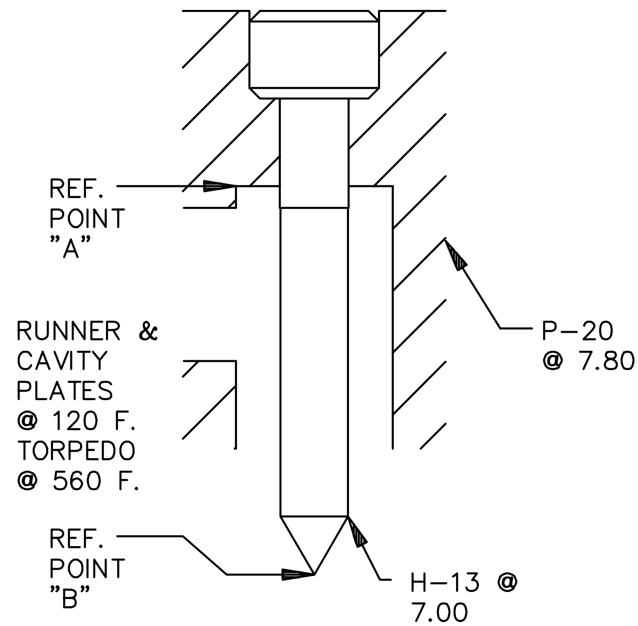
Torpedo Thermal Expansion Calculations

Dimensional relationships between the torpedo tip and the gate affects pressure drops, shear rates and the physical appearance of the gate vestige on the molded part. Absolute control of this dimensional relationship is essential to final molded part quality. The differential thermal expansion between the torpedo and the mold plates can alter this dimensional relationship and must be taken into account when establishing the room temperature location of the torpedo tip.



Typical Insulated Runner Mold Design Detailing The Required Thermal Expansion Review Data

Torpedo Thermal Expansion Evaluation

A preliminary evaluation of the thermal expansion characteristics of the torpedo and system is the first required step in establishing proper torpedo tip location. Expected operating temperatures and expansion coefficients of the torpedo and the various plates through which it passes must be reviewed. Note reference locations where differential expansion between the torpedo and mold will occur. The drawing and data shown illustrate this evaluation process.

In the insulated runner system shown, the mounting area of the torpedo is expanding at nearly the same rate as the mold plate and will not alter the relationship between tip and gate and may be excluded from expansion calculations. The portion of the torpedo in the sprue (Points "A" and "B") expands at a much higher rate than the mold plates and this differential expansion must be accounted for when establishing room temperature tip location.

In the hot runner system shown, the mounting area of the torpedo and the torpedo length within the sprue area of the hot runner manifold (Points "A" and "B") are expanding at nearly the same rate and will not alter the relationship between tip and gate and may be excluded from expansion calculations. The area of the torpedo in the sprue portion of the cavity plate (Points "B" and "C") expands at a much higher rate than that area of the mold plate and the room temperature tip location must allow for this differential expansion.

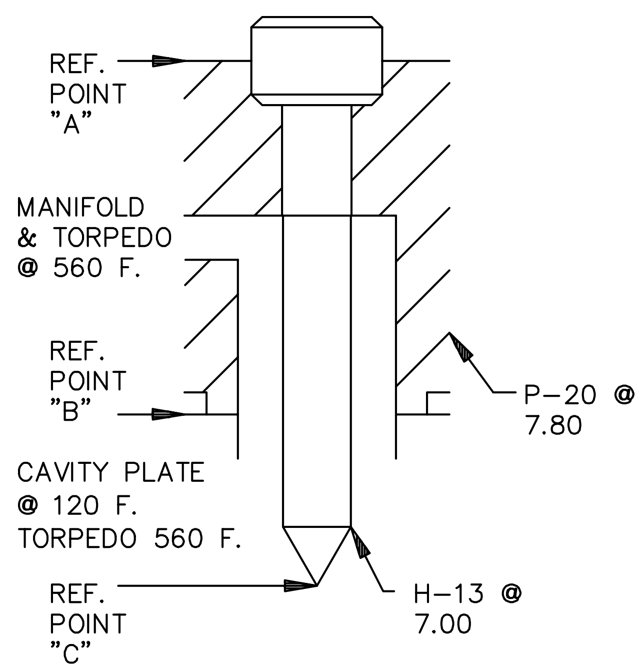
Torpedo Thermal Expansion Calculations

Two methods of establishing room temperature torpedo tip location have been provided and are detailed on the page opposite.

The first method shown utilizes a graph from which the actual expansion per inch of torpedo may be selected for any given operating temperature. This expansion can then be multiplied by the length of the torpedo affected to obtain the total change in torpedo length. This graphical method provides sufficient accuracy for most common runnerless applications involving standard length torpedoes.

The second method requires calculation of expansion based on actual expansion coefficient and torpedo operating temperature. This calculation procedure provides reasonable accuracy in establishing room temperature location of the torpedo tip. For more accurate calculations, a separate calculation for both the torpedo and plate must be carried out. By subtracting plate expansion from torpedo expansion true differential expansion can be obtained. Establishing the room temperature location of the tip based on true differential expansion provides more accurate results and is preferred for molds involving long torpedoes and more precise torpedo tip location.

Regardless of the procedure used, the torpedo tip location will normally require additional adjustment to obtain the final desired molding conditions and molded part characteristics.

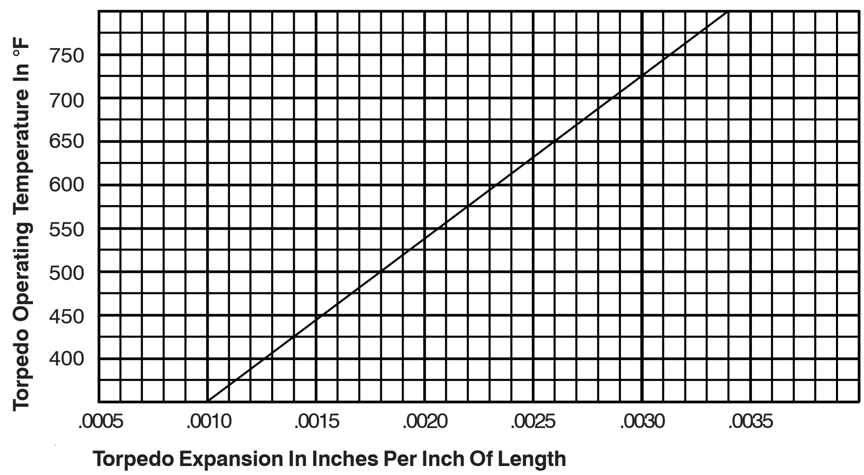


Typical Hot Runner Mold Design Detailing The Required Thermal Expansion Review Data

Torpedo Thermal Expansion Calculations

Graphical Expansion Solution

The graph on the right establishes values for torpedo expansion in inches per inch of length at operating temperature. The graph and the simple procedures outlined below provide a reasonably accurate value for total torpedo expansion. The data supplied applies to all "SOLUTION" torpedoes manufactured of standard H-13 tool steel.

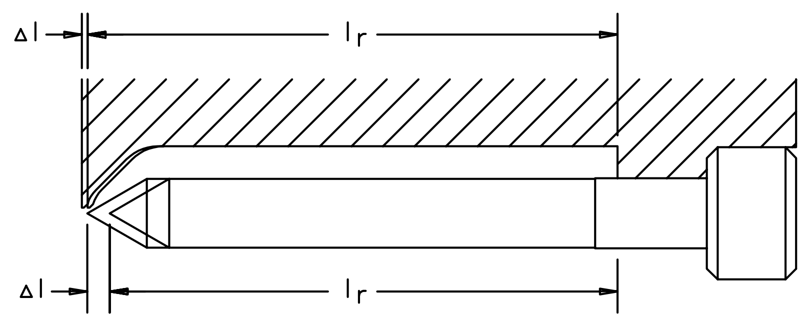


1 Find the torpedo operating temperature on the Y axis of the graph for the area of the torpedo where differential expansion must be determined.

2 Locate the horizontal intersection of this temperature point with the plot line of expansion versus temperature.

3 Read the expansion value in inches per inch of heated length from the X axis directly below this point.

4 Multiply the expansion value obtained by the inches of heated length where differential expansion occurs. This value represents the total expansion of the torpedo during operation and can be used to establish room temperature torpedo tip location.



Calculated Expansion Solution

The equation provided permits calculation of torpedo expansion based on the expansion coefficient of the materials used in the torpedo and mold. Short torpedoes only require calculations for torpedo expansion. Applications requiring longer torpedo lengths should include the additional calculations for mold plate expansion which must be subtracted from torpedo expansion to obtain actual differential expansion between the torpedo and the plates.

1 Select the appropriate torpedo expansion coefficient from the table of values provided. The expansion coefficient is expressed in values of 10^{-6} requiring the decimal be shifted 6 places to the left.

2 In the equation, substitute appropriate values for expansion coefficient, length, and temperatures.

3 Solve the equation for the length change total in inches and use this figure to determine the room temperature location of the torpedo in the mold. If additional accuracy is required, proceed to the additional steps 4 through 6.

4 Select the appropriate mold plate expansion coefficient from the table of values provided. The expansion coefficient is expressed in values of 10^{-6}, requiring the decimal be shifted 6 places to the left.

5 In the equation, substitute appropriate values for mold plate expansion coefficient, affected length, and temperatures.

6 Solve the equation for plate length change in inches and subtract this figure from the previously calculated length change value for the torpedo. The final value obtained represents the true differential expansion which will occur during system operation and provides the most accurate adjustment of room temperature torpedo tip location.

If the length of the torpedo has several areas where rates of differential expansion vary, these same calculations can be repeated for each area and then added together to reach the cumulative total.

Regardless of the calculation method used, additional adjustment will be required to fine tune the molding process.

Thermal Expansion Equation

$$\Delta l = \infty * l_r * (t_o - t_r)$$

Δl = **Length Change Total**

∞ = **Coefficient Of Expansion**

l_r = **Length @ Room Temp.**

t_o = **Operating Temperature**

t_r = **Room Temperature**

Expansion Coefficient For Common Tool Materials	
H-13 7.00	S-7 7.60
D-2 6.63	A-2 7.19
P-20 7.80	BeCu 9.70

Expansion coefficients (**∞**) are expressed in units of (in. / in. / °F. x 10^{-6}).

Recommended Torpedo Gate And Sprue Configurations

Torpedo Tip Configurations And Applications

The “SOLUTION” series torpedoes are offered in three standard tip configurations suitable for use in most common pin gating applications. The heating element designs used in conjunction with these standard tip designs have been precision engineered to provide optimum heat profile characteristics for that specific tip.

The popular single 60° included angle tip provides the most uniform heating of the gate area. The thermal characteristics of this tip configuration are enhanced by the improved heat transfer of the relatively large tip mass and the ability to extend the heating element further into the tip.

Double 30/60° angle tips are useful in applications where access into the immediate area of the gate is restricted by cavity design requirements. This tip configuration allows the use of a 70° included gate angle, rather than the normal 90° gate angle used with the other tip configurations. The smaller tip cross-section in the gate area combined with the 70° gate angle minimizes flow restriction while maximizing strength of the orifice and land area.

Double radius tip designs feature a double 40/90° angled tip with blend radii located at the angle intersections. These tip configurations locate the element closer to the tip for improved heating while minimizing flow restriction in the gate orifice area. This tip design improves resin flow in applications requiring extremely small gates.

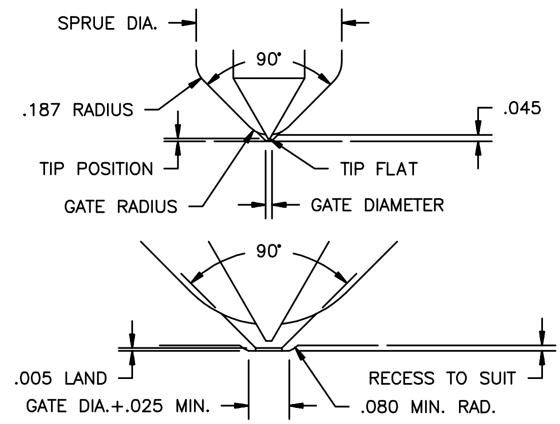
Gate Dimensional Specifications And Modifications

Gate designs are resin, part and process dependent and normally require application specific dimensions. The basic gate designs shown are dimensionally representative of those used in common applications, but typically require modification to optimize the molding process and part quality. Modifications normally involve adjustment of gate orifice diameter. Gate diameters of .035 to .050 are commonly used for small and medium size parts molded of high flow materials such as polyethylene, polypropylene and nylon. Diameters of .050 to .150 are common in the case of larger parts and lower flow resins such as ABS, polycarbonate and acrylic. Tip flats can increased and used in combination with even larger gate orifices. Heated tip position is normally adjusted for flush to .010 back from gate face.

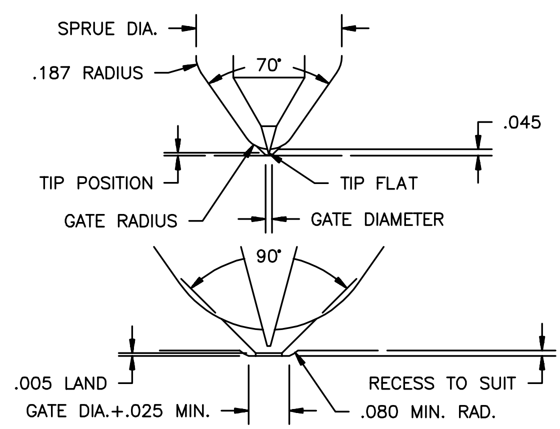
Adherence to gate design recommendations will ensure superior processing of both general purpose and temperature sensitive resins. Recommended gate land dimensions must be maintained. Lands in excess of those specified will increase pressure drop, create large gate marks and result in gate stringing. Avoid gate and sprue modifications which decrease strength of the gate area or restrict resin flow through the gate. Such modifications may result in breakage of the gate area.

Torpedo Series	Body Dia.	Gate Radius	Sprue Diameter
.312	.250	.156	.625
.375	.312	.187	.687
.394	.384	.187	.875
.500	.490	.187	1.000
.625	.615	.250	1.125
.750	.740	.250	1.250
.875	.865	.312	1.375
1.000	.990	.312	1.500

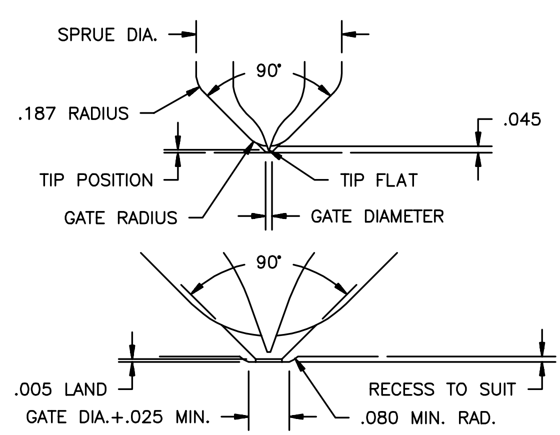
Typical Gate For 60° Single Angle Tip



Typical Gate For 30/60° Double Angle Tip



Typical Gate For 40/90° Angle Double Radius Tip



Recommended Torpedo Stabilizer Fin And Ring Configurations

Stabilizer fins and rings centralize the torpedo tip in the gate in applications involving long torpedo lengths. Standard "SOLUTION" series torpedoes feature a unique heat profile designed to accommodate the additional fin induced heat losses. Installation and machining recommendations must be followed to achieve the desired torpedo heating characteristics. Note that all stabilizer designs utilize three contact points 1/16" wide at 120° and contact the torpedo for a 1/16" length. The reduced tip end body diameter improves tip heating performance.

Face Mount Stabilizer Rings

Face mount stabilizer rings are commonly used in hot runner molds and insulated runner molds with internally heated runners. Since normal operation seldom requires complete removal of resin from the mold, the need to melt the ring free of the solidified plastic in the runner poses only minor inconvenience.

Torpedo Series	Body Dia.	Sprue Dia.	Seat Dia.
250	.250	.625	.875 +.001/-.000
312	.312	.687	.937 +.001/-.000
394	.384	.875	1.062 +.001/-.000
500	.490	1.000	1.187 +.001/-.000
625	.615	1.125	1.312 +.001/-.000
750	.740	1.250	1.437 +.001/-.000
875	.865	1.375	1.562 +.001/-.000
1000	.990	1.500	1.687 +.001/-.000

Sprue Mount Stabilizer Rings

Sprue mount stabilizer rings are utilized in insulated runner molds requiring more frequent removal of the runner system for color change or system cleaning. This design removes the stabilizer ring during the runner removal process and allows new rings to be substituted into the system with the intention of melting the ring free of the solidified plastic in the runner at a more convenient time after restarting the mold.

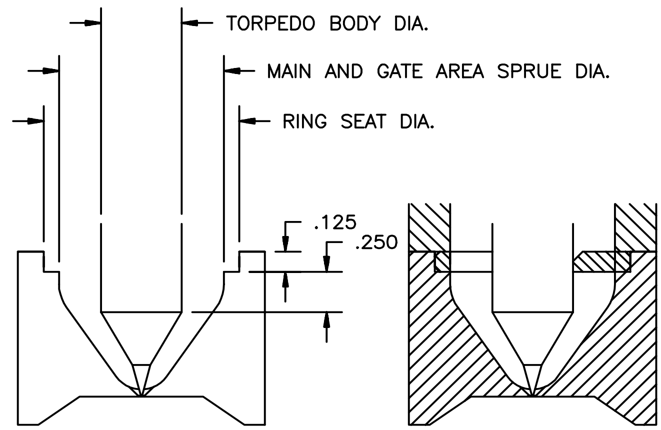
Torpedo Series	Body Dia.	Tip End Dia.	Sprue Dia.	Seat Dia.
394	.384	.364	1.072	1.062 +.001/-.000
500	.490	.436	1.197	1.187 +.001/-.000
625	.615	.561	1.322	1.312 +.001/-.000
750	.740	.686	1.447	1.437 +.001/-.000
875	.865	.811	1.572	1.562 +.001/-.000
1000	.990	.936	1.697	1.687 +.001/-.000

Integral Sprue Stabilizer Fins

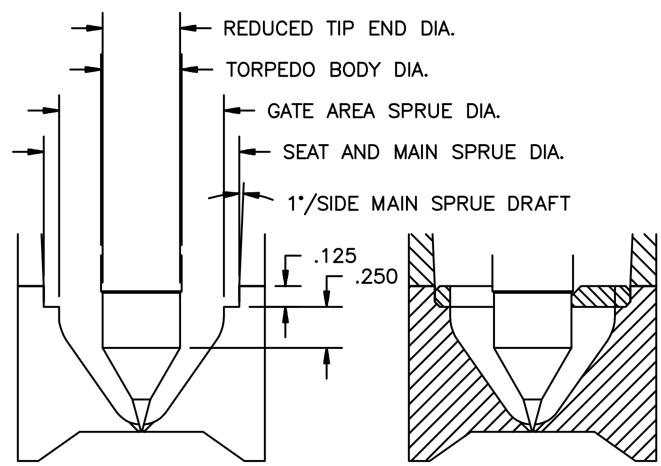
Integral sprue mount stabilizer fins can be used in any insulated runner mold but require more extensive machining. This tooling design allows the normal runner removal procedure to be followed and does not require the removal of the centering device from the mold.

Torpedo Series	Body Dia.	Tip End Dia.	Sprue Dia.	Fin Bore Dia.
394	.384	.364	.875	.365 +/-.0005
500	.490	.436	1.000	.437 +/-.0005
625	.615	.561	1.125	.562 +/-.0005
750	.740	.686	1.250	.687 +/-.0005
875	.865	.811	1.375	.812 +/-.0005
1000	.990	.936	1.500	1.687 +/-.0005

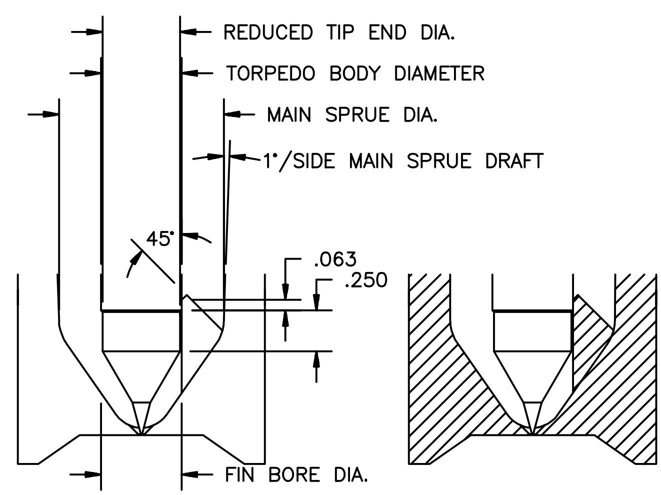
Face Mount Stabilizer Ring Installation



Sprue Mount Stabilizer Ring Installation



Integral Sprue Stabilizer Fin Dimensions



Torpedo Tip And Element Dimensional Relationship

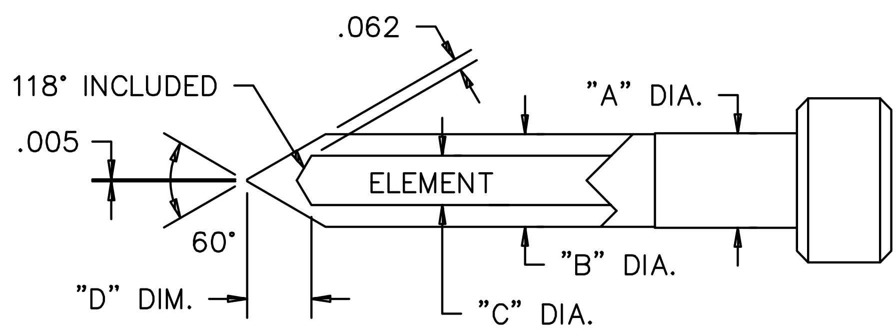
The data and drawings shown below are primarily intended for use in torpedo modification and repair. The appropriate dimensional information should be examined carefully prior to attempting any welding or machining operations on the tip and body portions of an integrally heated torpedo.

Machining operations must not reduce the wall thickness surrounding the heating element to a value of less than .040 inches at any location. Machining of the torpedo body will not alter the compressive strength of the torpedo but may reduce the flexural strength below acceptable limits.

Welding operations can be used in both repair and modification provided that the appropriate filler materials are used. Special care must be taken to avoid melting through the torpedo wall. Use minimum weld current settings and prevent excessive heat buildup during welding operations.

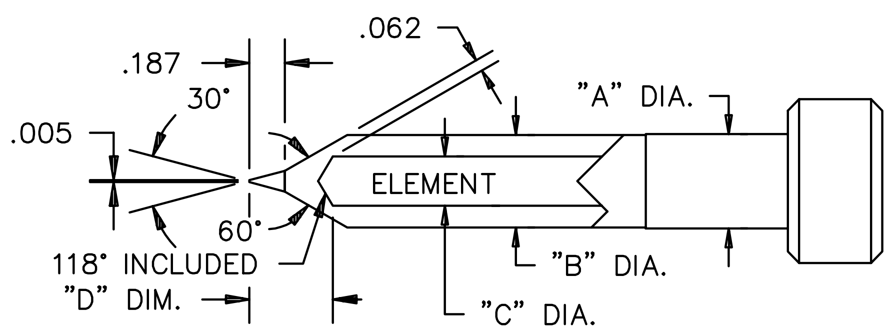
Standard 60 Degree Single Angle Gating Torpedo

"A" Dia.	"B" Dia.	"C" Dia.	"D" Dim.
.312	.250	.180	.272
.375	.312	.180	.272
.394	.384	.260	.340
.500	.490	.260	.340
.625	.615	.320	.394
.750	.740	.320	.394
.875	.865	.320	.394
1.000	.990	.415	.476
1.250	1.240	.415	.476



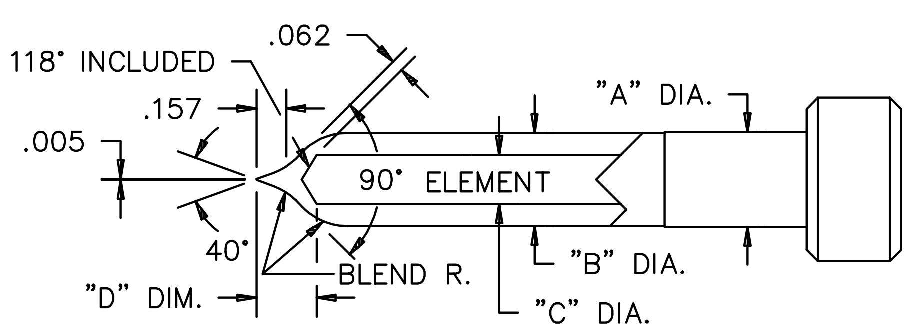
Standard 30/60 Degree Double Angle Gating Torpedo

"A" Dia.	"B" Dia.	"C" Dia.	"D" Dim.
.312	.250	.180	.372
.375	.312	.180	.372
.394	.384	.260	.441
.500	.490	.260	.441
.625	.615	.320	.494
.750	.740	.320	.494
.875	.865	.320	.494
1.000	.990	.415	.577
1.250	1.240	.415	.577



Standard 40/90 Degree Double Radius Gating Torpedo

"A" Dia.	"B" Dia.	"C" Dia.	"D" Dim.
.312	.250	.180	.278
.375	.312	.180	.278
.394	.384	.260	.340
.500	.490	.260	.340
.625	.615	.320	.345
.750	.740	.320	.345
.875	.865	.320	.345
1.000	.990	.415	.476
1.250	1.240	.415	.476



Torpedo Tip And Element Dimensional Relationship

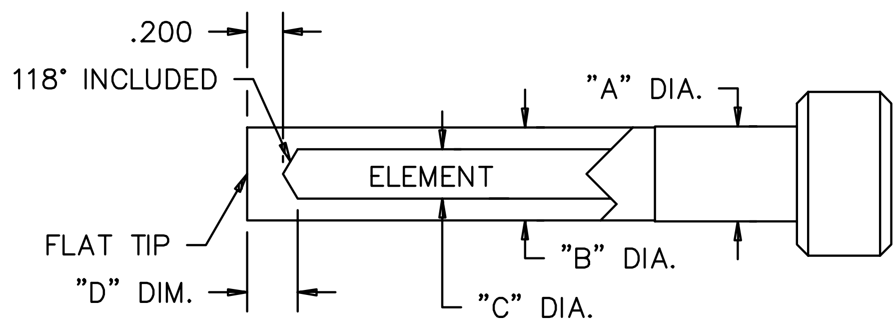
The drawings and data below should be examined carefully before attempting repair or modification. Wall thickness should not be reduced to a value less than .040 inches. When welding, use low current settings and minimize heat buildup to avoid the possibility of melting through the torpedo wall.

The dimensional data provided for the tunnel gating torpedo configuration is particularly important as the torpedo is shipped with an unfinished tip intended for final machining by the customer. Tip design and machining specifications for standard tunnel gating applications are provided in this catalog.

Tunnel gate tooling applications requiring special tip configurations may dictate the use of additional tip machining stock to satisfy final wall thickness requirements after customer machining. Tip stock can be customer specified or developed from customer supplied tip drawings.

Standard 180 Degree Flat Tip Tunnel Gating Torpedo

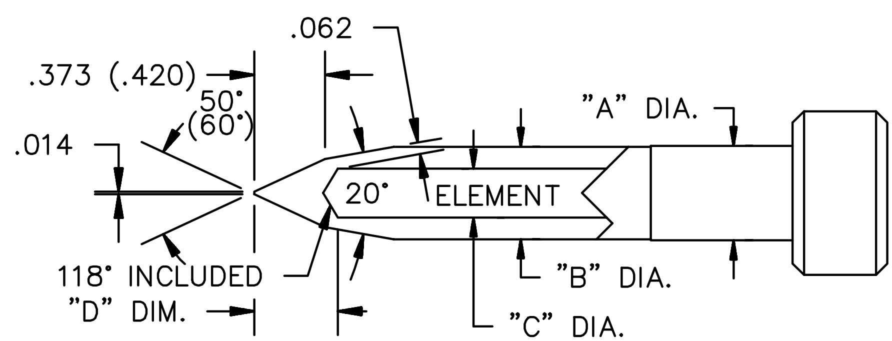
"A" Dia.	"B" Dia.	"C" Dia.	"D" Dim.
.312	.250	.180	.254
.375	.312	.180	.254
.394	.384	.260	.278
.500	.490	.260	.278
.625	.615	.320	.296
.750	.740	.320	.296
.875	.865	.320	.296
1.000	.990	.415	.325
1.250	1.240	.415	.325



Standard 50/20 And 60/30 Degree Double Angle Gating Torpedo

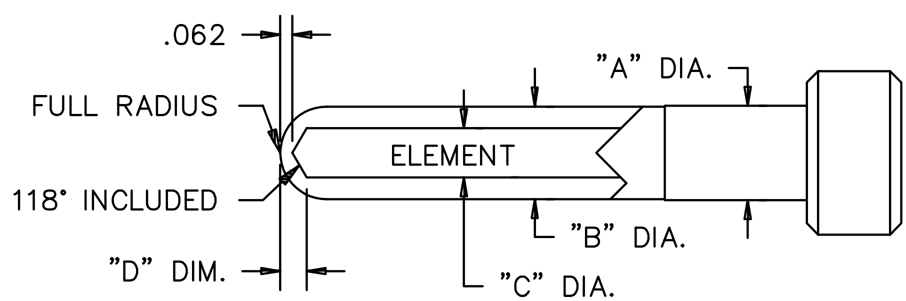
"A" Dia.	"B" Dia.	"C" Dia.	"D" Dim.
.500	.490	.260	.441
.625	.556	.260	.441
.625	.615	.320	.394
.750	.687	.320	.394
.750	.740	.320	.394
.875	.865	.320	.394
1.000	.990	.415	.483
1.250	1.240	.415	.483

Note: Drawing dimensions in parentheses refer to torpedoes with "B" diameter of .615 and larger.



Standard Full Radius Runner Torpedo

"A" Dia.	"B" Dia.	"C" Dia.	"D" Dim.
.312	.250	.180	.116
.375	.312	.180	.116
.394	.384	.260	.140
.500	.490	.260	.140
.625	.615	.320	.158
.750	.740	.320	.158
.875	.865	.320	.158
1.000	.990	.415	.187
1.250	1.240	.415	.187



Basic Torpedo And Thermocouple Testing And Troubleshooting

Testing of heaters, sensors and wiring circuits is required during system setup and maintenance. The procedures used in component and system testing are fairly basic but require expertise in electrical theory, test procedures and use of test equipment.

Heating Element Test Procedures

The integral heating element of “SOLUTION” series components consists of one or more nickel-chromium wire coil assemblies connected to solid nickel pin conductors. Resistance checking is easily accomplished by disconnection of the control cable from the mold and measuring resistance of each individual component. Resistance values are noted on the components identification tag but can also be readily calculated from the components' catalog specified voltage and wattage.

Open Electrical Circuits - A multimeter, set to a resistance scale, can be used to test for open power circuit conditions. Open circuits will result in resistance readings substantially higher than the readings specified. Open circuits due to lead wire damage can be factory repaired. Internally open heating elements are not repairable.

Shorted Electrical Circuits - A multimeter, set to a resistance scale, can be used to test for shorted power circuit conditions. Short circuits will result in component resistance values substantially lower than the resistance values specified.

Grounding - A megohmmeter with a minimum 500 volt test potential should be used for insulation testing.

Thermocouple Test Procedures

Thermocouple sensors consist of two dissimilar materials, usually in wire form, joined at one end. Most thermocouples are used in conjunction with extension circuits which route the sensor output to the control. Extension circuits typically include male and female connectors and additional lengths of thermocouple wire and cable. It is imperative that polarity is maintained throughout the circuit.

Polarity Reversal - A multimeter, set to a millivolt scale, can be used to test for reversed polarity. With the positive lead of the multimeter on the positive lead of the thermocouple and the negative lead of the multimeter on the negative lead of the thermocouple, room temperature millivolt values of will increase as heat is applied to the junction area of the thermocouple.

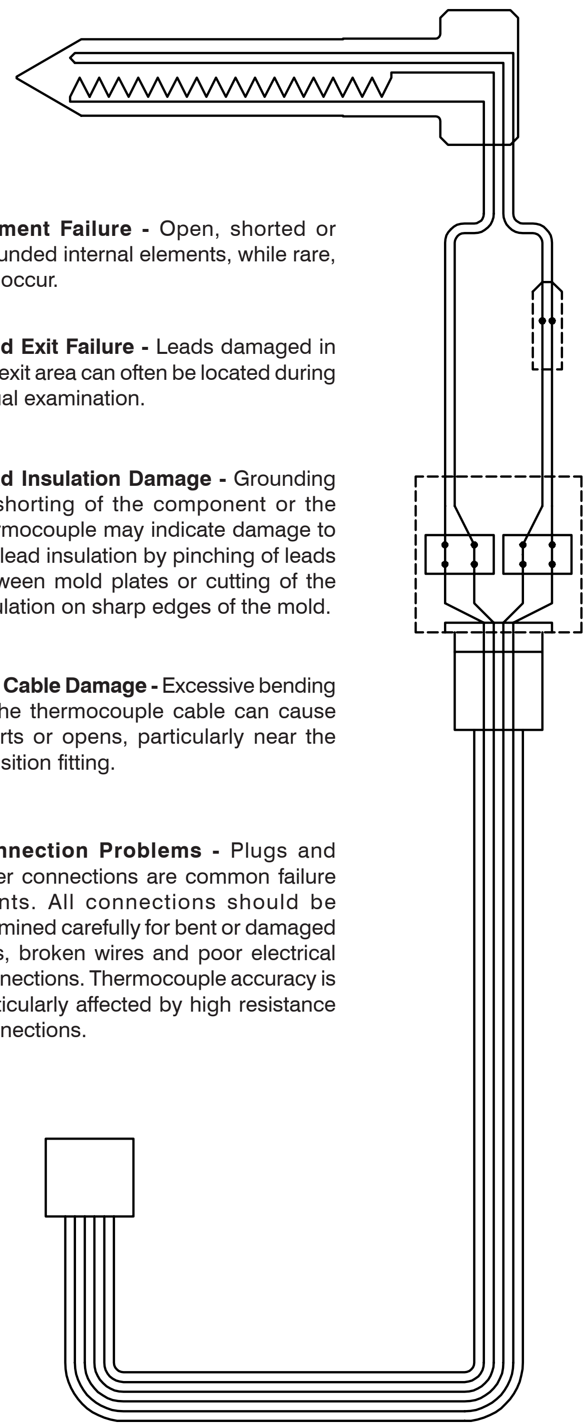
Open Thermocouple Circuits - A multimeter, set to a resistance scale, can be used to test for open thermocouple circuit conditions. Open thermocouple circuits will result in resistance readings substantially higher than those specified for the component.

Shorted Thermocouple Circuits - A multimeter, set to a resistance scale, can be used to test for shorted thermocouple circuit conditions. Shorted thermocouple circuits will result in resistance readings substantially below the values specified for the component.

Grounding - The majority of thermocouples used in runnerless systems are of the grounded junction variety with the measuring circuit intentionally grounded to the component and the mold in the junction area. Additional grounds in the thermocouple measuring circuit will cause secondary junctions which average the temperature reading between the two ground locations. Additional grounds in the thermocouple circuit will result in reduced resistance readings and can be determined in the same manner as shorted thermocouple circuits.

Potential Areas Of Component Damage And Failure.

The primary areas where component and circuit damage can cause system operational problems are described and illustrated below. Note that most circuit and component failures are lead related and can be field or factory repaired depending on failure location.



Element Failure - Open, shorted or grounded internal elements, while rare, do occur.

Lead Exit Failure - Leads damaged in the exit area can often be located during visual examination.

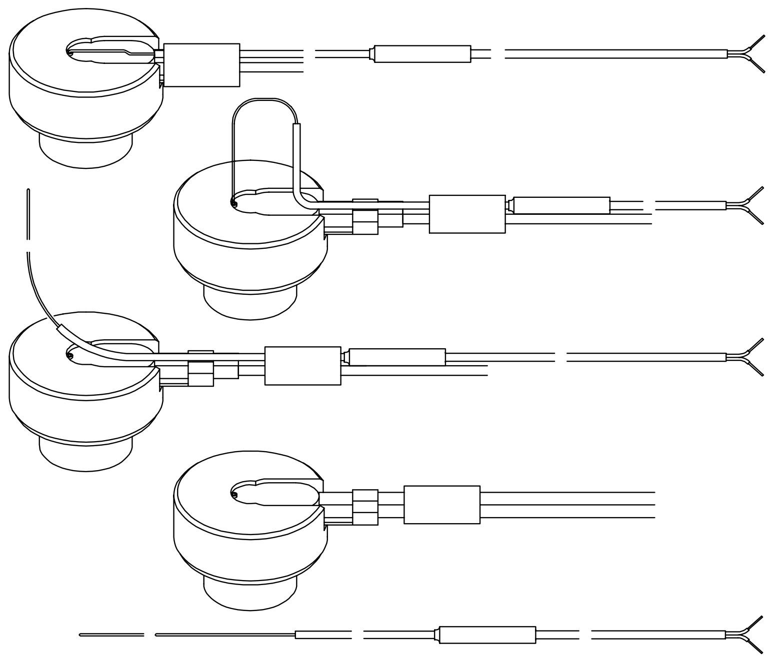
Lead Insulation Damage - Grounding or shorting of the component or the thermocouple may indicate damage to the lead insulation by pinching of leads between mold plates or cutting of the insulation on sharp edges of the mold.

T/C Cable Damage - Excessive bending of the thermocouple cable can cause shorts or opens, particularly near the transition fitting.

Connection Problems - Plugs and other connections are common failure points. All connections should be examined carefully for bent or damaged pins, broken wires and poor electrical connections. Thermocouple accuracy is particularly affected by high resistance connections.

Torpedo Thermocouple Replacement Procedures

Thermocouple Removal



The initial step in thermocouple replacement consists of removing the malfunctioning or damaged thermocouple.

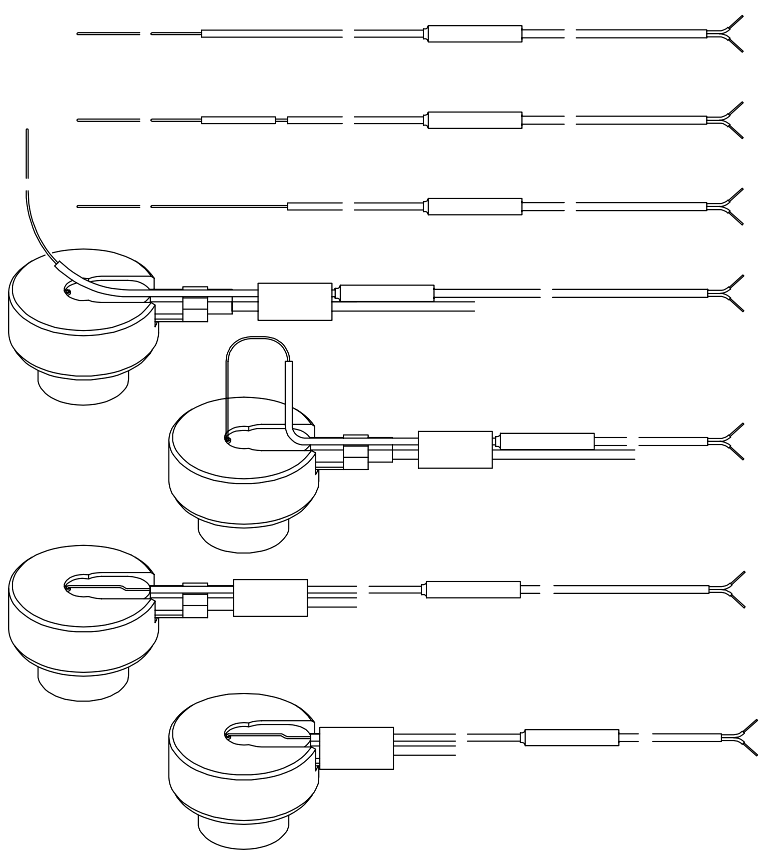
Slide the expandable fiberglass sleeve off the clip support to allow free movement of the thermocouple within the sleeve.

Insert the tip of a scribe or other pointed rod under the thermocouple cable and lift the cable into the loop type removal position.

Grasp the cable with a needle nose pliers and pull the cable end of the thermocouple out of the well approximately one inch. Repeat this procedure until the cable end of the thermocouple is pulled completely from the well. Ensure that the probe is removed intact from the well and that the well is clear for installation of a new thermocouple. A length of .020 diameter music wire can be pushed into the well to test insertion depth and for cleaning purposes.

Complete the removal process by pulling the thermocouple free of the sleeve.

Thermocouple Installation



Installation of a new thermocouple requires a bare probe length equal to the torpedo length. Trim the grey protective sleeve to expose the probe. Place the probe on a flat surface and trim by rolling a sharp knife or safety razor blade around the diameter. Avoid excessive pressure while trimming. Slide the trimmed portion off the probe.

Slide the sleeve back from the clip support and insert the thermocouple probe through the sleeve.

Form the probe into a loop and insert the tip into the well.

Slide the probe into the well until it stops against the bottom of the well. If hand insertion is difficult, grasp the probe firmly with a small pair of needle nose pliers 3/16" above the torpedo and push the probe into the well. Repeat this process until the probe seats against the bottom of the well.

Pull gently on the lead side of the thermocouple until the probe forms a 90 bend at the top of the well. Push the exposed portion of the probe below the surface of the torpedo head.

To complete the installation process, twist and slide the expandable sleeve into position on the clip support.