |                |                |  |
|-----------------------------|--|-----|---------------------|----------------|----------------|----------------|----------------|----------------|--|
|                             |  |     | 5MM<br>(.1968)      | 1/4<br>(.2500) | 5/16<br>(.312) | 3/8<br>(.3750) | 7/16<br>(.437) | 1/2<br>(.5000) |  |
| <b>P - Steels</b>           |  |     |                     |                |                |                |                |                |  |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, O1  | 260 | .0010-.0035         | .0010-.0045    | .0020-.0076    | .0023-.009     | .0025-.0096    | .0026-.0100    |  |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 350 | .0035               | .0042          | .0076          | .0090          | .0096          | .0100          |  |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 260 | .0035               | .0045          | .0076          | .0090          | .0096          | .0100          |  |
| <b>M - Stainless Steels</b> |  |     |                     |                |                |                |                |                |  |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 180 | .0035               | .0046          | .0076          | .0090          | .0096          | .0100          |  |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 125 | .0035               | .0046          | .0076          | .0090          | .0096          | .0100          |  |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 125 | .0035               | .0046          | .0076          | .0090          | .0096          | .0100          |  |
| <b>K - Cast Irons</b>       |  |     |                     |                |                |                |                |                |  |
| Ductile                     | A536, J434, 60-40-18   | 260 | .0039               | .0047          | .0076          | .0094          | .0100          | .0110          |  |
| Gray                        | A48, A436, A319, Class 20, G4000   | 400 | .0039               | .0047          | .0076          | .0094          | .0100          | .0110          |  |
| Malleable                   | A220, A602, J158   | 260 | .0039               | .0047          | .0076          | .0094          | .0100          | .0110          |  |
| <b>N - Non-Ferrous</b>      |  |     |                     |                |                |                |                |                |  |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | 500 | .0030               | .0066          | .0110          | .0120          | .0130          | .0140          |  |
| Aluminum High Silicon       | A380, A390   | 350 | .0030               | .0066          | .0110          | .0120          | .0130          | .0140          |  |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | 400 | .0035               | .0042          | .0110          | .0130          | .0150          | .0160          |  |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | N/A | N/A                 | N/A            | N/A            | N/A            | N/A            | N/A            |  |
| Copper                      |  | 300 | .0035               | .0046          | .0110          | .0130          | .0140          | .0150          |  |
| Magnesium                   |  | 300 | .0035               | .0046          | .0110          | .0130          | .0140          | .0150          |  |
| <b>S - High Temp Alloys</b> |  |     |                     |                |                |                |                |                |  |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 80  | .0007               | .0014          | .0025          | .0028          | .0034          | .0040          |  |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | 60  | .0007               | .0014          | .0025          | .0028          | .0034          | .0040          |  |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700          | 80  | .0007               | .0014          | .0025          | .0028          | .0034          | .0040          |  |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 160 | .0020               | .0024          | .0040          | .0050          | .0060          | .0070          |  |

NOTE: Speeds and Feeds listed are estimated and will vary by application.



## Multi-Material, Coolant Fed, X-Long Length Drills Deep Hole Drilling Techniques



### Step 1

Using a coolant or non-coolant pilot drill, start by producing a hole 1.5 x to 3 x diameter deep. Make sure the pilot drill has a point angle the same as or greater than the deep hole drill. You should run this drill at 100% of the final drill speed and 1/2 the normal feed.

### Step 2

Retract, then tool change to the final deep hole drill.

### Step 3

Ensuring not to exceed 400 to 500 RPM, rapid to clearance plane and enter the pilot hole at 25% of the final speed and 1 to 2 IPM—this helps with true position by eliminating drill whip. Once into the hole, turn on the coolant and advance to the material start. It is here that you can add a dwell to clear any chips that have been left from the previous drill and let the spindle get to full speed. Increase the speed and feed to final drilling parameters.

### Step 4

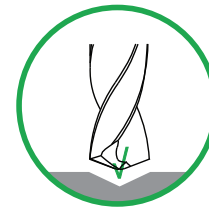
Drill one shot to the final hole depth or through.

### Step 5

If you experience any squeaking, this could mean that chip packing is occurring. As a result, you may need to retract the drill and increase your feed.

### Step 6

Once through the material, reducing the RPM may be required to eliminate breakage of the drill due to drill whip. Now retract to the clearance plane.



**CORRECT**  
Make contact  
here with drill



**INCORRECT**  
Do not make  
contact here  
with drill

#### Machine Requirements:

High Pressure Pump System (1,000 PSI)  
Tool runout of .0003" (.008 mm) Max.



## Aluminum & Non-Ferrous Drills Technical Information

- RedLine Aluminum & Non-Ferrous High Performance Drills have been specifically designed for high penetration rates, great chip evacuation, and improved hole quality, speed and performance for lower hole costs!
- All shanks are manufactured to h6 tolerance, suitable for use in shrink-fit holders.
- Aluminum & Non-Ferrous, High Performance Drills found on pages 280-283.

| Aluminum & Non-Ferrous, Speeds & Feeds |  |     |                     |                 |                |                |                |                |                |                |
|--|--|-----|---------------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Material                               | Grades   | SFM | Tool Diameter (IPR) |                 |                |                |                |                |                |                |
|  |  |     | 1/32<br>(.0312)     | 1/16<br>(.0625) | 1/8<br>(.1250) | 1/4<br>(.2500) | 3/8<br>(.3750) | 1/2<br>(.5000) | 5/8<br>(.6250) | 3/4<br>(.7500) |
| <b>N - Non-Ferrous</b>                 |  |     |                     |                 |                |                |                |                |                |                |
| Aluminum Alloys                        | 2014, 2024, 6061, 7075                               | 750 | .0020               | .0030           | .0080          | .0120          | .0140          | .0180          | .0220          | .0240          |
| Aluminum High Silicon                  | A380, A390   | 500 | .0010               | .0020           | .0030          | .0060          | .0080          | .0100          | .0110          | .0120          |
| Brass/Bronze                           | Aluminum Bronze, Low Silicon Bronze                  | 225 | .0010               | .0020           | .0030          | .0060          | .0080          | .0100          | .0110          | .0120          |
| Composites                             | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics | 300 | .0010               | .0020           | .0030          | .0060          | .0080          | .0100          | .0110          | .0120          |
| Copper                                 |  | 225 | .0010               | .0020           | .0030          | .0060          | .0080          | .0100          | .0110          | .0120          |

NOTE: Speeds and Feeds listed are estimated and will vary by application.

| Aluminum & Non-Ferrous Tolerances (Inch) |                                |                                |
|--|--------------------------------|--------------------------------|
| Drill Size                               | Tolerance by Drill $\phi$ (m7) | Tolerance by Shank $\phi$ (h6) |
| <b>.0000-.1181</b>                       | +0.0008/+0.0047                | +0/-0.0024                     |
| <b>.1182-.2362</b>                       | +0.0016/+0.0063                | +0/-0.0031                     |
| <b>.2363-.3937</b>                       | +0.0024/+0.0083                | +0/-0.0035                     |
| <b>.3938-.7087</b>                       | +0.0027/+0.0098                | +0/-0.0043                     |
| <b>.7088-.7500</b>                       | +0.0031/+0.0114                | +0/-0.0051                     |

| Aluminum & Non-Ferrous Tolerances (Metric) |                                |                   |
|--|--------------------------------|-------------------|
| Drill Size                                 | Tolerance by Drill $\phi$ (m7) | Shank $\phi$ (h6) |
| <b>0-3.0</b>                               | +0.02/+0.12                    | +0/-0.006         |
| <b>3.01-6.00</b>                           | +0.04/+0.16                    | +0/-0.008         |
| <b>6.01-10.00</b>                          | +0.06/+0.21                    | +0/-0.009         |
| <b>10.01-18.00</b>                         | +0.07/+0.25                    | +0/-0.011         |
| <b>18.01-20.0</b>                          | +0.08/+0.29                    | +0/-0.013         |



## General Purpose Carbide Drills Speeds & Feeds

| Material                    | Grades   | SFM      |         |             |             |             |             |
|-----------------------------|--|----------|---------|-------------|-------------|-------------|-------------|
|                             |  | Uncoated | AlTiN   | 1/8         | 1/4         | 3/8         | 1/2         |
|                             |  |          |         | (.1250)     | (.2500)     | (.3750)     | (.5000)     |
| <b>P - Steels</b>           |  |          |         |             |             |             |             |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01  | 100-175  | 140-210 | .0004-.0015 | .0010-.0020 | .0010-.0025 | .0015-.0030 |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 100-175  | 140-210 | .0005-.0015 | .0010-.0025 | .0010-.0030 | .0015-.0040 |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 125-175  | 175-245 | .0005-.0015 | .0010-.0025 | .0010-.0030 | .0015-.0040 |
| <b>M - Stainless Steels</b> |  |          |         |             |             |             |             |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 100-175  | 140-210 | .0004-.0015 | .0005-.0015 | .0010-.0015 | .0010-.0030 |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 100-150  | 140-210 | .0004-.0015 | .0008-.0020 | .0010-.0035 | .0015-.0040 |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 125-175  | 175-245 | .0004-.0015 | .0008-.0020 | .0010-.0035 | .0015-.0040 |
| <b>K - Cast Irons</b>       |  |          |         |             |             |             |             |
| Ductile                     | A536, J434, 60-40-18   | 125-250  | 175-350 | .0010-.0030 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Gray                        | A48, A436, A319, Class 20, G4000   | 125-250  | 175-350 | .0010-.0030 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Malleable                   | A220, A602, J158   | 125-250  | 175-350 | .0010-.0030 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| <b>N - Non-Ferrous</b>      |  |          |         |             |             |             |             |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | 150-300  | 210-420 | .0010-.0020 | .0015-.0040 | .0020-.0045 | .0030-.0060 |
| Aluminum High Silicon       | A380, A390   | 100-200  | 140-280 | .0008-.0015 | .0010-.0030 | .0015-.0035 | .0020-.0050 |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | 125-300  | 175-420 | .0010-.0020 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | 150-300  | 210-420 | .0010-.0020 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Copper                      |  | 150-300  | 210-420 | .0010-.0020 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Magnesium                   |  | 200-500  | 280-700 | .0010-.0020 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| <b>S - High Temp Alloys</b> |  |          |         |             |             |             |             |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 80-150   | 110-210 | .0004-.0010 | .0005-.0020 | .0010-.0025 | .0010-.0040 |
| Iron Base                   | Incoloy 800-802, Multimet N-155, Timkin 16-25-6, Carpenter 22-b3   | 150-200  | 210-280 | .0008-.0015 | .0010-.0020 | .0015-.0035 | .0020-.0040 |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoloy, Udimet 500 & 700         | 100-150  | 140-210 | .0004-.0015 | .0008-.0015 | .0010-.0025 | .0015-.0040 |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 150-200  | 210-280 | .0008-.0015 | .0010-.0020 | .0015-.0030 | .0020-.0040 |

**NOTES:** (1) Speeds and Feeds listed are estimated and will vary by application.  
 (2) Reduce Speeds by 20-30% when exceeding 2x length to diameter.

These tools can be found on pages 284-290.

### Straight Flute Carbide Drills Speeds & Feeds

| Material                    | Grades   | SFM      |         |             |             |             |             |
|-----------------------------|--|----------|---------|-------------|-------------|-------------|-------------|
|                             |  | Uncoated | AlTiN   | 1/8         | 1/4         | 3/8         | 1/2         |
|                             |  |          |         | (.1250)     | (.2500)     | (.3750)     | (.5000)     |
| <b>P - Steels</b>           |  |          |         |             |             |             |             |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01  | 125-175  | 175-245 | .0004-.0015 | .0010-.0020 | .0010-.0025 | .0015-.0030 |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 150-200  | 210-280 | .0005-.0015 | .0010-.0025 | .0010-.0030 | .0015-.0040 |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 125-175  | 175-245 | .0005-.0015 | .0010-.0025 | .0010-.0030 | .0015-.0040 |
| <b>M - Stainless Steels</b> |  |          |         |             |             |             |             |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 150-200  | 210-280 | .0004-.0015 | .0005-.0015 | .0010-.0015 | .0010-.0030 |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 125-175  | 175-245 | .0004-.0015 | .0008-.0020 | .0010-.0035 | .0015-.0040 |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 150-200  | 210-280 | .0004-.0015 | .0008-.0020 | .0010-.0035 | .0015-.0040 |
| <b>K - Cast Irons</b>       |  |          |         |             |             |             |             |
| Ductile                     | A536, J434, 60-40-18   | 150-250  | 210-350 | .0010-.0030 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Gray                        | A48, A436, A319, Class 20, G4000   | 150-250  | 210-350 | .0010-.0030 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Malleable                   | A220, A602, J158   | N/A      | N/A     | .0010-.0030 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| <b>N - Non-Ferrous</b>      |  |          |         |             |             |             |             |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | N/A      | N/A     | .0010-.0020 | .0015-.0040 | .0020-.0045 | .0030-.0060 |
| Aluminum High Silicon       | A380, A390   | N/A      | N/A     | .0008-.0015 | .0010-.0030 | .0015-.0035 | .0020-.0050 |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | N/A      | N/A     | .0010-.0020 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | 150-300  | 210-420 | .0010-.0020 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Copper                      |  | N/A      | N/A     | .0010-.0020 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| Magnesium                   |  | N/A      | N/A     | .0010-.0020 | .0010-.0030 | .0015-.0035 | .0025-.0040 |
| <b>S - High Temp Alloys</b> |  |          |         |             |             |             |             |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 100-150  | 140-210 | .0004-.0010 | .0005-.0020 | .0010-.0025 | .0010-.0040 |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | 175-200  | 245-280 | .0008-.0015 | .0010-.0020 | .0015-.0035 | .0020-.0040 |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700          | 125-175  | 175-245 | .0004-.0015 | .0008-.0015 | .0010-.0025 | .0015-.0040 |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 150-200  | 210-280 | .0008-.0015 | .0010-.0020 | .0015-.0030 | .0020-.0040 |

NOTES: (1) Speeds and Feeds listed are estimated and will vary by application.  
 (2) Reduce Speeds by 20-30% when exceeding 2x length to diameter.

These tools can be found on pages 291-292.

## Cobalt & HSS Drills Speeds & Feeds

| Material                    | Grades   | SFM     |         |         | Tool Diameter (IPR) |             |             |             |             |             |             |
|-----------------------------|--|---------|---------|---------|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                             |  |         |         |         | <=1/8               | 1/4         | 3/8         | 1/2         | 3/4         | 1           | 1-1/2+      |
|                             |  | HSS     | HSS-HD  | Cobalt  | (.1250)             | (.2500)     | (.3750)     | (.5000)     | (.7500)     | (1.000)     | (1.500)+    |
| <b>P - Steels</b>           |  |         |         |         |                     |             |             |             |             |             |             |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01  | 30-65   | 33-75   | 33-75   | .0007-.0020         | .0030-.0040 | .0040-.0065 | .0060-.0070 | .0065-.0075 | .0070-.0080 | .0075-.0085 |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 95      | 95      | 95      | .0009-.0050         | .0060-.0070 | .0090-.0100 | .0100-.0110 | .0110-.0120 | .0120-.0130 | .0130-.0140 |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 115     | 115     | 115     | .0009-.0050         | .0060-.0070 | .0090-.0120 | .0110-.0120 | .0110-.0130 | .0120-.0140 | .0130-.0150 |
| <b>M - Stainless Steels</b> |  |         |         |         |                     |             |             |             |             |             |             |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 26      | 36      | 36      | .0010-.0030         | .0035-.0050 | .0050-.0075 | .0080-.0090 | .0009-.0100 | .0100-.0110 | .0110-.0120 |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 50      | 70      | 72      | .0010-.0024         | .0025-.0037 | .0040-.0055 | .0050-.0060 | .0060-.0070 | .0070-.0080 | .0080-.0090 |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 20      | 30      | 30      | .0020-.0030         | .0030-.0040 | .0040-.0050 | .0050-.0060 | .0060-.0070 | .0070-.0080 | .0080-.0090 |
| <b>K - Cast Irons</b>       |  |         |         |         |                     |             |             |             |             |             |             |
| Ductile                     | A536, J434, 60-40-18   | 45      | 55      | 55      | .0007-.0025         | .0025-.0035 | .0040-.0060 | .0060-.0070 | .0065-.0075 | .0070-.0080 | .0075-.0085 |
| Gray                        | A48, A436, A319, Class 20, G4000   | 80-100  | 90-115  | 90-115  | .0006-.0030         | .0030-.0060 | .0040-.0090 | .0070-.0100 | .0080-.0120 | .0009-.0130 | .0100-.0140 |
| Malleable                   | A220, A602, J158   | 80-100  | 90-115  | 90-115  | .0006-.0030         | .0030-.0060 | .0040-.0090 | .0070-.0100 | .0080-.0120 | .0009-.0130 | .0100-.0140 |
| <b>N - Non-Ferrous</b>      |  |         |         |         |                     |             |             |             |             |             |             |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | 90-98   | 95-100  | 95-100  | .0007-.0050         | .0004-.0080 | .0060-.0110 | .0080-.0120 | .0090-.0130 | .0120-.0140 | .0130-.0150 |
| High Silicon                | A380, A390   | 60-80   | 80-95   | 80-95   | .0007-.0050         | .0004-.0080 | .0060-.0110 | .0080-.0120 | .0090-.0130 | .0120-.0140 | .0130-.0150 |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | 90-115  | 90-130  | 90-130  | .0008-.0040         | .0035-.0070 | .0050-.0075 | .0075-.0090 | .0080-.0100 | .0090-.0110 | .0100-.0120 |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | 100-125 | 125-175 | 125-175 | .0040-.0060         | .0030-.0050 | .0040-.0060 | .0050-.0070 | .0060-.0080 | .0070-.0090 | .0080-.0100 |
| Copper                      |  | 108     | 125     | 125     | .0010-.0035         | .0038-.0065 | .0070-.0090 | .0080-.0110 | .0100-.0120 | .0110-.0130 | .0110-.0130 |
| Magnesium                   |  | 90-115  | 90-130  | 90-130  | .0008-.0040         | .0035-.0070 | .0050-.0075 | .0075-.0090 | .0100-.0120 | .0110-.0130 | .0110-.0130 |
| <b>S - High Temp Alloys</b> |  |         |         |         |                     |             |             |             |             |             |             |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | N/A     | N/A     | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         | N/A         |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | N/A     | N/A     | N/A     | N/A                 | N/A         | N/A         | N/A         | N/A         | N/A         | N/A         |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoly, Udimet 500 & 700          | 10-20   | 20-23   | 20-23   | .0004-.0013         | .0013-.0020 | .0020-.0030 | .0030-.0035 | .0003-.0040 | .0035-.0045 | .0040-.0050 |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 20-75   | 35-90   | 35-90   | .0006-.0025         | .0020-.0040 | .0030-.0055 | .0040-.0060 | .0045-.0065 | .0005-.0070 | .0006-.0065 |

**NOTE:** Speeds and Feeds listed are estimated and will vary by application. These tools can be found on pages 293-317.

| High Speed Steel Drills Feed Rate Per Revolution Based on Cut |             |             |             | Cobalt Drills Feed Rate Per Revolution Based on Cut |             |             |             |                     |             |             |
|---|-------------|-------------|-------------|---|-------------|-------------|-------------|---------------------|-------------|-------------|
| Drill Size  | Light       | Medium      | Heavy       | Drill Size  | Cobalt      |             |             | AlTiN Coated Cobalt |             |             |
|   |             |             |             |   | Light       | Medium      | Heavy       | Light               | Medium      | Heavy       |
| 1/16"-1/8"  | .0005-.0010 | .0010-.0020 | .0020-.0030 | 1/16"-1/8"  | .0006-.0011 | .0011-.0022 | .0022-.0033 | .0007-.0013         | .0013-.0026 | .0026-.0040 |
| 1/8"-1/4"   | .0010-.0030 | .0030-.0050 | .0050-.0070 | 1/8"-1/4"   | .0011-.0033 | .0033-.0055 | .0055-.0077 | .0013-.0040         | .0040-.0066 | .0066-.0092 |
| 1/4"-1/2"   | .0030-.0050 | .0050-.0070 | .0070-.0090 | 1/4"-1/2"   | .0033-.0055 | .0055-.0077 | .0077-.0099 | .0040-.0066         | .0066-.0092 | .0092-.0119 |
| 1/2"-3/4"   | .0050-.0080 | .0080-.0110 | .0110-.0140 | 1/2"-3/4"   | .0055-.0088 | .0088-.0121 | .0121-.0154 | .0066-.0106         | .0106-.0145 | .0145-.0185 |
| 3/4"-1"   | .0080-.0110 | .0110-.0140 | .0140-.0170 | 3/4"-1"   | .0088-.0121 | .0121-.0154 | .0154-.0187 | .0106-.0145         | .0145-.0185 | .0185-.0224 |
| >1"   | .0120-.0150 | .0150-.0200 | .0200-.0250 | >1"   | .0132-.0165 | .0165-.0220 | .0220-.0275 | .0158-.0198         | .0198-.0264 | .0264-.0330 |

### Countersink Speeds

| Material                    | Grades   | SFM     |         |         |
|-----------------------------|--|---------|---------|---------|
|                             |  | HSS     | Cobalt  | Carbide |
| <b>P - Steels</b>           |  |         |         |         |
| High Strength Tool Steel    | A2, D2, P20, H11, H13, S2, 01  | 20-30   | 30-60   | 50-100  |
| Low Carbon                  | A36, 12L14, 12L15, 1005, 1018, 1020, 1108-1119, 1213-1215, 1513-1518, 4012, 5015, 9310   | 60-90   | 70-100  | 125-300 |
| Medium Carbon               | 1040-1095, 1140-1151, 1330-1345, 1520-1572, 4023-4063, 4120-4161, 4330-4340, 4620-4640, 8620-8660, 8740-8750, 6150, 51000, 52100 | 30-70   | 40-80   | 100-180 |
| <b>M - Stainless Steels</b> |  |         |         |         |
| Austenitic                  | 301-304L, 310, 316L, 321, 347  | 20-50   | 30-60   | 100-300 |
| Martensitic                 | 403, 410, 416, 420, 430, 431, 440  | 30-70   | 35-75   | 50-100  |
| Precipitation Hardening     | 12/8, 15/5, 17/4, AM-350/355/363, PH13-8MO, PH14-8/MO  | 15-50   | 25-70   | 50-100  |
| <b>K - Cast Irons</b>       |  |         |         |         |
| Ductile                     | A536, J434, 60-40-18   | 30-70   | 40-80   | 75-180  |
| Gray                        | A48, A436, A319, Class 20, G4000   | 60-90   | 70-100  | 150-225 |
| Malleable                   | A220, A602, J158   | 80-120  | 85-120  | 100-180 |
| <b>N - Non-Ferrous</b>      |  |         |         |         |
| Aluminum Alloys             | 2014, 2024, 6061, 7075   | 150-200 | 175-250 | 350-500 |
| Aluminum High Silicon       | A380, A390   | 125-170 | 130-175 | 300-425 |
| Brass/Bronze                | Aluminum Bronze, Low Silicon Bronze  | 100-300 | 100-300 | 200-400 |
| Composites                  | G-10, Fiberglass, Graphite, Graphite Epoxy, Plastics   | 100-225 | 150-300 | 250-350 |
| Copper                      |  | 70-100  | 80-110  | 150-300 |
| Magnesium                   |  | 200-400 | 210-400 | 300-500 |
| <b>S - High Temp Alloys</b> |  |         |         |         |
| Cobalt Base                 | Stellite, HS-21, Haynes 25/188, X40, L605  | 15-30   | 20-40   | 60-80   |
| Iron Base                   | Incoloy 800-802, Multmet N-155, Timkin 16-25-6, Carpenter 22-b3  | 15-30   | 20-40   | 60-80   |
| Nickel Base                 | Inconel 625/718, Inco 700, 713C, 718, Monel 400-401, 404, K401, Rene, Rene 41 & 95 Hastelloy, Waspoley, Udimet 500 & 700         | 20-50   | 25-50   | 75-180  |
| Titanium                    | Commercially Pure, 6Al-4V, ASTM 1/2/3, 6Al-25N-4Zr-2Mo-Si, Ti-8Al-1Mo, Ti-8Al-4Mo  | 20-50   | 30-60   | 30-100  |

**NOTE :** Speeds listed are estimated and will vary by application. These tools can be found on pages 318-321.